

Revised Checklist of Branchiopoda (Crustacea) in Uzbekistan Highlights Existing Blind Spots in the Knowledge of Regional Fauna

Ivan A. Dadykin^{1,*}, Polina A. Volkova², Maqsadjon J. Madumarov³, Saodatxon O. Madumarova⁴, Elena N. Ginatullina⁵, and Alexey A. Kotov¹

¹A.N. Severtsov Institute of Ecology and Evolution of Russian Academy of Sciences, Leninsky Pr., 33, 119071 Moscow, Russia.

*Correspondence: E-mail: ivan.dadykin@gmail.com (Dadykin)

E-mail: alexey-a-kotov@yandex.ru (Kotov)

²I.D. Papanin Institute for Biology of Inland Waters of Russian Academy of Sciences, Borok, Nekouz District, 152742 Yaroslavl Region, Russia.

E-mail: polina.an.volkova@gmail.com (Volkova)

³Kokand State University, Turon str. 23, Kokand, 150700 Ferghana Province, Uzbekistan. E-mail: maqsadjon_mj84@mail.ru (MJ Madumarov)

⁴Kokand University, Turkiston str. 28-A, Kokand, 150700 Ferghana Province, Uzbekistan. E-mail: saodatxon_mo88@umail.uz (SO Madumarova)

⁵Astrakhan State Technical University, branch of Uzbekistan, Universitetskaya str. 2, Kibray District, 100164 Tashkent Province, Uzbekistan.

E-mail: e-ginatullina@yandex.ru (Ginatullina)

Received 22 January 2025 / Accepted 9 February 2026 / Published 1 April 2026

Communicated by Benny K.K. Chan

After ca. 150 years of faunistic and taxonomic research, the branchiopods (Crustacea: Branchiopoda) of Central Asia still remain one of the poorly studied groups, despite their importance for freshwater ecosystems. Within the region, the most actively investigated country is Uzbekistan, containing a large diversity of water bodies. However, to date a large body of published literature devoted to the local branchiopod fauna lacks critical reviews. Here, we aim to summarize the existing knowledge of Uzbek Branchiopoda based on previous studies and original samples collected in twelve regions of Uzbekistan. Of 47 branchiopod taxa collected in this study, two species—*Camptocercus uncinatus* Smirnov, 1971 and *Ilyocryptus spinifer* Herrick, 1882 (Cladocera: Anomopoda)—are new records for the local fauna. Also, we confirm the presence of four more rare taxa in Uzbekistan and provide a list of branchiopod records for each province of the country. With the new records, the list of Branchiopoda in Uzbekistan contains 107 species, which are unequally distributed within the country: Karakalpakstan has the richest fauna (82 species), followed by provinces of northeast Uzbekistan (40 or more taxa), while local faunas of Kashkadarya, Khorezm, Navoiy and Syrdarya Provinces include fewer than 25 taxa each. Such inequality might be due to several reasons, of which research effort seems to be the most significant. Faunistic compositions of the species-rich provinces appear to be uniform and are similar to those of West and South Tajikistan, comprising high proportions of cosmopolitan, boreal and thermophilic south temperate/tropical taxa. The best studied cladoceran local faunas of the Karakalpakstan and the Fergana valley resemble that of Tajikistan and, to a lesser extent, those of the Mediterranean countries. Thus, these local faunas together form West Eurasian cluster, which fits the biogeographic pattern observed in the northern Palearctic. However, final conclusions about Uzbek Branchiopoda and similarity of the local faunas should not be made to date, as our study highlights a lack of research in several regions, taxonomic groups (Anostraca, Notostraca, Spinicaudata) and particular water body types (temporary pools, montane water bodies). Also, faunistic composition might be distorted by cryptic endemism or extinction of some branchiopod species due to environmental changes. We hope that the presented checklist will encourage further faunistic, taxonomic and phylogeographic research in Uzbekistan.

Keywords: Biogeography, Central Asia, Cladocera, Diversity, Zooplankton

BACKGROUND

Branchiopoda Latreille, 1817 is a diverse group of crustaceans playing a pivotal role in continental waters. Due to their ability to form resting eggs that tolerate drought and spread easily, branchiopods often serve as pioneers colonizing newly formed and temporary water bodies (Hairston 1996; Louette and De Meester 2005; Moreno et al. 2019). Being able to survive in a wide range of salinities and temperatures, some representatives of Branchiopoda have become notorious invasive species (Telesh and Ojaveer 2002; Muñoz et al. 2014; Walsh et al. 2017; Kotov et al. 2022a). Nowadays, branchiopods are widely used in fish farming and aquaculture as an excellent food source for plankton-feeding fish, prawns, and other aquatic predators (Nakamoto et al. 2008; Bengtson et al. 2018; Rasdi et al. 2020). Moreover, branchiopods such as *Daphnia* O.F. Müller, 1785, *Moina* Baird, 1850 and *Artemia* Leach, 1819 are widely used in ecology, toxicology, physiology, and developmental biology as model objects (Dodson et al. 2010; Alyuruk et al. 2013; Ebert 2022).

However, despite the great importance of branchiopods, their diversity in many regions remains insufficiently studied. In particular, this is true for Central Asia, the region encompassing Uzbekistan, Tajikistan, Kyrgyzstan, Turkmenistan, southern Kazakhstan, and Xinjiang Province of China (Liu et al. 2019). Today, Central Asia bordering the Caspian and the Aral Seas is hypothesized to have played a crucial role in latitudinal transition of freshwater species through the Ponto-Caspian region during the Cenozoic (Bianco 1990; Artamonova et al. 2021). Nevertheless, the scarcity of recent phylogenetic and phylogeographic studies in this region is evident (Dadykin et al. 2024, but see Ketmaier et al. 2008).

Uzbekistan is one of the largest Central Asian countries harbouring a high diversity of landscapes and water bodies. Most of the territory of Uzbekistan is occupied by two major river basins: those of the Amu Darya and Syr Darya rivers (Rakhmatullaev et al. 2013; Abuduwaili et al. 2018). These rivers and their tributaries are actively used for irrigation (Rakhmatullaev et al. 2013; Petrov et al. 2017), providing water supply for rice fields, fishponds and running channels of East (Andijan, Fergana, Namangan, Tashkent, Syrdarya, Samarkand, Surkhandarya, Kashkadarya, Bukhara Provinces) and West (Khorezm Province, Karakalpakstan) Uzbekistan. The middle and lower reaches of the Amu Darya and Syr Darya rivers are highly affected by drainage discharge. Lowland lakes are large but not numerous and are located mostly in floodplains or river deltas (Abuduwaili et al. 2018).

Among them, the Aydar-Arnasay lake system is the largest (Rakhmatullaev et al. 2013), with the exception of the Large Aral Sea which borders Uzbekistan in the west. The Aydar-Arnasay lake system is located in northern Uzbekistan (Djizak and Navoiy Provinces) and is largely formed by drainage discharge from irrigated lands and, to a lesser degree, by water inflow from Chardara Reservoir (Ergasheva 2022). However, most lakes in Uzbekistan are concentrated in mountainous areas (Petrov et al. 2017; Abuduwaili et al. 2018). These lakes, fed by glaciers, are located mostly above 3000 m a.s.l. in Tashkent, Surkhandarya and Kashkadarya Provinces (Petrov et al. 2017). Montane water bodies are present to a lesser extent in Fergana and Samarkand Provinces. Also, there are more than 50 large reservoirs in Uzbekistan, located mostly in the eastern and southern parts of the country (Rakhmatullaev et al. 2013) and exceeding the total area of natural lakes (Abuduwaili et al. 2018). Additionally, depending on the season, various ephemeral pools can be found throughout Uzbekistan, including those in towns and villages, river floodplains, and in uninhabited lowland and mountainous areas.

Investigations of branchiopod fauna in Uzbekistan started at the end of the 19th century (Ulyanin 1875; Walter 1888; Richard 1892). In the most extensive of these early works, Ulyanin (1875) provided notes on eight species of Anomopoda Sars, 1865 collected in Fergana, Djizak, Samarkand, and Tashkent Provinces, although nowadays some of the attributed toponyms are unclear. The first half of the 20th century was a period of intense faunistic studies in Uzbekistan, conducted by Keiser (1925 1937 1950) and other hydrobiologists (Meisner 1906; Behning 1938; Sokolov 1931; Pazhitnova 1935; Nikolsky and Pankratova 1934; Akatova 1950), while taxonomic revisions were scarce (Daday 1910 1914; Smirnov 1949). The abovementioned publications cover several large lake systems (Lake Sudochye, the Aral Sea and the lower reaches of the Amu Darya), fishponds of west and northeast Uzbekistan (Karakalpakstan, Samarkand, Bukhara, Tashkent, Andijan, and Fergana Provinces) and rice fields of the Syr Darya and the Amu Darya basins (Karakalpakstan, Khorezm, Syrdarya, and Tashkent Provinces).

In the second half of the 20th century, intense studies were conducted in South Uzbekistan, including reservoirs of Surkhandarya and Kashkadarya Provinces (Mukhamediev and Mukhitdinov 1967; Mukhitdinov 1967; Afanasyeva et al. 1972; Sibirtseva et al. 1972; Niyazov 1979). Along with these works, results of the faunistic investigations in Northeast Uzbekistan were summarized in two monographs devoted to the hydrobiology of the Fergana Valley (Mukhamediev

1967–1986). Also, Aripov (1972) reviewed the abiotic conditions, flora and fauna of rice fields in Khorezm Province and Karakalpakstan, reporting a total of 28 valid branchiopod species from there. Finally, the data on Uzbek branchiopod fauna were summarised in a number of wide-scale reviews (Manuilova 1964; Smirnov 1974–1976, etc.).

Between 1990 and 2010 the taxonomy of Uzbek branchiopods became a subject of intense studies, along with the faunal diversity. A significant contribution to the knowledge of the order Ctenopoda Sars, 1865 was made by N.M. Korovchinsky, resulting in a description of two new species and review of *Diaphanosoma* distribution in Uzbekistan (Korovchinsky 1987–2000; Korovchinsky and Mirabdullayev 1995–2001). Several taxonomic revisions were performed for different families of Anomopoda – particularly Moinidae Goulden, 1968 (Mirabdullayev 1993–1998), Daphniidae Straus, 1820 (Rakhmatullaeva and Mirabdullayev 1998; Berner and Rakhmatullaeva 2001), and Chydoridae Dybowski et Grochowski, 1894 (Sinev 2001). In addition, Rakhmatullaeva (1998) published a review of the morphological and ecological diversity of Daphniidae in Uzbekistan, focusing on distribution of the group in the region. These studies resulted in a preliminary checklist of Uzbek Cladocera Latreille, 1817 (Mirabdullayev et al. 1997).

During the last two decades, the fauna of Uzbekistan has been investigated actively, including both its general composition (e.g., Ginatullina et al. 2006b; Ginatullina 2010; Abdinazarov et al. 2019a; Khakimova et al. 2021) and ecological affinities (Ginatullina 2006a; Ginatullina et al. 2017–2023a). Nowadays, much attention is paid to the bioindication based on cladoceran diversity and abundance (Crotoft et al. 2015; Ginatullina 2022; Mirzambetov and Mirabdullayev 2022). The most recent data were summarized in three Ph.D. dissertations on the faunistic composition of mineralized lakes and reservoirs, and Fergana Valley water bodies (Ginatullina 2010; Abdinazarov 2018; Kuzmetov 2019). Recent studies mostly concern large natural and artificial water bodies, e.g., the Sudochoye lake system in Karakalpakstan, the Aydar-Arnasay lake system in Djizak Province, and Tuyabuguz Reservoir in Tashkent Province (Ginatullina et al. 2006a–2017–2023a c; Mirabdullayev et al. 2016; Abdullaeva et al. 2021; Erkabaev et al. 2024). Numerous investigations considering the Large Aral Sea should be mentioned particularly (Andreev 1989; Plotnikov 2013; Aladin et al. 2019–2021; Plotnikov et al. 2021).

Consequently, the branchiopod fauna of Uzbekistan seems to be relatively well-studied as compared to the faunas of the neighbouring countries.

Previous investigations have covered both large and small water bodies, such as lakes, reservoirs, fishponds, and rice fields. However, great changes observed recently in water bodies of Central Asia (Aladin et al. 2019; Plotnikov et al. 2021; Erkabaev et al. 2024) have resulted in significant shifts in the diversity and structure of aquatic assemblages (Ginatullina et al. 2017), stimulating the need for continuous hydrobiological monitoring. Unfortunately, several recent publications used an outdated taxonomy (e.g., Mustafaeva and Mirzayev 2018a; Khodjayeva and Shamsiyev 2020; Khakimova et al. 2021; Abdinazarov and Madumarov 2022), which complicates the interpretation of their results. Also, there is an evident lack of actual large-scale reviews of the data on taxonomy and fauna of the Branchiopoda in Uzbekistan, despite a large body of published case studies. The recent attempt to summarize the scattered information of the Uzbek fauna was made by Rakhmatullaeva (2007), who presented an online checklist of Cladocera in Uzbekistan including 88 taxa. However, this summary does not consider a significant portion of the relevant literature and thus misses taxa recorded earlier. Also, notes on synonymy and distribution are unavailable for most of the listed records. Another recent summary of planktonic organisms observed in reservoirs of Uzbekistan includes only 35 species (Kuzmetov and Abdinazarov 2016), and thus also cannot be considered as exhaustive.

Clearly, the data on Uzbek branchiopod fauna need to be revised. In this study, we summarize and validate the knowledge on Branchiopoda in Uzbekistan using both literature data and original samples from various types of water bodies. The study covers most of Uzbekistan's territory, including water bodies frequently investigated by other authors. Also, we aim to compare Uzbekistan's local faunas with those from other Eurasian regions of comparable latitude.

MATERIALS AND METHODS

Field sampling

Qualitative samples were collected by M. Madumarov, S. Madumaroova, I. Dadykin and P. Volkova in twelve regions of Uzbekistan (Andijan, Bukhara, Djizak, Fergana, Khorezm, Namangan, Navoiy, Syrdarya, Samarkand and Tashkent Provinces, and the Republic of Karakalpakstan) from March to August 2023–2024 (Table 1; Fig. 1A, B). A variety of water bodies were studied, including lakes, reservoirs, ponds, springs, channels, rice fields and temporary pools. I. Dadykin and P. Volkova collected the samples in the shallow littoral zones of the waterbodies which

primarily contained littoral crustaceans (Fig. 1B, locs. 1–70). A simple plankton net (25 cm diameter, 50 µm mesh size) was hauled horizontally through the shallow zone of the water body and scraped macrophytes if present. In some cases, an additional sample was taken from the same site by scratching the bottom and collecting the disturbed sediment. Each sample was filtered through the net and fixed in 96% ethanol, with the ethanol replaced at 12 and 24 hours after collection. M. Madumarov and S. Madumarova mostly sampled pelagic zones (lacking macrophytes), collecting primarily plankton (Fig. 1B, locs. 71–108). For sampling, a simple plankton net (25 cm diameter, 50 µm mesh) was hauled vertically through the water column at depths of 2–15 m. In the case of shallow water bodies, water was scooped several times by a 2 L glass container and filtered through the net. Samples were fixed in 96% ethanol replaced once, 48 or 72 h after collection.

Laboratory processing and images

Specimens of the branchiopods (orders Anomopoda, Ctenopoda, Onychopoda, Haplopoda, Anostraca and Spinicaudata) were provisionally identified using an Olympus SZ-51 stereomicroscope (Olympus Corporation, Japan) directly from the unsorted samples. For further identification, crustaceans were individually picked by a pipette or by forceps, placed in a drop of glycerol, dissected by electrolytically sharpened tungsten needles (Kotov and Štifter 2006) and studied using an Olympus CZ-41 (Olympus Corporation, Japan) high-power optical microscope. Identifications were based on Korovchinsky et al. (2021) and Rogers et al. (2017 2019). For photography, a LOMO BLM-L compound optical microscope equipped with an MS-12 digital camera (LOMO-MA, Russia) was used. Each specimen was photographed using focus stacking; the resulting series of image files was

Table 1. List of samples collected in Uzbekistan in March–August 2023–2024 by I. Dadykin, P. Volkova, M. Madumarov and S. Madumarova

Locality	Water body type	Region and District	Latitude, °N	Longitude, °E	Collectors	Date
1	large brackish lake with <i>Myriophyllum</i> and <i>Stuckenia</i> (benthos sample)	Djizak Province, Forish District	40.81968	67.90863	I. Dadykin, P. Volkova	24 June 2024
1a	large brackish lake with <i>Myriophyllum</i> and <i>Stuckenia</i> (plankton sample)	Djizak Province, Forish District	40.81968	67.90863	I. Dadykin, P. Volkova	24 June 2024
2	small drying brackish lake	Djizak Province, Forish District	40.82679	67.90714	I. Dadykin, P. Volkova	24 June 2024
3	channel with fast current, <i>Phragmites</i>	Djizak Province, Forish District	40.82811	67.88626	I. Dadykin, P. Volkova	24 June 2024
4	large lake with muddy sediment, <i>Phragmites</i> and <i>Myriophyllum</i> (plankton sample)	Djizak Province, Forish District	40.82606	67.88126	I. Dadykin, P. Volkova	24 June 2024
4a	large lake with muddy sediment, <i>Phragmites</i> and <i>Myriophyllum</i> (benthos sample)	Djizak Province, Forish District	40.82606	67.88126	I. Dadykin, P. Volkova	24 June 2024
5	channel with concrete banks, <i>Potamogeton</i>	Djizak Province, Forish District	40.82606	67.88126	I. Dadykin, P. Volkova	24 June 2024
6	large lake with muddy sediment, <i>Phragmites</i> and <i>Potamogeton</i>	Djizak Province, Forish District	40.85007	67.86377	I. Dadykin, P. Volkova	24 June 2024
7	large lake with muddy sediment, <i>Myriophyllum</i>	Djizak Province, Forish District	40.84490	67.88982	I. Dadykin, P. Volkova	24 June 2024
7a	large lake with sandy sediment, <i>Potamogeton</i> and <i>Myriophyllum</i>	Djizak Province, Forish District	40.84490	67.88982	I. Dadykin, P. Volkova	24 June 2024
8	small roadside brackish lake with <i>Stuckenia</i>	Djizak Province, Forish District	40.82227	67.88913	I. Dadykin, P. Volkova	24 June 2024
9	small lake with <i>Stuckenia</i>	Djizak Province, Forish District	40.83833	67.87122	I. Dadykin, P. Volkova	25 June 2024
10	Lake Arnasay, sandy littoral with <i>Phragmites</i> and <i>Potamogeton</i> (plankton sample)	Djizak Province, Forish District	40.94334	67.97201	I. Dadykin, P. Volkova	25 June 2024
10a	Lake Arnasay, sandy littoral with <i>Phragmites</i> and <i>Potamogeton</i> (benthos sample)	Djizak Province, Forish District	40.94334	67.97201	I. Dadykin, P. Volkova	25 June 2024
11	hypersaline lake with muddy sediment	Djizak Province, Forish District	40.95166	67.98301	I. Dadykin, P. Volkova	25 June 2024
12	Lake Arnasay, muddy littoral with <i>Phragmites</i> (benthos sample)	Djizak Province, Forish District	40.96393	67.98075	I. Dadykin, P. Volkova	25 June 2024
12a	Lake Arnasay, muddy littoral with <i>Phragmites</i> (plankton sample)	Djizak Province, Forish District	40.96393	67.98075	I. Dadykin, P. Volkova	25 June 2024
13	Lake Arnasay, sandy littoral with <i>Potamogeton</i>	Djizak Province, Forish District	40.90362	67.94786	I. Dadykin, P. Volkova	25 June 2024
14	drying lake with <i>Phragmites</i>	Djizak Province, Forish District	40.88358	67.93370	I. Dadykin, P. Volkova	25 June 2024
15	small lake with <i>Phragmites</i> and <i>Zannichellia</i>	Djizak Province, Forish District	40.45797	67.65411	I. Dadykin, P. Volkova	26 June 2024
16	fish pond with muddy sediment, <i>Phragmites</i>	Djizak Province, Forish District	40.45834	67.65301	I. Dadykin, P. Volkova	26 June 2024
17	small channel with slow current, <i>Phragmites</i> , <i>Potamogeton</i>	Djizak Province, Forish District	40.45864	67.65137	I. Dadykin, P. Volkova	26 June 2024
18	large brackish lake with muddy sediment	Djizak Province, Forish District	40.45844	67.64989	I. Dadykin, P. Volkova	26 June 2024

Table 1. (Continued)

Locality	Water body type	Region and District	Latitude, °N	Longitude, °E	Collectors	Date
19	deep channel with muddy sediment, <i>Phragmites</i> and <i>Typha</i>	Djizak Province, Forish District	40.45352	67.68476	I. Dadykin, P. Volkova	27 June 2024
19a	deep channel with muddy sediment, <i>Phragmites</i> and <i>Typha</i> (benthos sample)	Djizak Province, Forish District	40.45352	67.68476	I. Dadykin, P. Volkova	27 June 2024
20	deep channel with muddy sediment, <i>Phragmites</i> and <i>Typha</i> (benthos sample)	Djizak Province, Forish District	40.45767	67.67861	I. Dadykin, P. Volkova	27 June 2024
21	irrigation ditch in the field	Djizak Province, Forish District	40.43914	67.66669	I. Dadykin, P. Volkova	27 June 2024
22	irrigation ditch in the field	Djizak Province, Forish District	40.43451	67.66322	I. Dadykin, P. Volkova	27 June 2024
23	roadside puddle near irrigation ditch	Djizak Province, Forish District	40.42509	67.67762	I. Dadykin, P. Volkova	27 June 2024
24	small puddle near irrigation ditch	Djizak Province, Forish District	40.40599	67.72261	I. Dadykin, P. Volkova	27 June 2024
25	Kly River oxbow, <i>Phragmites</i> , <i>Najas</i> , <i>Ruppia</i>	Djizak Province, Forish District	40.33251	67.70544	I. Dadykin, P. Volkova	27 June 2024
26	drying lake with muddy sediment, algae	Djizak Province, Forish District	40.33180	67.70249	I. Dadykin, P. Volkova	27 June 2024
27	Karatepa Lake, muddy sediment and <i>Phragmites</i>	Djizak Province, Sharof Rashidov District	40.28253	67.72492	I. Dadykin, P. Volkova	28 June 2024
28	roadside puddle in Timiryazev	Djizak Province, Forish District	40.28961	67.74672	I. Dadykin, P. Volkova	28 June 2024
29	fish pond with muddy sediment, <i>Phragmites</i>	Djizak Province, Sharof Rashidov District	40.28423	67.75184	I. Dadykin, P. Volkova	28 June 2024
30	small pond with rocky sediment, <i>Phragmites</i>	Djizak Province, Forish District	40.35774	67.37540	I. Dadykin, P. Volkova	28 June 2024
31	spring with sandy sediment, filamentous algae	Djizak Province, Forish District	40.36007	67.37982	I. Dadykin, P. Volkova	28 June 2024
32	small stream with slow current, muddy sediment, <i>Chara</i>	Djizak Province, Forish District	40.36859	67.38802	I. Dadykin, P. Volkova	29 June 2024
33	small stream with slow current, sandy sediment, <i>Chara</i> and <i>Batrachium</i>	Djizak Province, Forish District	40.36859	67.38802	I. Dadykin, P. Volkova	29 June 2024
34	running pond with muddy sediment, filamentous algae	Djizak Province, Forish District	40.37217	67.38575	I. Dadykin, P. Volkova	29 June 2024
35	running pond with muddy sediment, filamentous algae, <i>Potamogeton</i> , <i>Batrachium</i>	Djizak Province, Forish District	40.37047	67.38522	I. Dadykin, P. Volkova	29 June 2024
36	running puddle with muddy sediment, algae, <i>Stuckenia</i>	Djizak Province, Forish District	40.34127	67.40240	I. Dadykin, P. Volkova	29 June 2024
37	large puddle with rocky sediment and muddy water	Djizak Province, Forish District	40.33622	67.40951	I. Dadykin, P. Volkova	29 June 2024
38	spring with muddy sediment in the spring valley	Djizak Province, Forish District	40.31083	67.33291	I. Dadykin, P. Volkova	29 June 2024
39	puddle with muddy sediment fed by spring	Djizak Province, Forish District	40.30874	67.28913	I. Dadykin, P. Volkova	30 June 2024
40	road puddle with muddy sediment	Djizak Province, Forish District	40.35911	67.29208	I. Dadykin, P. Volkova	30 June 2024
41	puddle in the bed of drying river, algae	Djizak Province, Forish District	40.37930	67.28047	I. Dadykin, P. Volkova	30 June 2024
42	Sentab Reservoir, muddy sediment, <i>Potamogeton</i> and <i>Myriophyllum</i>	Navoiy Province, Nurata District	40.64245	66.68204	I. Dadykin, P. Volkova	30 June 2024
43	small stream with muddy sediment, filamentous algae	Navoiy Province, Nurata District	40.56441	66.61379	I. Dadykin, P. Volkova	1 July 2024
44	small stream with sandy sediment	Navoiy Province, Nurata District	40.56441	66.61379	I. Dadykin, P. Volkova	1 July 2024
44a	small stream with sandy sediment, filamentous algae	Navoiy Province, Nurata District	40.56441	66.61379	I. Dadykin, P. Volkova	1 July 2024
45	small stream with fast current, <i>Chara</i> and terrestrial plants	Navoiy Province, Nurata District	40.56298	66.61950	I. Dadykin, P. Volkova	1 July 2024
46	puddle with sandy sediment fed by spring	Navoiy Province, Nurata District	40.55194	66.60079	I. Dadykin, P. Volkova	1 July 2024
47	Lake Fozilmon, muddy sediment, <i>Potamogeton</i> , <i>Stuckenia</i> (plankton sample)	Navoiy Province, Nurata District	40.55045	66.59095	I. Dadykin, P. Volkova	1 July 2024
47a	Lake Fozilmon, muddy sediment, <i>Potamogeton</i> , <i>Stuckenia</i> (benthos sample)	Navoiy Province, Nurata District	40.55045	66.59095	I. Dadykin, P. Volkova	1 July 2024
48	deep lake with muddy sediment fed by spring, <i>Batrachium</i>	Samarkand Province, Koshrabad District	40.56648	66.57979	I. Dadykin, P. Volkova	1 July 2024
49	small lake with muddy sediment	Samarkand Province, Koshrabad District	40.56725	66.58156	I. Dadykin, P. Volkova	1 July 2024
50	puddle with muddy sediment fed by spring	Navoiy Province, Nurata District	40.61133	66.60261	I. Dadykin, P. Volkova	2 July 2024
51	immersed quarry with rocky sediment and fast current (benthos sample)	Navoiy Province, Nurata District	40.60357	66.63001	I. Dadykin, P. Volkova	2 July 2024
52	shallow stream with slow current, algal mats	Navoiy Province, Nurata District	40.60508	66.64560	I. Dadykin, P. Volkova	2 July 2024
53	shallow stream with slow current, <i>Zannichellia</i> , tadpoles	Navoiy Province, Nurata District	40.60508	66.64560	I. Dadykin, P. Volkova	2 July 2024
54	running pond with rocky sediment, <i>Zannichellia</i> and filamentous algae, tadpoles	Navoiy Province, Nurata District	40.61276	66.64411	I. Dadykin, P. Volkova	2 July 2024
55	small puddle with immersed terrestrial plants	Samarkand Province, Jambay District	39.60312	67.19952	I. Dadykin, P. Volkova	3 July 2024
56	stream with slow current, immersed terrestrial plants	Samarkand Province, Jambay District	39.61184	67.19388	I. Dadykin, P. Volkova	3 July 2024
57	drying oxbow with muddy sediment	Samarkand Province, Jambay District	39.61866	67.18569	I. Dadykin, P. Volkova	3 July 2024
58	small lake with muddy sediment, immersed terrestrial plants	Samarkand Province, Jambay District	39.61923	67.18592	I. Dadykin, P. Volkova	3 July 2024

Table 1. (Continued)

Locality	Water body type	Region and District	Latitude, °N	Longitude, °E	Collectors	Date
59	stream with slow current, muddy sediment	Samarkand Province, Jambay District	39.62366	67.18306	I. Dadykin, P. Volkova	3 July 2024
60	channel with rocky sediment, <i>Chara</i> and <i>Potamogeton</i>	Samarkand Province, Jambay District	39.63186	67.17927	I. Dadykin, P. Volkova	3 July 2024
61	puddle with decomposing organic matter, <i>Stuckenia</i> , <i>Caulinia</i>	Samarkand Province, Jambay District	39.63233	67.18022	I. Dadykin, P. Volkova	3 July 2024
62	dump lake in the quarry, rocky sediment	Samarkand Province, Jambay District	39.61108	67.23461	I. Dadykin, P. Volkova	4 July 2024
63	Karaultepa Reservoir, muddy littoral	Djizak Province, Gallaorol District	39.86082	67.51754	I. Dadykin, P. Volkova	4 July 2024
64	roadside puddle, muddy sediment and plant matter	Djizak Province, Sharof Rashidov District	40.07512	67.94738	I. Dadykin, P. Volkova	5 July 2024
65	river Akhangaran lower to Tuyabuguz Reservoir dam, muddy sediment	Tashkent Province, Orta Chirchiq District	40.98997	69.28961	I. Dadykin, P. Volkova	5 July 2024
66	small pond with muddy sediment fed by springs, <i>Chara</i> and terrestrial plants	Tashkent Province, Orta Chirchiq District	40.99481	69.27816	I. Dadykin, P. Volkova	5 July 2024
66a	small pond with muddy sediment fed by springs, shallow part with terrestrial plants	Tashkent Province, Orta Chirchiq District	40.99481	69.27816	I. Dadykin, P. Volkova	5 July 2024
67	large fish pond with muddy sediment, <i>Potamogeton</i>	Tashkent Province, Orta Chirchiq District	40.99506	69.27882	I. Dadykin, P. Volkova	5 July 2024
68	Tuyabuguz Reservoir, muddy littoral with <i>Najas</i> and <i>Potamogeton</i>	Tashkent Province, Orta Chirchiq District	40.99106	69.31135	I. Dadykin, P. Volkova	6 July 2024
69	Tuyabuguz Reservoir, muddy littoral with <i>Caulinia</i>	Tashkent Province, Orta Chirchiq District	40.99203	69.31203	I. Dadykin, P. Volkova	6 July 2024
70	Tuyabuguz Reservoir, <i>Potamogeton</i> bush	Tashkent Province, Orta Chirchiq District	40.98314	69.31465	I. Dadykin, P. Volkova	6 July 2024
71	Lake Sarikamish	Karakalpakstan, Kungrad District	42.30778	57.47611	M. Madumarov	10 July 2024
72	Lake Sudochye	Karakalpakstan, Muynak District	43.57278	58.54417	M. Madumarov	9 July 2024
73	Lake Sudochye	Karakalpakstan, Muynak District	43.58686	58.54653	M. Madumarov	11 July 2024
74	Lake Karateren	Karakalpakstan, Takhtakupir District	43.29527	60.38422	M. Madumarov	12 July 2024
75	Lake Govukkul	Khorezm Province, Khiva District	41.40556	60.38500	M. Madumarov	13 July 2024
76	Lake Govukkul	Khorezm Province, Khiva District	41.40647	60.38628	M. Madumarov	13 July 2024
77	Lake Ulugshurkul	Khorezm Province, Yangiariq District	41.26307	60.48550	M. Madumarov	13 July 2024
78	Lake Karakir	Bukhara Province, Peshkun District	40.40028	63.27472	M. Madumarov	14 Aug 2024
79	Lake Dengizkul	Bukhara Province, Olot District	39.16679	64.03006	M. Madumarov	14 Aug 2024
80	Lake Khadicha	Bukhara Province, Karaulbazar District	39.26424	64.52188	M. Madumarov	11 June 2024
81	Lake Ayakagitma	Bukhara Province, Gijduvon District	40.60640	64.54212	M. Madumarov	7 June 2024
82	Lake Devkhona	Bukhara Province, Karaulbazar District	39.19148	64.62842	M. Madumarov	9 June 2024
83	Lake Kuyumazar	Navoiy Province, Kiziltepa District	39.85610	64.72556	M. Madumarov	15 July 2024
84	Lake Aydarkul	Navoiy Province, Nurata District	40.91444	66.09167	S. Madumarova	8 May 2023
85	Lake Aydarkul	Navoiy Province, Nurata District	41.05778	66.42944	M. Madumarov	14 June 2023
86	Lake Tuzkan, open pelagic in the southern part	Djizak Province, Forish District	40.55592	67.46889	M. Madumarov	25 May 2024
87	Lake Tuzkan, open pelagic near the eastern shore	Djizak Province, Forish District	40.61806	67.61528	M. Madumarov	26 June 2024
87a	Lake Tuzkan, open pelagic near the eastern shore	Djizak Province, Forish District	40.61806	67.61528	M. Madumarov	29 June 2024
88	rice field near Bakhmal	Syrdarya Province, Saykhunabad District	40.77448	68.75041	M. Madumarov	30 June 2024
88a	rice field near Bakhmal	Syrdarya Province, Saykhunabad District	40.77448	68.75041	M. Madumarov	30 June 2024
89	rice field near Yangikhaiot	Syrdarya Province, Mirzaabad District	40.35207	68.78440	M. Madumarov	30 June 2024
90	fishpond near Baimuradabad	Syrdarya Province, Khavast District	40.25236	68.95152	M. Madumarov	30 June 2024
91	small pool in Uzbekistan National University	Tashkent City	41.34809	69.20254	S. Madumarova	28 Apr 2024
92	Tuyabuguz Reservoir, western part, open pelagic	Tashkent Province, Orta Chirchiq District	40.97030	69.30000	M. Madumarov	17 Aug 2024
93	Tuyabuguz Reservoir, eastern part, open pelagic	Tashkent Province, Orta Chirchiq District	40.93763	69.34520	M. Madumarov	26 May 2024
94	Lake Sarikamish	Fergana Province, Beshariq District	40.40444	70.38333	M. Madumarov	31 Mars 2024
95	oxbow of Syr Darya River	Fergana Province, Beshariq District	40.57034	70.59685	M. Madumarov	15 Apr 2024
96	fishpond near Usmanabad	Fergana Province, Beshariq District	40.57105	70.59954	M. Madumarov	7 July 2024
97	fishpond in Sarvaksay River valley	Namangan Province, Pop District	40.89105	70.69702	M. Madumarov	20 June 2023
98	Lake Mulaturak	Namangan Province, Pop District	41.37062	70.74892	M. Madumarov	13 Aug 2024
99	fishpond near Navbakhor	Namangan Province, Mingbulak District	40.76648	71.10736	M. Madumarov	22 Apr 2024
100	Rezaksay Reservoir, open pelagic	Namangan Province, Chust District	40.93367	71.29776	S. Madumarova	15 May 2023
101	Ertikan Reservoir, open pelagic	Namangan Province, Kasansay District	41.15882	71.55718	S. Madumarova	30 June 2023
102	Eskiyer Reservoir, open pelagic	Namangan Province, Yangikurgan District	41.16363	71.71596	M. Madumarov	20 June 2023
103	Chartak Reservoir, open pelagic	Namangan Province, Chartak District	41.17922	71.81655	S. Madumarova	23 June 2024
104	Central Fergana Reservoir, open pelagic	Fergana Province, Yazyavan District	40.64778	71.50152	S. Madumarova	25 Aug 2023
105	fishpond near Akaltyn	Andijan Province, Ulugnar District	40.73663	71.70763	S. Madumarova	5 Apr 2024
106	fishpond near Avulmat	Andijan Province, Ulugnar District	40.72671	71.76746	S. Madumarova	26 June 2023
107	Lake in Nodirabegim Park, Andijan	Andijan Province, Andijan District	40.79356	72.37471	S. Madumarova	15 June 2024
108	Atchapar Reservoir	Andijan Province, Andijan District	40.80010	72.54056	S. Madumarova	27 June 2023

The locality numbers correspond to that in figure 1.

subsequently merged with Helicon Focus 8 software (Helicon Soft Ltd., Ukraine). The localities and regions were visualized on a map in QGIS 3.34.6 software (QGIS Development Team, USA), with the CartoDB Positron (retina) and the Natural Earth Vector data (<https://www.naturalearthdata.com/>) as base layers.

Checklist processing

For the construction of the checklist, we used both original data and published literature, including Ulyanin (1875); Meisner (1906); Daday (1910 1914); Keiser (1925 1937); Pazhitnova (1929 1935); Nikolsky and Pankratova (1934); Behning (1938); Smirnov (1949); Akatova (1950); Stepanova and Ledyeva (1957); Aripov (1966 1972); Mukhamediev (1967 1986); Mukhamediev and Mukhitdinov (1967); Mukhitdinov (1967); Afanasyeva et al. (1972); Lyakhnovich et al. (1972); Sibirtseva et al. (1972); Lebedeva and Rakhmanova (1982); Korovchinsky (1987 2000); Mordukhai-Boltovskoi and Rivier (1987); Kazakhbaev (1988); Andreev (1989); Mirabdullayev (1993 1998); Korovchinsky and Mirabdullayev (1995

2001); Kuzmetov (1998 2019); Rakhmatullaeva and Mirabdullayev (1998); Berner and Rakhmatullaeva (2001); Rakhmatullaeva and Khurshut (2001); Sinev (2001 2015); Rogers (2003 2020); Dobrynina (2004); Ginatullina et al. (2006a b 2017 2023a b c); Mustafaeva et al. (2006 2021a b 2022); Ketmaier et al. (2008); Van Damme and Dumont (2008); Arashkevich et al. (2009); Ginatullina (2010 2022 2023); Marden et al. (2012); Plotnikov (2013); Crootof et al. (2015); Atashbar et al. (2016); Kuzmetov and Abdinazarov (2016); Turemuratova and Kuzmetov (2016); Abdinazarov (2018); Ginatullina and Temirova (2018); Mustafaeva and Mirzayev (2018a b); Turemuratova et al. (2018 2021 2022 2024); Abdinazarov et al. (2019a b); Aladin et al. (2019 2021); Saparov et al. (2019); Khodjayeva and Shamsiyev (2020); Abdullaeva et al. (2021); Atamuratova (2021); Karimov (2021); Korovchinsky et al. (2021); Khakimova et al. (2021); Shao et al. (2021); Turemuratova and Nagmetov (2021); Abdinazarov and Madumarov (2022); Mirzambetov and Mirabdullayev (2022); Utemuratova et al. (2022); Mukhamediev and Bekchonova (2023); Temirbekov et al. (2023); Erkaeva et al. (2024); Madumarov et al. (2024); Turemuratova



Fig. 1. Locations of the studied water bodies. (A) global position of Uzbekistan in Eurasia. (B) location of the studied water bodies. The locality numbers correspond to that in the table 1. Green filling indicates protected areas, Uzbekistan provinces are labelled.

and Kosymbetova (2024); Sinev et al. (2024). The synonymy of taxa is given following Rogers (2013 2020), Rogers et al. (2019), and Korovchinsky et al. (2021). The checklist is organised according to modern taxonomy of the branchiopods (WoRMS 2025).

The administrative division and city names follow the Government Portal of the Republic of Uzbekistan (2024). Distribution data is mainly given in accordance with Rogers et al. (2017), Rogers (2020), and Korovchinsky et al. (2021). For classifying the distribution types of Branchiopoda, a strongly modified system of Kotov (2016) initially proposed for East Asia is used. The following faunistic complexes are recognised: CAE, Central Asian endemics; EA, taxa primarily distributed in East Asia; PAL, taxa widely distributed in the Palearctic or Holarctic; PCA, taxa of the Ponto-Caspian origin; ST, species widely distributed in the south temperate zone (the South Palearctic); TR, tropical taxa; WE, West Eurasian taxa; WU, cosmopolitan unrevised taxa. In the case of some Anomopoda and Ctenopoda, the data on species distribution were supplemented with information from Korovchinsky et al. (2021).

Region comparisons

For comparison of faunistic richness between the provinces and regions and visualising the results, R 4.3.2 package (R Core Team 2023) was applied. The most studied regions of Uzbekistan, the Fergana Valley (including Andijan, Namangan, and Fergana provinces) and Karakalpakstan, were compared with relatively well-explored regions of Eurasia located at the same latitudes, to the extent that their faunistic lists could be obtained from few recently published reviews. Only the representatives of Cladocera (Anomopoda, Ctenopoda, Haplopoda, Onychopoda) were included in the analysis, as the diversity of the remaining groups is only provisionally studied in Uzbekistan. The local faunas of Spain, Italy, Greece, Russian North Caucasus, Russian Ciscaucasia, Turkey, Tajikistan, Mongolia, Chinese Tibet, Chinese Xinjiang Uyghur Autonomous Region, Chinese Inner Mongolia, and South Korea were compared. Data for these regions was obtained from Behning (1941); Margaritora (1985); Alonso (1996 2010); Flößner et al. (2005); Kaya and Altındağ (2007); Güher (2014); Jeong et al. (2015); Ji et al. (2015); Ustaoglu (2015); Xiang et al. (2015); Błedzki and Rybak (2016); Chertoprud et al. (2017); Kotov et al. (2017 2022b); Bozkurt and Bozça (2019); Aksenova et al. (2021); Gu et al. (2021); Korovchinsky et al. (2021); Stamou et al. (2022); Sheveleva et al. (2023); Dadykin et al. (2024). The resulting dataset is shown in table S2. It should be noted that the local fauna of Tajikistan

comprises two different components, the lowland one and the high-altitude one, which is specific to the Tajik Pamir (Dadykin et al. 2024). Nevertheless, these components each comprise a relatively small number of species; thus, they were unified in our analysis. The local faunas were compared by Sørensen–Dice similarity coefficient (KS) widely used for comparison of faunistic lists (Dice 1945; Murguía and Villaseñor 2003; Albuquerque et al. 2022). Anticipating incomplete data, we used just the Sørensen–Dice index based on the species presence in a particular region and ignoring absences (Murguía and Villaseñor 2003). Hierarchical clustering was performed using the R 4.3.2 package, using the Sørensen–Dice dissimilarity ($1 - KS$) as a distance measure and “ward.D2” as an agglomeration method.

RESULTS

New and rare records of Branchiopoda

In the original set of samples, 47 branchiopod taxa were identified (Table 2, bold font; see Table S1 for a database of records). The species list was significantly expanded for Navoiy, Djizak, Tashkent, and Samarkand Provinces (12, 11, 7 and 7 new records, respectively, Table 2). The majority of the new records belong to common (or relatively common) benthic taxa previously observed in Uzbekistan. However, two water fleas of the order Anomopoda, *Camptocercus uncinatus* Smirnov, 1971 and *Ilyocryptus spinifer* Herrick, 1882, have not previously been reported from the country (Figs. 2C–F and 3A–D). Also, we confirm the presence of several rare anomopod species in Uzbekistan and provide short remarks on their morphology and distribution.

Class Branchiopoda Latreille, 1817
Superorder Diplostraca Latreille, 1829
Order Anomopoda Sars, 1865
Family Daphniidae Straus, 1820
***Ceriodaphnia laticaudata* P.E. Müller, 1867**
 (Fig. 2A, B)

In Uzbekistan, the species is rare and has been reported from a few lakes in Karakalpakstan (Rakhmatullaeva 1998) and from the Kokon vicinity, Fergana Province (Ulyanin 1875). In this study, few specimens of *C. laticaudata* were observed in a lake with a muddy sediment (loc. 26) in Djizak Province. *Ceriodaphnia laticaudata* is widely distributed in North Eurasia and Africa (Korovchinsky et al. 2021). The diagnostic characters of *C. laticaudata* are as follows: postabdominal claw basal pectens are similar in length

and thickness (Fig. 2B, black arrow), postabdomen has its greatest height in basal portion (Fig. 2B, black arrow).

Family Ilyocryptidae Smirnov, 1992
***Ilyocryptus spinifer* Herrick, 1882**
 (Fig. 2C–F)

This is a new record for Uzbekistan. A few specimens of *Ilyocryptus spinifer* were collected in the littoral zone of the Arnasay lake system, Djizak Province (loc. 13). *Ilyocryptus spinifer* is very common in the tropical and subtropical zones of all continents; in Eurasia, this species penetrates far north from its typical range (Korovchinsky et al. 2021). In Central Asia, the

species was recorded in Southwest Tajikistan (Dadykin et al. 2024). Some previous records of *I. agilis* from Uzbekistan might in fact belong to *I. spinifer*, as the two species differ mainly in moulting pattern. *Ilyocryptus spinifer* differs from its relatives in incomplete moulting and presence of retained exuviae on the valves and headshield (Fig. 2C, F, black arrows), presence of spinose setae at posterior margin of valve (Fig. 2F, black arrows), and in armature of postabdomen, which bears a proximalmost lateral seta of postanal margin far removed from the anal opening (Fig. 2D, black arrow; Fig. 2E) and a very short seta located ventral to the claw base (Fig. 2E) (Kotov and Štifter 2006; Korovchinsky et al. 2021). See Kotov and Štifter (2006) for a complete morphological description.

Table 2. List of Branchiopoda taxa recorded in Uzbekistan

Taxon	Distribution type	KAR	KH	NAV	BU	KAS	SAM	SU	DJ	SYR	TAS	NAM	FE	AN
Class Branchiopoda Latreille, 1817														
Subclass Sarsostraca Tasch, 1969														
Order Anostraca Sars, 1867														
Family Artemiidae Leach, 1819														
<i>Artemia</i> sp. !	WU	1								1*				
Family Branchinectidae Daday, 1910														
<i>Branchinecta orientalis</i> Sars, 1901 ?	ST				1									
Family Thamnocephalidae Packard, 1883														
<i>Phallocryptus spinosus</i> (Milne-Edwards, 1840) sensu Rogers, 2003	ST	1												
Subclass Phyllopoda Preuss, 1951														
Order Notostraca Sars, 1867														
Family Triopsidae Keilhack, 1909														
<i>Triops cancriformis</i> (Bosc, 1801) s. lat. ?	WU							1						
Superorder Diplostraca Latreille, 1829														
Order Anomopoda Sars, 1865														
Family Daphniidae Straus, 1820														
<i>Ceriodaphnia cornuta</i> Sars, 1885 s. lat.	WU	1	1					1		1	1	1	1	1
<i>Ceriodaphnia dubia</i> Richard, 1894 s. lat.	WU	1									1			
<i>Ceriodaphnia laticaudata</i> P.E. Müller, 1867	WU	1							1*				1	
<i>Ceriodaphnia pulchella</i> Sars, 1862 s. lat.	WU	1	1							1	1		1	
<i>Ceriodaphnia quadrangula</i> (O.F. Müller, 1785) s. lat.	WU	1	1	1*			1*	1			1	1	1	1
<i>Ceriodaphnia reticulata</i> (Jurine, 1820)	WU	1	1		1		1	1	1*	1		1	1	1*
<i>Ceriodaphnia turkestanica</i> Berner et Rakhmatullaeva 2001	CAE	1	1		1	1		1	1		1	1	1	1
<i>Daphnia</i> (<i>Ctenodaphnia</i>) <i>lumholtzi</i> Sars, 1885	TR	1						1						
<i>Daphnia</i> (<i>Ctenodaphnia</i>) <i>magna</i> Straus, 1820	WU	1	1	1*	1	1	1	1	1		1	1	1	1
<i>Daphnia</i> (<i>Ctenodaphnia</i>) <i>similis</i> Claus, 1876	ST	1				1	1*	1			1			
<i>Daphnia</i> (<i>Daphnia</i>) <i>cucullata</i> Sars, 1862	WE	1		1			1	1	1			1*		
<i>Daphnia</i> (<i>Daphnia</i>) <i>curvirostris</i> Eylmann, 1887	WE	1	1		1	1		1	1	1	1		1	1
<i>Daphnia</i> (<i>Daphnia</i>) <i>galeata</i> Sars, 1863 s. lat.	WU	1	1	1*	1	1	1	1	1		1	1	1	1
<i>Daphnia</i> (<i>Daphnia</i>) <i>hyalina</i> Leydig, 1860	PAL	1						1			1			
<i>Daphnia</i> (<i>Daphnia</i>) <i>longispina</i> O.F. Müller, 1776 s. lat. +	WU	1	1	1*	1	1	1	1	1	1	1*	1	1	1
<i>Daphnia</i> (<i>Daphnia</i>) <i>pulex</i> (Linnaeus, 1758) s. lat.	WU	1	1		1	1	1	1	1		1		1	1
<i>Daphnia</i> (<i>Daphnia</i>) <i>pulicaria</i> Forbes, 1893 s. lat.	WU				1			1	1		1	1	1	1
<i>Megafenestra aurita</i> (Fischer, 1849)	WE							1		1	1		1	1
<i>Scapholeberis kingii</i> Sars, 1888 s. lat. ! +	TR	1	1	1*			1*	1	1*	1	1	1	1	1
<i>Scapholeberis mucronata</i> (O.F. Müller, 1776) s. lat.	PAL	1	1				1		1		1	1	1	1
<i>Simocephalus</i> (<i>Aquipiculus</i>) <i>heilongjiangensis</i> Shi et Shi, 1994	EA		1								1			

Table 2. (Continued)

Taxon	Distribution type	KAR	KH	NAV	BU	KAS	SAM	SU	DJ	SYR	TAS	NAM	FE	AN
<i>Simocephalus (Crowncephalus) serrulatus</i> (Koch, 1841)	WU	1	1								1*	1	1	
<i>Simocephalus (Echinocaudus) expinosus</i> (De Geer, 1778) s. lat.	WU	1	1	1*			1	1			1	1	1	1
<i>Simocephalus (Simocephalus) mixtus</i> Sars, 1903	WU	1	1			1		1		1	1	1	1	1
<i>Simocephalus (Simocephalus) vetulus</i> (O.F. Müller, 1776)	WU	1	1		1		1	1	1	1*	1	1	1	1
Family Moinidae Goulden, 1968														
<i>Moina brachiata</i> (Jurine, 1820) s. lat. +	WU	1	1	1*	1		1	1	1	1	1	1	1	1
<i>Moina lipini</i> Smirnov, 1976 s. lat.	PAL							1				1	1	
<i>Moina macrocopa</i> (Straus, 1820) s. lat.	WU	1	1				1*	1	1		1		1	1
<i>Moina micrura</i> Kurz, 1874 s. lat.	WU	1	1		1		1	1	1	1	1	1	1	1
<i>Moina salina</i> Daday, 1888 s. lat.	ST	1	1		1*				1	1*		1*	1*	1*
<i>Moina weismanni</i> Ishikawa, 1896	EA	1						1				1	1	1
Family Acantholeberidae Smirnov, 1976														
<i>Acantholeberis curvirostris</i> (O.F. Müller, 1776)	WE											1	1	
Family Macrothricidae Norman et Brady, 1867 emend. Smirnov, 1976														
<i>Lathonura rectirostris</i> (O.F. Müller, 1776) ?	PAL	1												
<i>Macrothrix hirsuticornis</i> Norman et Brady, 1867	WU	1						1				1	1	1
<i>Macrothrix laticornis</i> (Jurine, 1820)	WU	1							1	1	1			
<i>Macrothrix odiosa</i> Gurney, 1916	TR	1	1				1	1		1*	1	1	1	1
<i>Macrothrix rosea</i> (Liévin, 1848)	WE			1*							1*		1	1
<i>Macrothrix spinosa</i> King, 1853	WU	1	1		1		1	1	1*		1*	1	1	1
<i>Macrothrix triserialis</i> Brady, 1886	TR	1	1									1	1	1
Family Ilyocryptidae Smirnov, 1992														
<i>Ilyocryptus agilis</i> Kurz, 1878	WE	1							1*		1*		1	1
<i>Ilyocryptus sordidus</i> (Liévin, 1848)	PAL							1	1	1	1		1	1
<i>Ilyocryptus spinifer</i> Herrick, 1882 *	TR								1*					
Family Bosminidae Baird, 1845 emend. Sars, 1865														
<i>Bosmina (Bosmina) longirostris</i> (O.F. Müller, 1776) s. lat.	WU	1	1		1		1	1	1	1	1	1	1	1
<i>Bosmina (Eubosmina) coregoni</i> (Baird, 1857) ?	WE										1			
Family Chydoridae Dybowski et Grochowski, 1894														
Subfamily Aloninae Dybowski et Grochowski, 1894														
<i>Acroperus harpae</i> (Baird, 1834)	PAL	1										1	1	
<i>Acroperus angustatus</i> Sars, 1862 ?	WE	1												
<i>Alona quadrangularis</i> (O.F. Müller, 1785)	WE	1						1			1	1	1	1
<i>Biapertura affinis</i> (Leydig, 1860)	PAL	1									1*			
<i>Camptocercus rectirostris</i> Schödler, 1862 ?	WU	1						1				1	1	
<i>Camptocercus uncinatus</i> Smirnov, 1971 *	ST, TR										1*			
<i>Coronatella (Coronatella) rectangula</i> (Sars, 1861)	WU	1	1	1*	1		1	1	1	1*	1	1	1	1
<i>Coronatella (Ephemeralona) anemae</i> (Van Damme et Dumont, 2008) ?	TR	1												
<i>Flavalona costata</i> (Sars, 1862)	PAL	1					1*		1		1	1	1	
<i>Graptoleberis testudinaria</i> (Fischer, 1851) s. lat.	PAL	1		1*				1				1	1	
<i>Karualona</i> sp. !	?	1	1				1	1					1	1
<i>Kurzia latissima</i> (Kurz, 1875)	WE												1	
<i>Leberis</i> sp. !	?	1	1				1					1	1	1
<i>Leydigia (Leydigia) leydigi</i> (Schödler, 1863)	PAL	1						1				1	1	1
<i>Leydigia (Neoleydigia) acanthocercoides</i> (Fischer, 1854)	WE	1	1	1*					1*			1		1
<i>Monospilus dispar</i> Sars, 1862 ?	WU							1						
<i>Ovalona cambouei</i> (Guerne et Richard, 1893) +	TR	1	1					1	1*		1	1	1	1
<i>Oxyurella tenuicaudis</i> (Sars, 1862)	WE	1							1		1			
<i>Prendalona guttata</i> (Sars, 1862)	PAL	1					1	1	1*	1	1		1	
Subfamily Chydorinae Dybowski et Grochowski, 1894														
<i>Alonella excisa</i> (Fischer, 1854)	WU	1												
<i>Alonella exigua</i> (Lilljeborg, 1853)	WU											1		
<i>Alonella nana</i> (Baird, 1850)	WU	1								1				
<i>Anchistropus emarginatus</i> (Sars, 1862) ?	PAL	1												
<i>Chydorus gibbus</i> Sars, 1890 ?	WU											1	1	
<i>Chydorus sphaericus</i> (O.F. Müller, 1776) s. lat.	WU	1	1	1*	1		1	1	1	1	1	1	1	1
<i>Disparalona rostrata</i> (Koch, 1841)	PAL							1		1	1			

Table 2. (Continued)

Taxon	Distribution type	KAR	KH	NAV	BU	KAS	SAM	SU	DJ	SYR	TAS	NAM	FE	AN
<i>Dunhevedia crassa</i> King, 1853	TR	1	1	1			1				1	1	1	1
<i>Ephemeroporus barroisi</i> (Richard, 1894) s. lat.	TR	1	1				1	1			1	1	1	1
<i>Pleuroxus aduncus</i> (Jurine, 1820)	WU	1	1	1			1*	1	1		1	1	1	1
<i>Pleuroxus laevis</i> (Sars, 1862)	WE	1										1	1	
<i>Pleuroxus quasidenticulatus</i> (Smirnov, 1996)	TR	1	1				1*	1	1*		1	1	1	1
<i>Pleuroxus striatus</i> Shödler, 1862 ?	WE											1		
<i>Pleuroxus trigonellus</i> (O.F. Müller, 1785) s. lat. !	WU	1									1	1	1	1
<i>Pleuroxus truncatus</i> (O.F. Müller, 1785)	WE								1					
<i>Pseudochydorus globosus</i> (Baird, 1843) ?	WU	1										1		
Family Euryceridae Kurz, 1875 emend. Dumont et Silva-Briano, 1998														
<i>Eurycerus</i> (<i>Eurycerus</i>) <i>lamellatus</i> (O.F. Müller, 1776)	PAL	1							1					
Order Ctenopoda Sars, 1865														
Family Sididae Baird, 1850														
<i>Diaphanosoma brachyurum</i> (Liévin, 1848)	PAL	1	1		1			1			1	1	1	1
<i>Diaphanosoma dubium</i> Manuilova, 1964	ST, TR	1				1					1		1	1
<i>Diaphanosoma excisum</i> Sars, 1885	TR										1			
<i>Diaphanosoma lacustris</i> Kořinek, 1981	ST, TR	1				1			1		1			
<i>Diaphanosoma macrophthalma</i> Korovchinsky et Mirabdullayev 1995	ST, TR	1	1			1					1	1	1	
<i>Diaphanosoma mongolianum</i> Ueno, 1938	ST, TR	1	1	1	1	1	1	1	1		1	1	1	1*
<i>Diaphanosoma orghidani</i> Negrea, 1982	WE	1							1		1			
<i>Diaphanosoma sarsi</i> Richard, 1894	TR	1	1			1		1		1	1	1	1	1
<i>Latonopsis australis</i> Sars, 1888 s. lat.	TR	1	1				1	1			1	1	1	1
<i>Sida crystallina</i> (O.F. Müller, 1776)	WE	1						1			1			
Order Onychopoda Sars, 1865														
Family Polyphemidae Baird, 1845														
<i>Polyphemus pediculus</i> (Linnaeus, 1758)	WU	1												
Family Cercopagididae Mordukhai-Boltovskoi, 1966 emend. Martin et Cash-Clark, 1995														
<i>Cercopagis pengoi</i> (Ostroumov, 1892) † +	PCA	1												
Family Podonidae Mordukhai-Boltovskoi, 1966														
<i>Evadne anonyx</i> Sars, 1897 †	PCA	1												
<i>Podonevadne angusta</i> (Sars, 1902) †	PCA	1												
<i>Podonevadne camptonyx</i> (Sars, 1897)	PCA	1												
<i>Podonevadne trigona</i> (Sars, 1897) †	PCA	1												
Order Haplopoda Sars, 1865														
Family Leptodoridae Lilljeborg, 1861														
<i>Leptodora kindtii</i> (Focke, 1844)	WE	1							1					
Order Spinicaudata Linder, 1945														
Family Cyzicidae Stebbing, 1910														
<i>Cyzicus tetracerus</i> (Krynicky, 1830) fide Audouin, 1837 s. lat. !	WU		1											
<i>Eocyzicus bouvieri</i> (Daday, 1914) fide Padhye et Rabet, 2017 ?	ST													
<i>Eocyzicus davidi</i> (Simon, 1886) s. lat. !	ST				1				1					
<i>Eocyzicus sahlbergi</i> (Simon, 1886) s. lat. ? !	PAL	1												
Family Leptestheriidae Daday, 1913														
<i>Leptestheria</i> sp. ? !	?						1							
Family Limnadiidae Baird, 1849														
<i>Eulimnadia</i> sp. ? !	?						1							
Total species number		80	41	16	18	14	32	48	39	22	57	53	60	47

Taxa highlighted by bold are recorded in the present study. Notifications: *, a new record; one for the province if placed to the province column, or one for the country if placed after the species name; ?, unconfirmed record; !, unclear taxonomic status; +, doubtful records of valid taxa or unrevised taxa included; †, probably extinct in Uzbekistan. Regions: KAR, Karakalpakstan; KHO, Khorezm Province; NAV, Navoiy Province; BU, Bukhara Province; KAS, Kashkadarya Province; SAM, Samarkand Province; SU, Surkhandarya Province; DJ, Djizak Province; SYR, Syrdarya Province; TAS, Tashkent Province and Tashkent City; NAM, Namangan Province; FE, Fergana Province; AN, Andijan Province. Distribution types: CAE, Central Asian endemics; EA, East Asian; PAL, Palearctic or Holarctic; PCA, taxa of Ponto-Caspian origin; ST, South temperate; TR, tropical; WU, widely distributed unrevised; WE, West Eurasian.

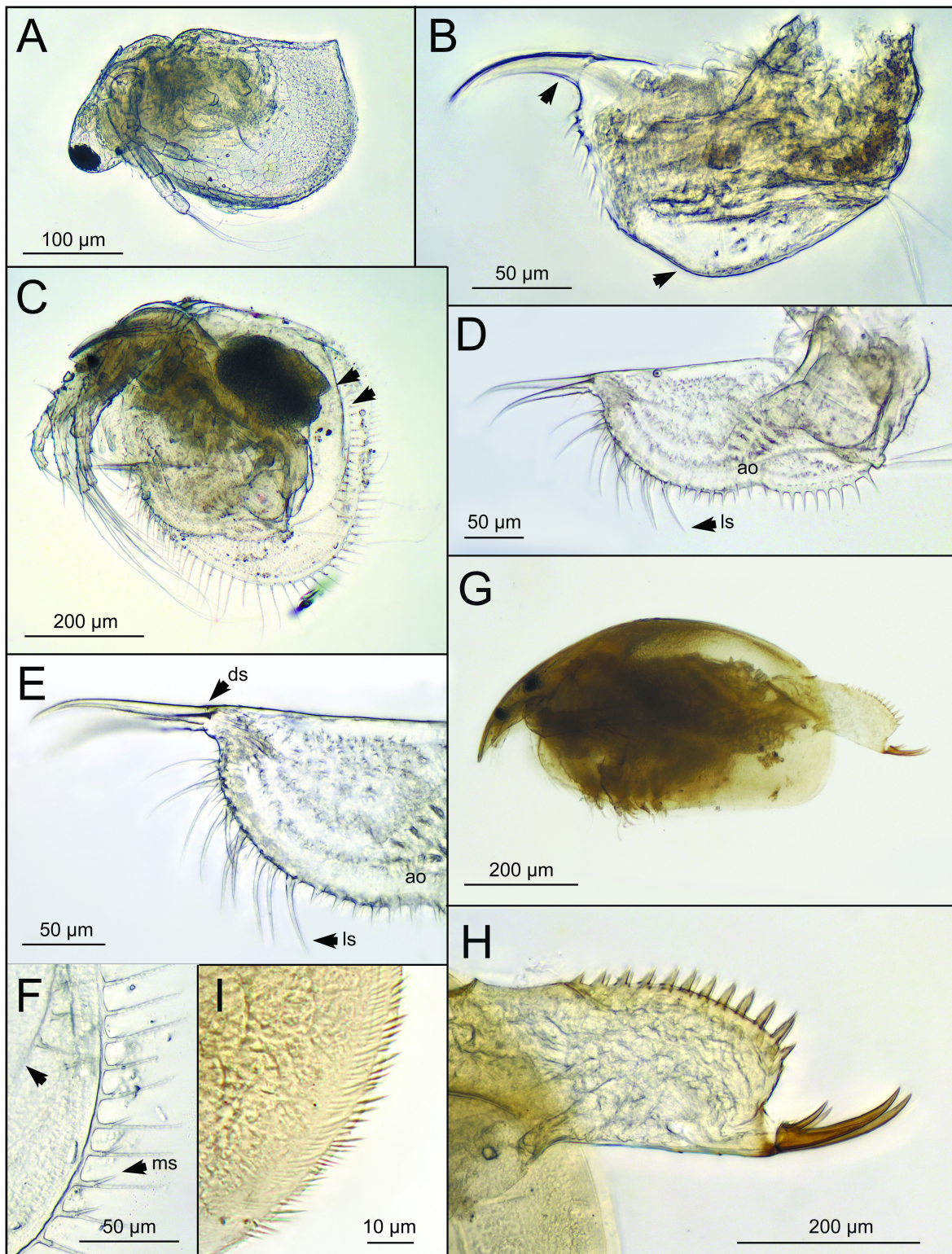


Fig. 2. New and rare Anomopoda species from Uzbekistan. (A–B) *Ceriodaphnia laticaudata* P.E. Müller, 1867, parthenogenetic female from an unnamed lake in Djizak Province (loc. 26). (A) general view; (B) postabdomen. (C–F) *Ilyocryptus spinifer* Herrick, 1882, parthenogenetic female from Lake Arnasay in Djizak Province (loc. 13). (C) general view; (D, E) postabdomen; (F) posterior valve margin. (G–I) *Biapertura affinis* (Leydig, 1860), parthenogenetic female from a drainage of Tuyabuguz Reservoir, Tashkent Province (loc. 65). (G) general view; (H) postabdomen; (I) posteroventral valve angle. Abbreviations of morphological characters are as follows: ao, anal opening; ls, lateral setae of postabdomen; ms, marginal setae of valve; vs, seta ventrally to the base of postabdominal claw.

**Family Chydoridae Dybowski et Grochowski,
1894**

***Biapertura affinis* (Leydig, 1860)**
(Fig. 2G–I)

In this study, two parthenogenetic females of *Biapertura affinis* were found in the drainage of Tuyabuguz Reservoir, Tashkent Province (loc. 65). The species is very rare in Uzbekistan, having been observed only in the littoral zone of Lake Khodjakul, Karakalpakstan (Ginatullina 2010). *Biapertura affinis* is a Palearctic taxon widely occurring in Central Asia (Korovchinsky et al. 2021), though it is uncommon in this region. The species is distinct from other alonines by an elongate body shape (Fig. 2G), the presence of two head pores, a large subrectangular postabdomen with dorsal margin evenly concave, bearing thick teeth (Fig. 2H). The absence of denticles at the valve posteroventral angle (Fig. 2I) distinguishes *B. affinis* from its relative, *B. sibirica* Sinev, Karabanov et Kotov, 2020 (Sinev et al. 2020).

***Camptocercus uncinatus* Smirnov, 1971**
(Fig. 3A–D)

This is a new record for Uzbekistan. A single parthenogenetic female was collected in the vegetated littoral zone of Tuyabuguz Reservoir, Tashkent Province (loc. 68). The species occurs in south temperate, subtropical and tropical regions of Eurasia, and in North Africa (Smirnov 1974; Korovchinsky et al. 2021), but has not been recorded previously in Central Asia. Nevertheless, it could have been previously identified as *Camptocercus rectirostris* Schödler, 1862. *Camptocercus uncinatus* differs from its relatives by absence of any teeth at the valve posteroventral angle (Fig. 3A); acute rostrum (Fig. 3B, black arrow); relatively short basal spine of postabdominal claw, progressively narrowing distally (Fig. 3C, black arrow); wide serrate postanal teeth (Fig. 3D, black arrows) (Korovchinsky et al. 2021). See Sinev (2014) for a complete description.

***Disparalona rostrata* (Koch, 1841)**
(Fig. 3E, F)

In this study, a single female of *Disparalona rostrata* was collected in the drainage of Tyabuguz Reservoir (loc. 65). In Uzbekistan, *D. rostrata* seems to be a very rare taxon; the only records are from the littoral of Lake Kalgansyr in Syrdarya Province, Uchqizil Reservoir in Surkhandarya Province, and Lake Kargaly in Tashkent Province (Keiser 1925; Mukhitdinov 1967, as *Rhynchotalona rostrata*). The

species is widespread in North Eurasia and Central Asia (Korovchinsky et al. 2021). *Disparalona rostrata* can be distinguished from its relatives by a long spine at the exopodite basal segment, exceeding the length of the next segment (Fig. 3E, black arrow); the postabdomen progressively narrowing distally (Fig. 3E, F); the short basal spine of the postabdominal claw (Fig. 3F, black arrow) (Smirnov 1974; Korovchinsky et al. 2021).

Order Onychopoda Sars, 1865

Family Podonidae Mordukhai-Boltovskoi, 1966

***Podonevadne camptonyx* (Sars, 1897)**
(Fig. 3G–I)

In this study, *Podonevadne camptonyx* was found in Lake Sarikamish, Karakalpakstan (loc. 94). In Uzbekistan, *P. camptonyx* has been observed in the Large Aral Sea but now appears to have gone extinct there (Aladin et al. 2021). The species is a Ponto-Caspian endemic and occurs in the Caspian Sea and the Small Aral Sea (Korovchinsky et al. 2021). The diagnostic characters for *P. camptonyx* are as follows: the head lacking projections (Fig. 3G); the short conical or rounded shell (Fig. 3G); the postabdominal claws present, divergent (Fig. 3H); the endopodite of the thoracic appendages II–IV bearing two setae (Fig. 3I) (Korovchinsky et al. 2021).

Faunal diversity of Branchiopoda in Uzbekistan

Taking into account the original and literature data, we compiled a checklist of Uzbek Branchiopoda that includes 107 species (80 taxa of Anomopoda, 10 of Ctenopoda, 6 of Onychopoda, 1 of Haplopoda, 6 of Spinicaudata, 1 of Notostraca Sars, 1867, 3 of Anostraca) (Table 2; Appendix). However, 14 of these records require further confirmation (Table 2, marked by ?), as they were observed in Uzbekistan only once and more than 30 years ago. Also, these records could easily have been confused with sibling taxa (see Appendix for notes on these records). The taxonomic status of at least six taxa should also be revised in accordance with recent identification guides (Table 2, marked by !). These taxa belong to the species groups containing taxa that are difficult to identify, and information provided by the authors of the records is insufficient to verify their real status. Additionally, earlier records of some potentially valid but unrevised taxa were combined with those of their sibling relatives (Table 2, marked by +): for instance, records of *Moina mukhamedievi* Mirabdullayev, 1998 were included with *M. brachiata* (Jurine, 1820) s. lat. (see notes on these records in Appendix). Four onychopod taxa, *Cercopagis pengoi* (Ostroumov, 1892), *Evadne anonyx* Sars, 1897,

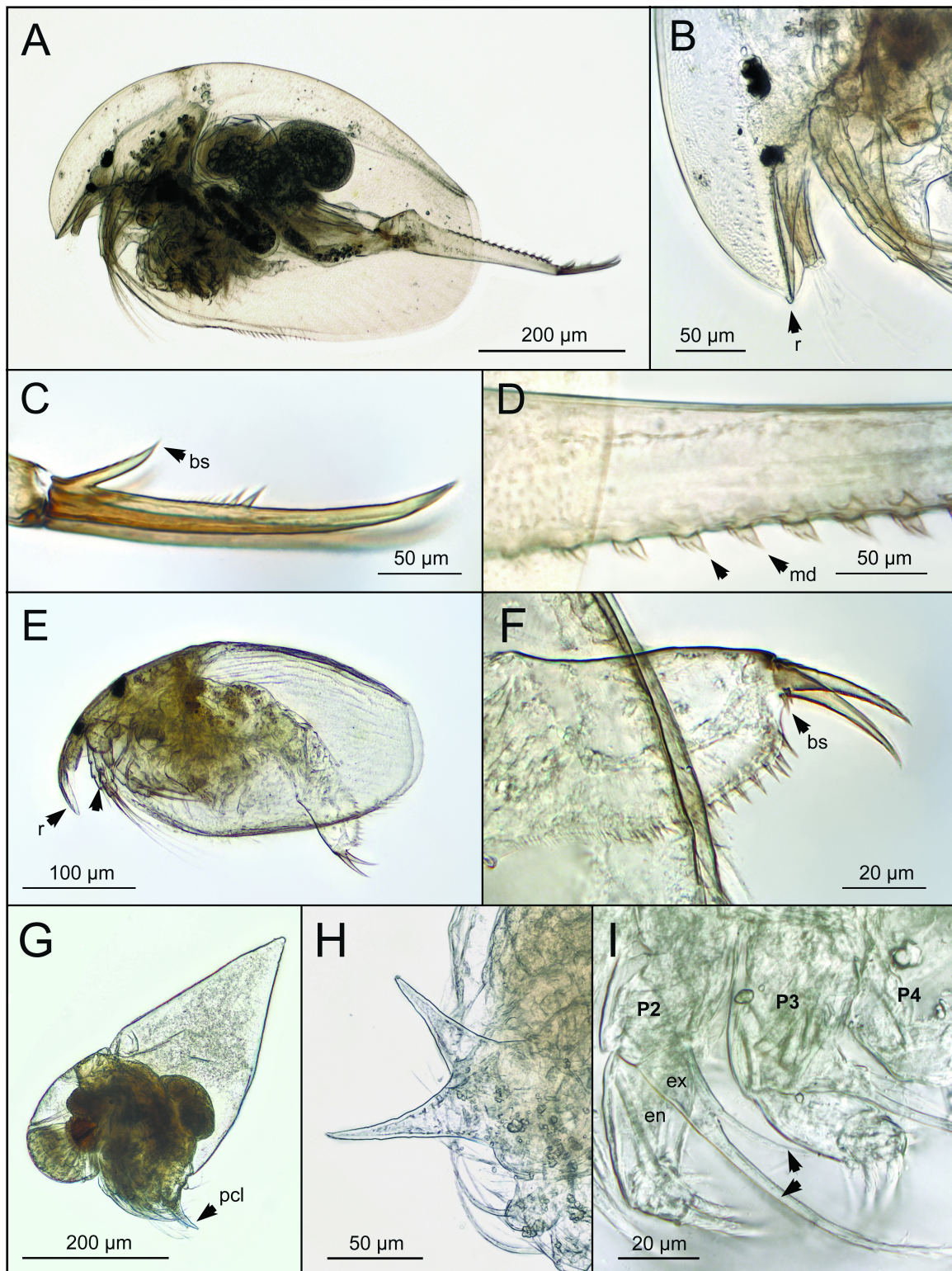


Fig. 3. New and rare Branchiopoda species from Uzbekistan. (A–D) *Camptocercus uncinatus* Smirnov, 1971, parthenogenetic female from Tuyabuguz Reservoir, Tashkent Province (loc. 68). (A) general view; (B) head in lateral view; (C) postabdominal claw; (D) postanal spines of postabdomen. (E–F) *Disparalona rostrata* (Koch, 1841), juvenile parthenogenetic female from the drainage of Tuyabuguz Reservoir (loc. 65). (E) general view; (F) postabdomen. (G–I) *Podonevadne camptonyx* (Sars, 1897) from Lake Sarikamish, Karakalpakstan (loc. 94). (G) general view; (H) postabdominal claws in anterior view; (I) thoracopod armature. Abbreviations of morphological characters are as follows: bs, basal spine of postabdomen; r, rostrum; en, endopodite; ex, exopodite; P2–4, thoracic appendages II–IV; pcl, postabdominal claw.

Podonevadne angusta (Sars, 1902) and *P. trigona* (Sars, 1897), are likely extinct in Uzbekistan (Table 2, marked by †) due to the disaster in the Aral Sea – the only water body where they have been recorded for the country. Finally, two taxa were erroneously listed for Uzbekistan. First, the record of *Daphnia atkinsoni* Baird, 1859 was published by Rakhmatullaeva (1998) and refers to the monograph of Mukhamediev (1986), but the latter reports *D. atkinsoni* only for the territory of North Tajikistan (Mukhamediev 1986). Second, the only record of *Bythotrephes longimanus* Leydig, 1860, listed by Rakhmatullaeva (1998), appears to be a misidentification of its relative, *Cercopagis pengoi*, and lacks any reference to literature source.

Combining literature data with our original records, we reveal a clear inequality in faunal richness among the provinces of Uzbekistan (Table 2; Fig. 4). The local fauna of Karakalpakstan is the most diverse and includes a total of 82 branchiopod taxa, followed by relatively rich faunas of Northeast and East Uzbekistan with 40 taxa or more each (Table 2; Fig. 4). At the same time, local faunas of Khorezm, Navoiy, Kashkadarya, and Syrdarya Provinces are relatively poor and include 25 or fewer taxa each (Fig. 4). General faunal

composition of the species-rich regions is quite similar and comprises a significant number of cosmopolitan taxa (WU), along with high proportions of boreal (PAL, WE, and EA) and south temperate/tropical (TR, ST, ST, and TR) taxa. Central Asian endemics (CAE) constitute a minor faunal component but are present in most regions. Finally, the fauna of Karakalpakstan includes five Ponto-Caspian onychopod taxa (PCA) specific to this province (Table 2; Fig. 4). The species-poor regional faunas include a high proportion of cosmopolitan taxa, but proportions of the other groups strongly vary between the regions (Fig. 4).

The performed comparison of the two most studied regions of Uzbekistan, the Fergana Valley and Karakalpakstan, with relatively well-explored Eurasian regions located at similar latitudes, shows a relatively high Sørensen similarity of both Uzbek regions to each other ($K_s = 0.75$) and to Tajikistan ($K_s = 0.66$ and 0.60 for the Fergana Valley and Karakalpakstan, respectively) (Fig. 5; Table S3). The local fauna of Karakalpakstan exhibits high similarity to those of Russian Ciscaucasia and Turkey (Table S3, $K_s = 0.70$ and 0.68 , respectively). Notably, local fauna of the Fergana Valley seems to be closer to some Mediterranean faunas (Turkey, Greece,

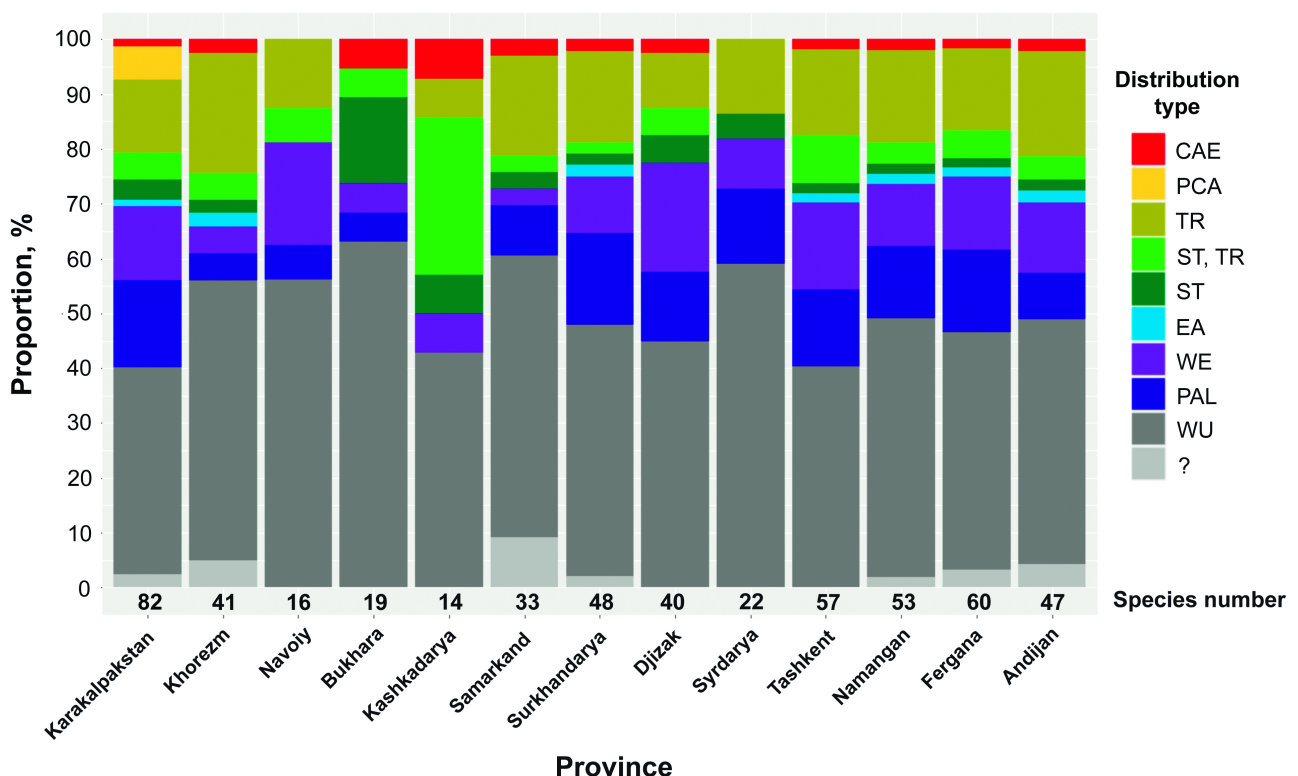


Fig. 4. Proportion of species belonging to different distribution types in local faunas of Uzbekistan provinces. Provinces are roughly ordered from west to east. Abbreviations: CAE, Central Asian endemics; EA, taxa primarily distributed in East Asia; PAL, taxa widely distributed in the Palearctic or Holarctic; PCA, taxa of the Ponto-Caspian origin; ST, taxa widely distributed in the south temperate zone; TR, tropical taxa; WE, West Eurasian taxa; WU, cosmopolitan unrevised taxa; ?, taxa with unclear distribution.

Italy, and Russian Ciscaucasia, $K_s = 0.59, 0.60, 0.58$ and 0.63 , respectively, Table S3), than to those of Mongolia and North China ($K_s = 0.42\text{--}0.55$, Table S3). As for Karakalpakstan, its fauna seems to be equally similar

to the Central Asian faunas (Tajikistan, Mongolia, and Chinese Xinjiang Uyghur Autonomous Region, $K_s = 0.60$, Table S3), and to those of the West Mediterranean (Greece, Italy and Spain, $K_s = 0.61, 0.63$, and 0.56 ,

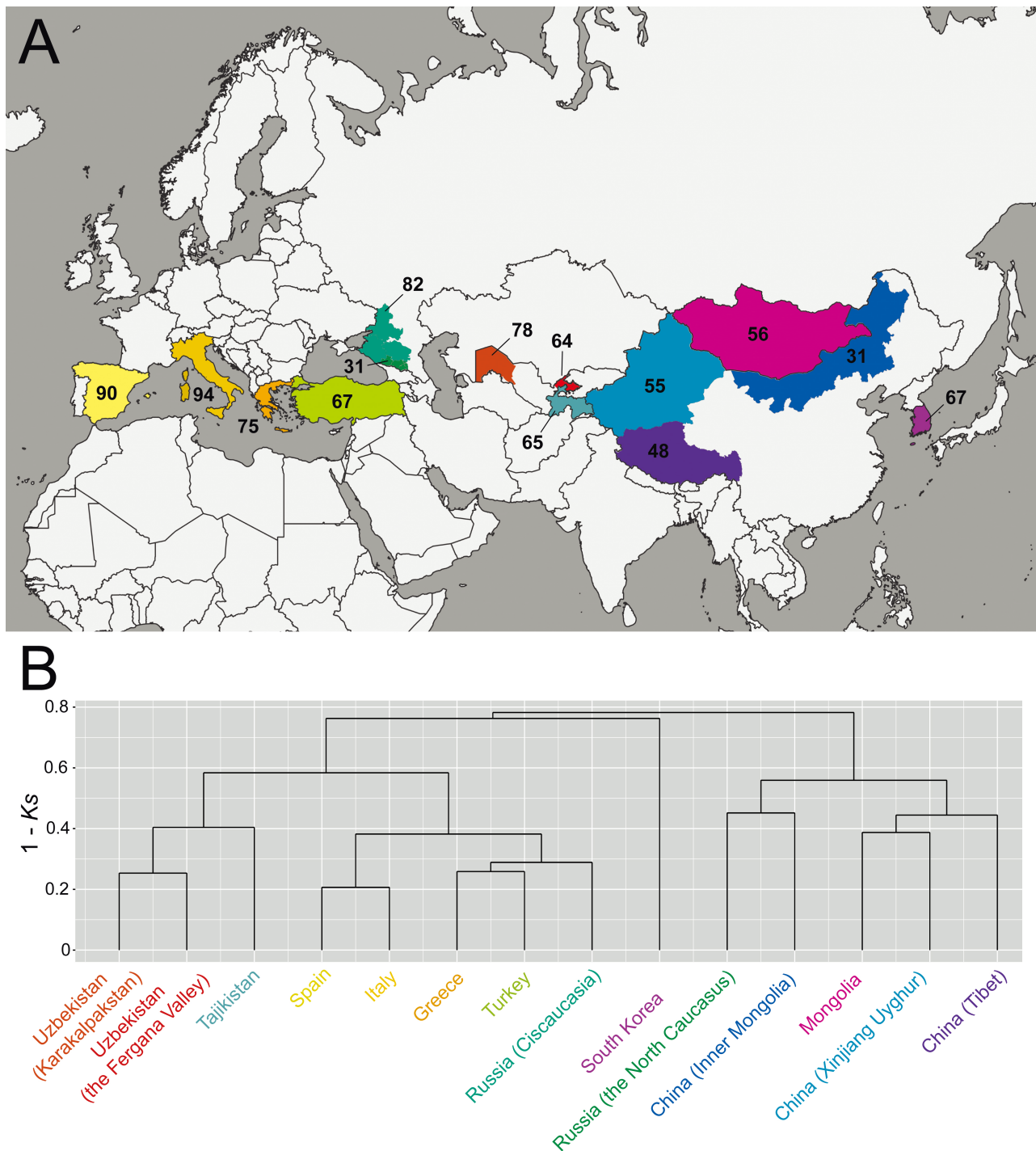


Fig. 5. Comparison of Cladocera local faunas between several regions of Eurasia. (A) location of the regions included to the analysis (numbers indicate total species richness of local faunas); (B) hierarchical clustering of the regions by Sørensen-Dice dissimilarity (ward.D2 agglomeration method). Label colour in figure 5B corresponds to the region filling in figure 5A. See table S2 for faunistic lists of the regions and table S3 for Sørensen-Dice similarity coefficients.

respectively). Local faunas of both Uzbekistan and Tajikistan are grouped with those of Mediterranean countries (Fig. 5A, B), together forming a major South European—West Asian cluster distinct from the East Asian cluster. Unfortunately, comparison of Uzbek branchiopod fauna with that of most neighbouring countries is very limited due to the lack of reliable data or published checklists.

DISCUSSION

General patterns of Branchiopoda diversity in Uzbekistan

This study provides a summary of Branchiopoda records in Uzbekistan. A review of published literature shows that documented faunal richness of the Uzbek provinces is very unequal (Fig. 4), which might be explained by several factors. First, geographical location and diversity of water bodies could contribute to the faunal richness of particular provinces. For instance, the highest number of recorded branchiopod taxa in Karakalpakstan could be explained by the high diversity of natural water bodies present there, including large lakes. In contrast, in neighbouring Khorezm Province the majority of water bodies are artificial, being built less than 150 years ago (Rosen et al. 2018), which might be a reason for its comparatively low local faunal diversity. However, the age and origin of the water body do not always determine its zooplankton diversity (Dodson et al. 2007; Alfonso et al. 2010), especially in intensively farmed areas (Dodson et al. 2007). Instead, the zooplankton richness depends to a higher degree on a number of biotic and abiotic factors, including size and productivity of the water body, density of water bodies in the area, predation pressure, etc. (Hobæk et al. 2002).

Second, research effort seems to be a factor strongly determining the documented diversity of the territory. This explains well the highest faunal richness of Karakalpakstan in comparison with other regions of Uzbekistan, which is likely to be due to a large body of published literature on this region, especially on the Aral Sea, the Sudochoye lake system and other water bodies of the lower reaches of the Amu Darya. In contrast, low numbers of species recorded in Khorezm, Navoiy, Kashkadarya, and Syrdarya Provinces are probably caused by insufficient research in these regions. For instance, only Lake Aydarkul and Tudakul Reservoir have been investigated in Navoiy Province to date (Ginatullina 2010; Khakimova et al. 2021), resulting in a total of four branchiopod records for Navoiy Province. However, our short sampling session

has already yielded 12 more taxa in small water bodies of the Nurata Mountains (Table 2) which have never been studied before. Similarly, only a small part of water bodies was explored in Khorezm and Syrdarya Provinces during the previous studies (Aripov 1972; Mirabdullayev 1998; Rakhmatullaeva 1998), because those studies were mainly focused on rice fields and fishponds (but see Crootof et al. 2015).

Sampling methods are the third important factor in revealing branchiopod diversity. The bulk of previous studies sampled only pelagic zone of water bodies (Mustafaeva et al. 2022; Khakimova et al. 2021; Abdullaeva et al. 2021), which explains a high number of new records for several provinces in this study. For instance, previous hydrobiological studies of Tuyabuguz Reservoir, Tashkent Province processed quantitative planktonic samples collected in different seasons in 2019, 2020, and 2022 by Jedi net (Atamuratova 2021; Abdullaeva et al. 2021; Ginatullina et al. 2023c), but recorded only seven branchiopod taxa, including two littoral (benthic or phytophilous) species. Unfortunately, the total number of collected planktonic samples was not reported by the authors. In the same water body, our study yielded 18 branchiopod species from just five samples (locs. 68–70, 92, 93), with 11 littoral records (Table S1; Appendix). A high diversity of littoral branchiopod taxa has been repeatedly demonstrated for different parts of the world (Walseng et al. 2006; MaiaBarbosa et al. 2008; Jeong et al. 2015) including Uzbekistan (Akatova 1950) and should be taken into account when conducting monitoring studies. Our results confirm that a simple planktonic net is quite sufficient for revealing littoral branchiopods when sampling the vegetated zone or the bottom of the water body.

The faunal composition of most species-rich Uzbek provinces is similar, representing a mixture of boreal and thermophilic south temperate/tropical taxa with a minor component of Central Asian endemics. The Karakalpakstan local fauna comprises several Ponto-Caspian species (Fig. 4) absent in other provinces, but these taxa are not numerous and have a very restricted distribution. Combination of boreal and thermophilic faunal components has already been observed in plain West and South Tajikistan (Dadykin et al. 2024), and thus might be expected for several poorly studied regions of Uzbekistan (Kashkadarya, Khorezm, Navoiy, and Syrdarya Provinces) and probably for lowland northern Afghanistan. Earlier, such a mixing of the boreal and tropical branchiopod faunas has been shown for plain East Asia, where it forms a distinct transitional zone (Garibian et al. 2020; Krolenko et al. 2023). In this area, faunal diversity decreases from north to south, along with changes in dominance structure (Garibian et

al. 2021). However, in the case of Central Asia, more monitoring studies are needed to compare diversity patterns between particular territories within the region.

Uzbek local faunas and general Cladocera distribution in Eurasia

To date, comparison of Uzbek fauna with that of neighbouring regions is strongly limited due to lack of reliable data. However, a number of regions of the same latitudinal zone (*i.e.*, so-called ‘South Palearctic,’ see our comments below) seem to be relatively well-studied (see the Region comparisons section in Materials and Methods for a list of references). A preliminary biogeographic analysis conducted in this study (Fig. 5; Table S3) supports a high similarity of the best studied Uzbek local faunas (Karakalpakstani and Ferganian) to each other and to that of Tajikistan (Fig. 5B), which as expected given their geographical proximity. Notably, based on the hierarchical clustering results, the local faunas of Karakalpakstan, the Fergana Valley, and Tajikistan seem to be closer to those of the Mediterranean, than to Mongolian and Chinese local faunas (Fig. 5B). The Mediterranean and Central Asia are supposed to have undergone multiple faunal exchanges via the Paratethys (Artamonova et al. 2021). Therefore, the observed faunal similarity could be a result of common palaeohistory of these regions. Unfortunately, the existing schemes of biogeographic regionalization for Cladocera (Korovchinsky 2004) do not have enough resolution to validate our results.

Our provisional data suggest that the Uzbek cladoceran local faunas fall within the West Eurasian cluster, which fits well to the existing knowledge of Cladocera biogeography in Eurasia. Indeed, recent phylogeographic studies have differentiated “European—Western Siberian” and “Eastern Siberian—Beringian” cladoceran faunas in Northern Eurasia, with a wide transitional zone in Central Siberia (Bekker et al. 2016; Kotov et al. 2025), located northeast to Uzbekistan. Moreover, it was shown that the traditional recognition of the Palearctic and Nearctic Provinces within the Holarctic is incorrect with reference to the Cladocera: biogeography of the latter implies three major provinces, the Western Holarctic, the Beringian and the Eastern Holarctic (Korovchinsky et al. 2021). We have demonstrated that Uzbek cladoceran fauna clearly belongs to that of the Western Holarctic Province, although such conclusions should be directly confirmed by future phylogeographic studies.

We believe that this general pattern is adequately revealed, but fine-scale comparisons between regions seem to be somewhat premature. Our biogeographic comparisons are sensitive to the revealed species

number, thus poor regional faunas tend to cluster with each other. This can significantly distort the analysis results (Dadykin et al. 2025). In our dataset, a similar trend can be observed for the poorly studied faunas of the North Caucasus and Inner Mongolia comprising only 31 species each (Fig. 5A, B). Also, the biogeographic comparison should take into account the area of the compared regions (Novichkova and Azovsky 2017). Moreover, incompleteness of faunal lists and a high number of unrevised taxa hamper the revelation of local biogeographic patterns. Populations of cosmopolitan taxa, such as *Daphnia longispina* O.F. Müller, 1776, *Chydorus sphaericus* (O.F. Müller, 1776), *Triops cancriformis* Bosc, 1801, and others, need further taxonomic revisions, as these taxa often prove to be groups of sibling species or genetically divergent lineages (Perez et al. 1994; Korn et al. 2006; Belyaeva and Taylor 2009; Bekker et al. 2016; Zuykova et al. 2019; Boyer et al. 2021; Asem et al. 2023 2024).

The status of several taxa listed for Uzbekistan remains unclear despite recent revisions in their respective groups. For instance, numerous records of *Scapholeberis kingii* Sars, 1888 *s. lat.* might refer to either a single or a few morphologically indistinct but valid species of this group, including *S. smirnovi* Garibian, Neretina, Taylor et Kotov, 2020 common in the Palearctic. Reliable identification of the group representatives can be made using gamogenetic stage morphology or standard molecular markers (Garibian et al. 2020), but no such research has been conducted to date. Similarly, application of molecular methods might be suitable for identification of parthenogenetic *Artemia* populations, although standard gene fragments might be unsuitable for differentiating closely related species and parthenogenetic lineages (Asem et al. 2023 2024). In the case of rare taxa such as *Karualona* sp. and *Leberis* sp., however, the major problem is collecting and thorough description of the material, rather than difficulties with its identification. Some of the existing records still require confirmation: these include mostly rare littoral taxa such as *Lathonura rectirostris* (O.F. Müller, 1776), *Monospilus dispar* Sars, 1862, *Anchistropus emarginatus* (Sars, 1862), and others, which usually have low density and are difficult to collect due to their association with a particular substrate. Also, unconfirmed records include pelagic anomopod *Bosmina* (*Eubosmina*) *coregoni* (Baird, 1857), which may be a misidentification of common *B. (Bosmina) longirostris* O.F. Müller, 1776.

To summarize, more studies are needed to compare Uzbek local faunas, for which incomplete knowledge on branchiopods in Uzbekistan is one of the important restrictions. In the next section, we highlight existing white spots in knowledge on branchiopod fauna

of Uzbekistan, in order to outline future perspectives of Branchiopoda studies in the country.

Future perspectives of branchiopod faunistic studies in Uzbekistan

Although studies having been conducted for about 150 years, there are still gaps in our knowledge on branchiopods of Uzbekistan. Most of the published literature in this field is devoted to crustacean fauna of lowland fishponds, reservoirs and lakes. As lowland water bodies in Central Asia are usually artificial or highly transformed by intense agriculture and farming (Karthe et al. 2015), a vast majority of recent studies concern a relatively small portion of branchiopod diversity. Moreover, the lowland water bodies of Uzbekistan and other Central Asian countries are highly affected by drought, mineralization, and pollution (Gu et al. 2021; Liu et al. 2019 2021; Zadereev et al. 2020), that causes a significant decrease in crustacean diversity (Ginatullina et al. 2017). These negative trends have been observed in a number of large lakes across Uzbekistan, including the Aydar-Arnasay lake system (Ginatullina 2010; Ginatullina et al. 2017; Erkabaev et al. 2024), which was also investigated in the present study. In the 1970s, a diverse oligohaline branchiopod complex including dominant *Daphnia* spp. and *Bosmina longirostris* was typical of the Aydar-Arnasay lake system (Fedorova 1970; Ginatullina et al. 2023a). Currently, however, this complex is restricted to areas with low mineralization, being replaced by a less diverse mesohaline assemblage with dominants *Diaphanosoma mongolianum* Ueno, 1938 and *Moina salina* Daday, 1888 (Ginatullina 2023; Ginatullina et al. 2023a), which were also recorded in this study. The Large Aral Sea is the best-studied case of salinization: since the 1970s, a diversity of Onychopoda (*Cercopagis pengoi*, *Evadne anonyx*, *Podonevadne angusta*, *P. camptonyx*, *P. trigona*), as well as several representatives of Anomopoda and Ctenopoda, has become extinct in the Large Aral Sea due to salinity level increase (Aladin et al. 2019 2021; Table 2). In this study, however, we unexpectedly recorded *Podonevadne camptonyx* in large Lake Sarikamish in Karakalpakstan, although the water body is also undergoing salinization (Matmuratov 2017). Nevertheless, the imminent extinction of *Podonevadne* in Lake Sarikamish is also likely.

In contrast, the knowledge on the fauna of montane waters of Uzbekistan remains limited. Elevated water bodies of Central Asia are less affected by anthropogenic pressure and drought and thus might become potential refugia for a variety of branchiopods. In Uzbekistan, montane lakes and small water bodies are numerous and widespread (Petrov et al. 2017).

However, knowledge about their fauna is extremely scarce: Stepanova and Ledyeva (1957) recorded four anomopod species in Lake Kokkul, Fergana Province. In this study, we provide the first data on a relatively rich boreal branchiopod assemblage (nine species) observed in Lake Fozilmon, Navoiy Province (Table S1; Appendix). In small water bodies of Lake Fozilmon vicinity (locs. 48, 49), branchiopod diversity was much lower, with two and three species were observed, respectively (Table S1). However, further studies of these and other montane waters might bring new branchiopod records, including some high-altitude species recorded in the Pamir mountains (Dadykin et al. 2024).

Temporary pools represent another type of habitat essential for the branchiopods (Brendonck et al. 2008) but poorly studied in Uzbekistan. Records of Anomopoda, Anostraca, Spinicaudata, and Notostraca from ephemeral water bodies of Uzbekistan are still mostly occasional (Daday 1910 1914; Mukhamediev 1986; Van Damme and Dumont 2008), which hampers the comprehensive study of these groups. As the systematics and taxonomy of ‘large branchiopods’ remain complicated due to their high cryptic diversity and morphological plasticity (Brendonck et al. 2008 2022), more integrative studies are needed to reveal diversity of Central Asian representatives. In particular, the taxonomy of Spinicaudata apparently requires further clarification, as many species of this group are known as endemics with narrow distribution ranges (Rogers 2020). To date, the status and presence of the most spinicaudatan taxa recorded for Uzbekistan remain questionable (Rogers et al. 2017 2020). In this study, a number of ephemeral water bodies were investigated in Djizak, Navoiy and Samarkand Provinces (locs. 23, 24, 28, 37, 40, 50, 61, 64). In these water bodies, 15 anomopod taxa were recorded, of which the two, a spinicaudatan *Eocyclus davidi* (Simon, 1866) s. lat. and anomopod *Macrothrix odiosa* Gurney, 1916, were not found in other habitat types during this study (Table S1). This highlights a high potential of ephemeral pools for branchiopod colonization and the importance of these water bodies for monitoring branchiopods.

Currently, non-indigenous branchiopod species have become an essential issue for the freshwater communities (Anufrieva and Shadrin 2018; Kotov et al. 2022a). Multiple cases of anthropogenic transportations have been recently observed among the branchiopods, particularly in Onychopoda and Anomopoda (Kotov et al. 2022a). From this point of view, West Uzbekistan is of particular interest, as the Ponto-Caspian region is considered to be a donor region of several important invasive onychopod species (Panov et al. 2007; Korovchinsky et al. 2021; Macêdo et al.

2024), including *Cercopagis pengoi* and *Bythotrephes longimanus*. Neither was recorded in this study, and in Uzbekistan both taxa seem to be rare or absent (Appendix). On the other hand, artificial water bodies actively used for fishery and agriculture are especially vulnerable to invasions (Johnson et al. 2008; Parkes and Duggan 2012), as well as systems experiencing salinity and hydrological fluctuations (Anufrieva and Shadrin 2018). As the most lowland water bodies in Uzbekistan are either artificial or transformed (Karte et al. 2015), alien aquatic species might soon become a crucial factor affecting Uzbek aquatic communities. However, no such cases have yet been reported for Central Asia.

Overall, our knowledge on the branchiopod fauna of Uzbekistan and Central Asia is still full of blind spots in many aspects. Therefore, the region retains potential for future faunistic, taxonomic and phylogeographic research on aquatic crustaceans. Given its geographical position and potential role in aquatic invertebrate migrations (Artamonova et al. 2021), Central Asia might provide a key to understanding global distribution patterns of Branchiopoda in Eurasia.

CONCLUSIONS

Our Branchiopoda checklist comprising 107 taxa is still preliminary, as Kashkadarya, Khorezm, Navoiy, and Syrdarya Provinces remain scarcely studied, while montane and temporary water bodies are poorly sampled across the whole territory of Uzbekistan. Our results enable more precise evaluation of branchiopod faunal diversity in Central Asian lowlands, with the exception of unrevised groups (Anostraca, Notostraca, and Spinicaudata). Placement of well-explored Uzbekistan Cladocera local faunas in the West Eurasian cluster corresponds well to the known biogeographical patterns for this group and might reflect a genesis of the faunal assemblages, although broader-scale studies in the South Palearctic are needed for precise conclusions regarding Cladocera biogeography. We hope that this study will serve as a base for further faunistic, taxonomic, and phylogeographic research. The presented checklist might also be suitable for tracking changes in branchiopod communities in Uzbekistan and Central Asia in the whole.

List of abbreviations

CAE, Central Asian endemics.
EA, taxa primarily distributed in East Asia.
PAL, taxa widely distributed in the Palearctic or Holarctic.
PCA, taxa of the Ponto-Caspian origin.

ST, species widely distributed in the south temperate zone (the South Palearctic).

TR, tropical taxa.

WE, West Eurasian taxa.

WU, cosmopolitan unrevised taxa.

Acknowledgments: We thank Russell J. Shiel for linguistic corrections in an earlier draft. We are also grateful to Petr G. Garibian (A.N. Severtsov IEE RAS, Moscow, Russia) and Artem Y. Sinev (M.V. Lomonosov MSU, Moscow, Russia) for their comments and remarks. The work of Polina A. Volkova was held within the state assignment of IBIW RAS (theme 124032100076-2). Final analysis of all data was supported by the Russian Science Foundation (grant 23-14-00128) for Ivan A. Dadykin and Alexey A. Kotov.

Authors' contributions: ID, PV, EG and AK prepared the manuscript. ID, PV, MM and SM performed field sampling. ID and MM identified crustaceans. ID performed photographing and combined literature records. AK and EG provided some literature for the study. All the authors gave final approval for publications.

Competing interests: The authors have no competing interests to declare.

Availability of data and materials: The original samples are deposited to a working collection of the Laboratory of Aquatic Ecology and Invasions stored in A.N. Severtsov Institute of Ecology and Evolution of Russian Academy of Sciences (Moscow, Russia). The original dataset is available in table S1.

Consent for publication: Not applicable.

Ethics approval consent to participate: Not applicable.

REFERENCES

- Abdinazarov HK. 2018. Zooplankton of water bodies of Fergana PhD dissertation, Institute of Zoology, Uzbekistan. (in Uzbek)
- Abdinazarov HK, Madumarov MJ. 2022. Cladocera species in the water bodies of the Republic of Karakalpakstan and the Fergana Valley. Egypt J Aquat Biol Fish 26:1301–1307. doi:10.21608/ejabf.2022.282532.
- Abdinazarov HK, Madumarov MJ, Haydarov SM. 2019a. Zooplankton of Sarikamish Lake (Uzbekistan). Open Access Lib J 6:1–8.
- Abdinazarov HK, Mirabdullayev IM, Kuzmetov AR, Temirova NT. 2019b. Zooplankton dynamics and abundance in fishery ponds of Fergana Province. Archivarius 9:4–9. (in Russian)
- Abdullaeva MS, Kuzmetov AR, Zaripov EZ, Yuldashev AA,

- Atamuratova MS. 2021. Tuyabogiz water reservoir: seasonal status of phyto and zooplankton organisms. *J Nat Rem* **22**:228–234.
- Abuduwalli J, Issanova G, Saparov G. 2018. Water resources and lakes in Uzbekistan. In: Abuduwalli J, Issanova G, Saparov G (eds) *Hydrology and limnology of Central Asia. Water Resources development and management*. Springer, Singapore. doi:10.1007/978-981-13-0929-8_10.
- Afanasyeva LI, Sibirtseva LK, Ledyeva AI. 1972. Directed fauna formation of Uchqizil Reservoir. In: Mukhamediev AM, Gurvich FV (eds) *Scientific basis of directed formation of feed invertebrates and fish in water bodies of Uzbekistan*. FAN, Tashkent. (in Russian)
- Akatova NA. 1950. Materials to the study of zooplankton of Amu Darya River lower reach. *Tr Zool Inst Akad Nauk SSSR* **9**:80–89. (in Russian)
- Aksenova MD, Chertoprud ES, Novichkova AA, Tsyganov AN, Pechenkin DS et al. 2021. Cladocera and Copepoda of montane peatlands of the North Caucasus, Russia: composition and formation patterns of species complexes. *Biol Bull* **48**:926–933. doi:10.1134/S1062359021070025.
- Aladin NV, Gontar VI, Zhakova LV, Plotnikov IS, Smurov AO et al. 2019. The zoocenosis of the Aral Sea: six decades of fast-paced change. *Environ Sci Pollut Res* **26**:2228–2237. doi:10.1007/s11356-018-3807-z.
- Aladin NV, Plotnikov IS, Smurov AO, Makrushin AV. 2021. Crustaceans of the Aral Sea. *Biol Bull* **48**:967–983. doi:10.1134/S1062359021070037.
- Albuquerque MA, Nascimento ER, Oliveira Barros KNN, Barros PSN. 2022. Comparison between similarity coefficients with application in forest sciences. *Res Soc Dev* **11**:e48511226046–e48511226046. doi:10.33448/rsd-v11i2.26046.
- Alfonso G, Belmonte G, Marrone F, Naselli-Flores L. 2010. Does lake age affect zooplankton diversity in Mediterranean lakes and reservoirs? A case study from southern Italy. In: Naselli-Flores L, Rossetti G (eds) *Fifty years after the “Homage to Santa Rosalia”: old and new paradigms on biodiversity in aquatic ecosystems*. Developments in Hydrobiology 213. Springer, Dordrecht. doi:10.1007/978-90-481-9908-2_12.
- Alonso M. 1996. Crustacea, Branchiopoda. *Fauna Iberica*, V. 7. Museo Nacional de Ciencias Naturales Consejo Superior de Investigaciones Científicas, Madrid. (in Spanish)
- Alonso M. 2010. Branchiopoda and Copepoda (Crustacea) in Mongolian saline lakes. *Mongol J Biol Sci* **8**:9–16.
- Alyuruk H, Demir GK, Cavas L. 2013. A video tracking based improvement of acute toxicity test on *Artemia salina*. *Mar Freshw Behav Physiol* **46**:251–266. doi:10.1080/10236244.2013.814224.
- Andreev NI. 1989. Zooplankton of the Aral Sea in the initial period of its salinization. *Tr Zool Inst Akad Nauk SSSR* **199**:26–52. (in Russian)
- Anufrieva EV, Shadrin NV. 2018. Extreme hydrological events destabilize aquatic ecosystems and open doors for alien species. *Quat Int* **475**:11–15. doi:10.1016/j.quaint.2017.12.006.
- Arashkevich EG, Sapozhnikov PV, Soloviev KA, Kudyshev TV, Zavalov PO. 2009. *Artemia parthenogenetica* (Branchiopoda: Anostraca) from the Large Aral Sea: abundance, distribution, population structure and cyst production. *J Mar Syst* **76**:359–366. doi:10.1016/j.jmarsys.2008.03.015.
- Aripov DA. 1966. Materials to rice field hydrobiology of Amu Darya lower reach. In: Dobrokhotov VI, Malinovskaya AS, Mitrofanov VP, Sidorov EG, Sidorova AF, Khusainova NZ, Ostroverkhov AP (eds) *Biological basics of fishery in water bodies of Central Asia and Kazakhstan*. Nauka, Alma-Ata. (in Russian)
- Aripov DA. 1972. Hydrobiology of rice fields in Amy Darya River lower reach and related water bodies. Candidate Dissertation, Ulugbek Fergana State Educational University, Uzbekistan. (in Russian)
- Asem A, Gajardo G, Hontoria F, Yang C, Shen CY et al. 2024. The species problem in *Artemia* Leach, 1819 (Crustacea: Anostraca), a genus with sexual species and obligate parthenogenetic lineages. *Zool J Linnean Soc* **202**:zlad192. doi:10.1093/zoolinnea/zlad192.
- Asem A, Yang C, Eimanifar A, Hontoria F, Varó I et al. 2023. Phylogenetic analysis of problematic Asian species of *Artemia* Leach, 1819 (Crustacea, Anostraca), with the descriptions of two new species. *J Crust Biol* **43**:ruad002. doi:10.1093/jcabi/ruad002.
- Artamonova VS, Bolotov IN, Vinarski MV, Makhrov AA. 2021. Fresh- and brackish-water cold-tolerant species of Southern Europe: migrants from the Paratethys that colonized the Arctic. *Water* **13**:1161. doi:10.3390/w13091161.
- Atamuratova MS. 2021. Ichthyofauna of reservoirs in the Akhangaran River basin. Candidate Thesis, Institute of Zoology, Uzbekistan. (in Uzbek with English abstract)
- Atashbar B, Agh N, Manaffar R, Van Stappen G, Mohamadyari A et al. 2016. Morphometric and preliminary genetic characteristics of *Branchinecta orientalis* populations from Iran (Crustacea: Anostraca). *Zootaxa* **4109**:31–45. doi:10.11646/zootaxa.4109.1.3.
- Behning AL. 1938. Subtropical fauna elements in rice fields of Uzbekistan. *Doklady Akad Nauk SSSR* **21**:293–296. (in Russian)
- Behning AL. 1941. Cladocera of the Caucasus. Gruzmedgiz, Tbilisi. (in Russian)
- Bekker EI, Karabanov DP, Galimov YR, Kotov AA. 2016. DNA barcoding reveals high cryptic diversity in the North Eurasian *Moina* species (Crustacea: Cladocera). *PLoS ONE* **11**:e0161737. doi:10.1371/journal.pone.0161737.
- Belyaeva M, Taylor DJ. 2009. Cryptic species within the *Chydorus sphaericus* species complex (Crustacea: Cladocera) revealed by molecular markers and sexual stage morphology. *Mol Phyl Evol* **50**:534–546. doi:10.1016/j.ympev.2008.11.007.
- Bengtson DA, Léger P, Sorgeloos P. 2018. Use of *Artemia* as a food source for aquaculture. In: Browne RA (ed) *Artemia* biology. CRC Press, Boca Raton. doi:10.1201/9781351069892-11.
- Berner DB, Rakhmatullaeva G. 2001. A new species of *Ceriodaphnia* from Uzbekistan and Kazakhstan. *Hydrobiol* **442**:29–39. doi:10.1023/A:1017586106850.
- Bianco PG. 1990. Potential role of the palaeohistory of the Mediterranean and Paratethys basins on the early dispersal of Euro-Mediterranean freshwater fishes. *Ichthyol Explor Freshw* **1**:167–184.
- Błędzi LA, Rybak JI. 2016. Freshwater crustacean zooplankton of Europe. Cladocera & Copepoda (Calanoida, Cyclopoida). Key to species identification. Springer, Cham. doi:10.1007/978-3-319-29871-9.
- Bozkurt A, Bozça M. 2019. Investigation of zooplankton fauna in water wells of Yayladağı District (Hatay, Turkey). *Turk J Zool* **43**:356–366. doi:10.3906/zoo-1903-33.
- Boyer L, Jabbour-Zahab R, Mosna M, Haag CR, Lenormand T. 2021. Not so clonal asexuals: Unraveling the secret sex life of *Artemia parthenogenetica*. *Evol Lett* **5**:164–174. doi:10.1002/evl3.216.
- Brendonck L, Rogers DC, Olesen J, Weeks S, Hoeh WR. 2008. Global diversity of large branchiopods (Crustacea: Branchiopoda) in freshwater. In: Balian EV, Lévêque C, Segers H, Martens K (eds) *Freshwater animal diversity assessment. Developments in hydrobiology* 198. Springer, Dordrecht. doi:10.1007/978-1-4020-8259-7_18.
- Brendonck L, Rogers DC, Vanschoenwinkel B, Pinceel T. 2022. Large branchiopods. In: Dalu T, Wasserman RJ (eds) *Fundamentals of tropical freshwater wetlands. From ecology to conservation*

- management. Elsevier, Amsterdam, etc. doi:10.1016/B978-0-12-822362-8.00007-4.
- Chertoprud ES, Sinev AY, Dimante-Deimantovica I. 2017. Fauna of Cladocera and Copepoda from Xinjiang Uyghur autonomous region (China). *Zootaxa* **4258**:561–573. doi:10.11646/zootaxa.4258.6.5.
- Crootof A, Mullabaev N, Saito L, Atwell L, Rosen MR et al. 2015. Hydroecological condition and potential for aquaculture in lakes of the arid region of Khorezm, Uzbekistan. *J Arid Environ* **117**:37–46. doi:10.1016/j.jaridenv.2015.02.012.
- Daday J. 1910. Monographie systématique des phyllopoètes anostracés. *Annal Sci Nat Zool* **9**:91–489. (in French and Latin)
- Daday J. 1914. Monographie systématique des phyllopoètes conchostracés. *Annal Sci Nat Zool* **20**:39–330. (in French and Latin)
- Dadykin IA, Ivanova MO, Volkova PA, Novichkova AA, Chertoprud ES. 2025. Filling the gaps: diversity of the freshwater microcrustaceans of Karaginsky Island (Kamchatka, Northwest Pacific). *Limnol* **26**:195–210. doi:10.1007/s10201-024-00770-9.
- Dadykin IA, Karimov GN, Sinev AY, Volkova PA, Kotov AA. 2024. Branchiopoda (Crustacea: Anostraca and Diplostroaca) diversity in Tajik Pamir and plain West and South Tajikistan. *Zootaxa* **5497**:1–32. doi:10.11646/zootaxa.5497.1.1.
- Dice LR. 1945. Measures of the amount of ecologic association between species. *Ecol* **26**:297–302.
- Dobrynina TI. 2004. Distribution of *Eocyzicus orientalis* Daday, 1914 (Crustacea, Conchostraca) in Russia and contiguous territories. *Biol Vnutr Vod* **2**:16–24. (in Russian)
- Dodson SL, Cáceres CE, Rogers DC. 2010. Cladocera and other Branchiopoda. In: Thorp JH, Covich AP (eds) *Ecology and classification of North American freshwater invertebrates*, 3d ed. Academic Press, Amsterdam, etc. doi:10.1016/B978-0-12-374855-3.00020-0.
- Dodson SI, Everhart WR, Jandl AK, Krauskopf SJ. 2007. Effect of watershed land use and lake age on zooplankton species richness. *Hydrobiol* **579**:393–399. doi:10.1007/s10750-006-0392-9.
- Ebert D. 2022. *Daphnia* as a versatile model system in ecology and evolution. *EvoDevo* **13**:16. doi:10.1186/s13227-022-00199-0.
- Ergasheva SK. 2022. The significance of the water of the KLi and Akbulok reservoirs in the formation of the water resources of the Aidar-Arnasay lake system. *Econ Soc* **12**:1126–1131. (in Russian)
- Erkabaev F, Madrimov R, Nurmatova V. 2024. Status quo analysis of the Aidar-Arnasay Lake System. E3S Web of Conferences **497**:02025. doi:10.1051/e3sconf/202449702025.
- Fedorova TI. 1970. Winter zooplankton of the Arnasay system. In: *Biological bases of fishery in Central Asia and Kazakhstan. Abstracts of the VI conference*, Alma-Ata, Balkhash, 1970. (in Russian)
- Flößner D, Horn W, Paul M. 2005. Notes on the Cladoceran and Copepod fauna of the Uvs Nuur basin (Northwest Mongolia). *Int Rev Hydrobiol* **90**:580–595. doi:10.1002/iroh.200410782.
- Garibian PG, Neretina AN, Korovchinsky NM, Sinev AY, Tchabovsky AV et al. 2021. The southern part of Russian Far East and Korean Peninsula as a transition zone between the boreal and tropical faunas of the waterfleas (Cladocera, Crustacea). *Biol Bull* **48**:865–879. doi:10.1134/S1062359021070128.
- Garibian PG, Neretina AN, Taylor DJ, Kotov AA. 2020. Partial revision of the neustonic genus *Scapholeberis* Schoedler, 1858 (Crustacea: Cladocera): decoding of the barcoding results. *PeerJ* **8**:e10410. doi:10.7717/peerj.10410.
- Ginatullina E, Atwell L, Saito L. 2017. Resilience and resistance of zooplankton communities to drought-induced salinity in freshwater and saline lakes of Central Asia. *J Arid Environ* **144**:1–11. doi:10.1016/j.jaridenv.2017.04.010.
- Ginatullina E, Mullabaev N, Mirabdullayev IM, Karimov B. 2006b. Zooplankton of reservoirs of Amu-Darya's lower reaches. *Uzb Biol J* **5**:51–56. (in Russian)
- Ginatullina EN. 2010. Zooplankton of transformed plain lakes of Uzbekistan. Candidate Dissertation. Institute of Zoology, Uzbekistan. (in Russian)
- Ginatullina EN. 2022. Water quality assessment in lakes of Karakalpakia (Uzbekistan) using zooplankton indices. In: Ashikhmina TY (ed) *Ecology of the native land: problems and solutions. Materials of the XVII All-Russian scientific and practical conference with international participation*, Kirov, 2022. (in Russian)
- Ginatullina EN. 2023. Changes in qualitative zooplankton composition of Lake Aydarkul due to increase of mineralization. In: Ashikhmina TY (ed) *Biodiagnostika sostoyaniya prirodnykh i prirodno-tekhnogennykh system. Materials of XXI international conference*, Kirov, 2023. (in Russian)
- Ginatullina EN, Kurbanov AR, Tuychiev KS. 2023a. Influence of environmental factors on the formation of zooplankton communities in a large lake system in Uzbekistan. E3S Web of Conferences **407**:01004. doi:10.1051/e3sconf/202340701004.
- Ginatullina EN, Mullabaev NR, Mirabdullayev IM. 2006a. Seasonal succession of species composition and quantitative characteristics of zooplankton of the Arnasay lake system. In: Rakhmatullaeva GM (ed) *Digest of articles devoted to the fishery of Uzbekistan*. KARLLO, Tashkent. (in Russian)
- Ginatullina EN, Mustafaeva ZA, Titova NO, Namozov SM. 2023b. Hydrobiont assemblages of the Yuzhno-Golodnostepskii Channel, Uzbekistan. In: Ashikhmina TY (ed) *Ecology of the native land: problems and solutions. Materials of the XVIII All-Russian scientific and practical conference with international participation*, Kirov, 2023. (in Russian)
- Ginatullina EN, Temirova NT. 2018. Zooplankton assemblages of fishponds in Yangiyol District. In: Aimbetov NK (ed) *VII International Scientific-Practical Conference "Problems of rational use and protection of natural resources of southern Aral Sea section"*. Proceedings, Part I, Nukus, 2018. (in Russian)
- Ginatullina EN, Titova NO, Tuychiev KS. 2023c. Methods for determining fish productivity in natural water bodies of Uzbekistan (a version for the Tuyabuguz Reservoir). *Nauch Tr Dalrybtuza* **63**:36–43. (in Russian)
- Gu YL, Huang Q, Xu L, Rizo EZ, Alonso M et al. 2021. Species diversity and community assembly of Cladocera in the sand ponds of the Ulan Buh Desert, Inner Mongolia of China. *Divers* **13**:502. doi:10.3390/d13100502.
- Güher H. 2014. A checklist for zooplankton (Rotifera, Copepoda, Cladocera) of European Turkey inland waters. *Ege J Fish Aquat Sci* **31**:221–225. doi:10.12714/egejfas.2014.31.4.08.
- Hairston NG Jr. 1996. Zooplankton egg banks as biotic reservoirs in changing environments. *Limnol Oceanogr* **41**:1087–1092. doi:10.4319/lo.1996.41.5.1087.
- Hobæk A, Manca M, Andersen T. 2002. Factors influencing species richness in lacustrine zooplankton. *Acta Oecol* **23**:155–163. doi:10.1016/S1146-609X(02)01147-5.
- Jeong H, Kotov AA, Lee W, Jeong R, Cheon S. 2015. Diversity of freshwater cladoceran species (Crustacea: Branchiopoda) in South Korea. *J Ecol Environ* **38**:361–366. doi:10.5141/ecoenv.2015.037.
- Ji GH, Xiang XF, Chen SZ, Yu GL, Kotov AA, Dumont HJ. 2015. Annotated checklist of Chinese Cladocera (Crustacea: Branchiopoda). Part II. Order Anomopoda (families Macrotrichidae, Eurycercidae and Chydoridae). *Zootaxa* **4044**:241–269. doi:10.11646/zootaxa.4044.2.4.
- Johnson PT, Olden JD, Vander Zanden MJ. 2008. Dam invaders: impoundments facilitate biological invasions into freshwaters.

- Front Ecol Environ **6**:357–363. doi:10.1890/070156.
- Karimov NA. 2021. Use of drainage water in fish farming in Uzbekistan. *Int Multidiscip Sci J* **1**:28–31.
- Karthe D, Chalov S, Borchardt D. 2015. Water resources and their management in Central Asia in the early twenty first century: status, challenges and future prospects. *Environ Earth Sci* **73**:487–499. doi:10.1007/s12665-014-3789-1.
- Kaya M, Altındağ A. 2007. Some cladoceran species from Turkish inland waters. *Süleyman Demirel Univ Fac Art Sci J Sci* **2**:60–76.
- Kazakhbaev S. 1988. Recent state of zooplankton of Lake Sudochoye. *In: Kazakhbaev S (ed) Structure of hydrobionts' assemblages in the lower reaches of Amu-Darya. FAN, Tashkent. (in Russian)*
- Keiser Z. 1925. To Copepoda and Cladocera fauna of Syr Darya River and its shoreline water bodies. *Rus Gidr J* **4**:76–83. (in Russian)
- Keiser Z. 1937. Hidrobiological review of rice fields of Uzbekistan. *Tr Uzb Zon Opyt Stantsii* **3**:7–87. (in Russian)
- Keiser Z. 1950. Plankton of Syr Darya oxbows. *Tr SAGU* **24**:7–57. (in Russian)
- Ketmaier V, Pirollo D, De Matthaes E, Tiedemann R, Mura G. 2008. Large-scale mitochondrial phylogeography in the halophilic fairy shrimp *Phallocryptus spinosa* (Milne-Edwards, 1840) (Branchiopoda: Anostraca). *Aquat Sci* **70**:65–76. doi:10.1007/s00027-007-7028-7.
- Khakimova R, Mullabaev N, Sobirov J, Kobilov A, Sobirov B. 2021. Ecological state of Tudakul reservoir in Uzbekistan and estimation of fish capture in last decades. *E3S Web of Conferences* **258**:08029. doi:10.1051/e3sconf/202125808029.
- Khodjayeva ZF, Shamsiyev NA. 2020. Lake Devkhona is as hydrobiological object. *Int J Faun Biol Stud* **7**:121–124.
- Korn M, Marrone F, Pérez-Bote JL, Machado M, Cristo M et al. 2006. Sister species within the *Triops cancriformis* lineage (Crustacea, Notostraca). *Zool Scripta* **35**:301–322. doi:10.1111/j.1463-6409.2006.00230.x.
- Korovchinsky NM. 1987. A study of *Diaphanosoma* species (Crustacea: Cladocera) of the “mongolianum” group. *Int Rev Gesamten Hydrobiol Hydrogr* **72**:727–758. doi:10.1002/iroh.19870720609.
- Korovchinsky NM. 2000. Redescription of *Diaphanosoma dubium* Manuilova, 1964 (Branchiopoda: Ctenopoda: Sidae), and description of a new, related species. *Hydrobiol* **441**:73–92. doi:10.1023/A:1017574921558.
- Korovchinsky NM. 2004. Water fleas of the order Ctenopoda of world fauna. KMK, Moscow. (in Russian)
- Korovchinsky NM, Mirabdullayev IM. 1995. A new species of the genus *Diaphanosoma* Fischer, 1850 (Crustacea: Daphniiformes: Sidae) from Central Asia and China. *Hydrobiol* **304**:235–242. doi:10.1007/BF02329317.
- Korovchinsky NM, Mirabdullayev IM. 2001. Review of the genus *Diaphanosoma* Fischer 1850 (Crustacea: Ctenopoda: Sidae) of Uzbekistan, with a pictorial key for species identification. *Arthropoda Sel* **10**:281–288.
- Korovchinsky NM, Kotov AA, Sinev AY, Neretina AN, Garibian PG. 2021. Cladocera (Crustacea) of North Eurasia. KMK, Moscow. (in Russian)
- Kotov AA. 2016. Faunistic complexes of the Cladocera (Crustacea, Branchiopoda) of Eastern Siberia and the Far East of Russia. *Biol Bull* **43**:970–987. doi:10.1134/S1062359016090041.
- Kotov AA, Karabanov DP, Van Damme K. 2022a. Non-indigenous Cladocera (Crustacea: Branchiopoda): from a few notorious cases to a potential global faunal mixing in aquatic ecosystems. *Water* **14**:2806. doi:10.3390/w14182806.
- Kotov AA, Štifter P. 2006. Cladocera: family Ilyocryptidae (Branchiopoda: Cladocera: Anomopoda). Kenobi Productions, Leiden and Backhuys, Ghent, Belgium.
- Kotov AA, Sinev AY, Garibian PG, Neretina AN, Jeong HG et al. 2017. Recent progress in studies of the Cladocera (Crustacea: Branchiopoda) of South Korea with seven new records for the Korean Peninsula. *J Species Res* **6**:227–246. doi:10.12651/JSR.2017.6(S).227.
- Kotov AA, Seleznev DG, Garibian PG, Korovchinsky NM, Neretina AN et al. 2022b. History of colonization of Jeju Island (Republic of Korea) by the water fleas (Crustacea: Cladocera) is reflected by the seasonal changes in their fauna and species associations. *Water* **14**:3394. doi:10.3390/w14213394.
- Kotov AA, Garibian PG, Neretina AN, Karabanov DP. 2025. A phylogeographic pattern of the trans-Palaeartic littoral water flea *Pleuroxus truncatus* (O.F. Müller, 1785) (Cladocera: Chydoridae). *PeerJ* **13**:e19355. doi:10.7717/peerj.19355.
- Krolenko II, Garibian PG, Kotov AA. 2023. The role of old relicts in structuring the boreal/tropical transitional zone: the case of East Asian planktonic Cladocera (Crustacea). *Divers* **15**:713. doi:10.3390/d15060713.
- Kuzmetov AR. 2019. Fauna, ecology and practical significance of zooplankton organisms in reservoirs of Uzbekistan. Doctoral Dissertation, Institute of Zoology, Uzbekistan. (in Russian)
- Kuzmetov AR. 1998. Zooplankton of fish farms in Uzbekistan. Candidate Thesis, Institute of Zoology, Tashkent. (in Russian)
- Kuzmetov AR, Abdinazarov XX. 2016. Ecological-faunistic characteristic of reservoirs' zooplankton in Uzbekistan. *Eur J Tech Nat Sci* **1-2**:3–6.
- Lebedeva LI, Rakhmanova AK. 1982. Reproduction of branchiopods (*Cyzicus teracerus* Kryn.) in the rice fields of Uzbekistan. *In: Yanshin AL (ed) Doklady MOIP: zoologia i botanika. Nekotorye aspekty izucheniya flory i fauny SSR. (in Russian)*
- Liu H, Chen Y, Ye Z, Li Y, Zhang Q. 2019. Recent lake area changes in Central Asia. *Sci Rep* **9**:16277. doi:10.1038/s41598-019-52396-y.
- Liu Y, Wang P, Gojenko B, Yu J, Wei L et al. 2021. A review of water pollution arising from agriculture and mining activities in Central Asia: facts, causes and effects. *Environl Pollut* **291**:118209. doi:10.1016/j.envpol.2021.118209.
- Louette G, De Meester L. 2005. High dispersal capacity of cladoceran zooplankton in newly founded communities. *Ecol* **86**:353–359. doi:10.1890/04-0403.
- Lyakhnovich VP, Polistschuk VS, But VP, Maryutina GN, Pridatkina NV et al. 1972. Application of fertilizers as method to intensification of fishery ponds. *In: Mukhamediev AM, Gurvich FV (eds) Scientific basis of directed formation of feed invertebrates and fish in water bodies of Uzbekistan. FAN, Tashkent. (in Russian)*
- Macêdo RL, Klippel G, Silva DP, Haubrock PJ, Vilela B et al. 2024. Intercontinental invasion dynamics of *Cercopagis pengoi*, an IUCN-listed planktonic invasive species. *Reg Environ Change* **24**:78. doi:10.1007/s10113-024-02244-1.
- Madumarov MJ, Madumarova SO, Raximov MS, Muminova RN, Abdinazarov HK. 2024. *Moina micrura* species in water bodies of Fergana Valley. *Egypt J Aquat Biol Fish* **28**:935–943.
- Maia-Barbosa PM, Peixoto RS, Guimaraes AS. 2008. Zooplankton in littoral waters of a tropical lake: a revisited biodiversity. *Braz J Biol* **68**:1069–1078. doi:10.1590/S1519-69842008000500014.
- Manuilova EF. 1964. Water fleas (Cladocera) of USSR fauna. Nauka, Leningrad, USSR. (in Russian)
- Marden B, Van Stappen G, Musaev A, Mirabdullayev I, Joldasova I et al. 2012. Assessment of the production potential of an emerging *Artemia* population in the Aral Sea, Uzbekistan. *J Mar Syst* **92**:42–52. doi:10.1016/j.jmarsys.2011.10.004.
- Margaritora FG. 1985. Cladocera. Fauna d'Italia, V. 23. Editioni Calderini, Bologna. (in Italian)
- Meisner VI. 1906. Microscopic representatives of the aquatic fauna of the Aral Sea and rivers flowing there in connection with the

- question of living conditions. Izv Turkestan Geogr Obshchestva 4:1–102. (in Russian)
- Mirabdullayev IM. 1993. *Moina gouldeni* n. sp. (Cladocera, Moinidae) from Central Asia. Crustaceana 64:192–196. doi:10.1163/156854093X00234.
- Mirabdullayev IM. 1998. *Moina mukhamedievi* n. sp. (Crustacea, Cladocera) from rice fields of Uzbekistan (Central Asia). Hydrobiol 385:11–16. doi:10.1023/A:1003436930510.
- Mirabdullayev IM, Rakhmatullaeva GM, Kuzmetov A, Turemuratova GI, Belozub LG et al. 1997. Crustacean biodiversity of Uzbekistan. Uzb Biol J 6:51–53. (in Russian)
- Mirabdullayev IM, Ginatullina EN, Kuzmetov AR, Musaev AK, Saparov KA et al. 2016. Plankton communities of hydroecosystems of wetland Sudoche (Aral Sea region, Uzbekistan). Nauch Tr Dalrybvtuza 39:38–48. (in Russian)
- Mirzambetov N, Mirabdullayev I. 2022. Zooplankton succession in fry fishponds of Karakalpakstan. In: Ledastscheva TN (ed) Recent problems of ecology and nature management, vol 1. Patrice Lumumba Peoples' Friendship University of Russia, Moscow. (in Russian)
- Mordukhai-Boltovskoi FD, Rivier IK. 1987. Predatory Cladocera of the world fauna. Nauka, Leningrad. (in Russian)
- Moreno E, Pérez-Martínez C, Conde-Porcuna JM. 2019. Dispersal of rotifers and cladocerans by waterbirds: seasonal changes and hatching success. Hydrobiol 834:145–162.
- Mukhamediev AM. 1967. Hydrobiology of water bodies of Fergana Valley. FAN, Tashkent, Uzbekistan. (in Russian)
- Mukhamediev AM. 1986. Crustaceans of water bodies of Fergana Valley. FAN, Tashkent, Uzbekistan. (in Russian)
- Mukhamediev MA, Bekchonova MF. 2023. On the issue of the usage of biological resources of the Karkidon Reservoir. News Educat Res XXI Cent 10:557–559. (in Russian)
- Mukhamediev MA, Mukhitdinov EM. 1967. Tropical and subtropical species of water fleas (Cladocera) from water bodies of Surkhandarya River Basin. In: Gan EI (ed) Useful and harmful invertebrates of Uzbekistan. FAN, Tashkent. (in Russian)
- Mukhitdinov EM. 1967. Materials to the study of reservoir hydrobiology of Surkhandarya River basin. In: Gan EI (ed) Useful and harmful invertebrates of Uzbekistan. FAN, Tashkent. (in Russian)
- Muñoz J, Gómez A, Figuerola J, Amat F, Rico C et al. 2014. Colonization and dispersal patterns of the invasive American brine shrimp *Artemia franciscana* (Branchiopoda: Anostraca) in the Mediterranean region. Hydrobiol 726:25–41. doi:10.1007/s10750-013-1748-6.
- Murguía M, Villaseñor JL. 2003. Estimating the effect of the similarity coefficient and the cluster algorithm on biogeographic classifications. Ann Bot Fenn 40:415–421.
- Mustafaeva ZA, Mirzayev UT. 2018a. Species of hydrobionts of lakes of Bukhara Region of Uzbekistan. East Eur Sci J 4:9–16. (in Russian)
- Mustafaeva ZA, Mirzayev UT. 2018b. The current state of hydrobionts of the Zarafshan river basin (Uzbekistan). Way Sci 4:13–16.
- Mustafaeva ZA, Mullabaev NR, Ginatullina EN, Kim SI. 2006. Vertical distribution and production capacity of plankton organisms in Eastern Arnasay. In: Rakhmatullaeva GM (ed) Digest of articles devoted to the fishery of Uzbekistan. KARLLO, Tashkent. (in Russian)
- Mustafaeva ZA, Kuvatov AK, Azizov NY, Mirzayev UT. 2021a. The lake Aydarkul – the current state of aquatic biocenoses. Nauch Tr Dalrybvtuza 56:5–14. (in Russian)
- Mustafaeva ZA, Namozov SM, Mirzayev UT. 2021b. The current state of planktonic assemblages and ichthyofauna of the Aydar-Arnasay lake system. Uzb Biol J 6:34–40. (in Russian)
- Mustafaeva ZA, Namozov SM, Titova NO, Sobirov JJ. 2022. The current state of hydrobionts of the Aydar-Arnasay systems of lakes. J Pharm Neg Res 13:3377–3387. doi:10.47750/pnr.2022.13.S06.452.
- Nakamoto T, Maruyama I, Kimura H, Inada Y, Hagiwara A. 2008. Two cladoceran species *Moina macrocopa* and *Diaphanosoma celebensis*, as live feed for larval prawn, *Penaeus japonicus*. Aquacult Sci 56:31–36. doi:10.1123/aquaculturesci.56.31.
- Nikolsky GV, Pankratova VY. 1934. Some data on hydrology, hydrobiology and ichthyology of Aibugrinskaya depression (Lake Sudoche). Tr Aral Otdel VNIRO 3:153–180. (in Russian)
- Novichkova AA, Azovsky AI. 2017. Factors affecting regional diversity and distribution of freshwater microcrustaceans (Cladocera, Copepoda) at high latitudes. Polar Biol 40:185–198. doi:10.1007/s00300-016-1943-9.
- Panov VE, Rodionova NV, Bolshagin PV, Bychek EA. 2007. Invasion biology of Ponto-Caspian onychopod cladocerans (Crustacea: Cladocera: Onychopoda). Hydrobiol 590:3–14. doi:10.1007/s10750-007-0752-0.
- Parkes SM, Duggan IC. 2012. Are zooplankton invasions in constructed waters facilitated by simple communities? Divers Distrib 18:1199–1210. doi:10.1111/j.1472-4642.2012.00913.x.
- Pazhitnova ZA. 1929. Materials to the study of rice field microfauna and biology of *Anopheles* larva on rice fields. Tr SAGU 8a:1–40. (in Russian)
- Pazhitnova ZA. 1935. Microfauna of typical rice field of the Samarkand oasis. Trudy SAGU 8a:1–64. (in Russian)
- Perez ML, Valverde JR, Batuecas B, Amat F, Marco R et al. 1994. Speciation in the *Artemia* genus: mitochondrial DNA analysis of bisexual and parthenogenetic brine shrimps. J Mol Evol 38:156–168. doi:10.1007/BF00166162.
- Petrov MA, Sabitov TY, Tomashevskaya IG, Glazirin GE, Chernomorets SS et al. 2017. Glacial lake inventory and lake outburst potential in Uzbekistan. Sci Total Environ 592:228–242. doi:10.1016/j.scitotenv.2017.03.068.
- Plotnikov IS. 2013. Changes in the species composition of the Aral Sea free-living invertebrates (Metazoa) fauna. Tr Zool Inst RAN 317:41–54. (in Russian)
- Plotnikov I, Smurov A, Aladin N. 2021. Large saline lakes of Central Asia. J Arid Land Stud 31:29–44. doi:10.14976/jals.31.2_29.
- R Core Team. 2023. R: A Language and Environment for Statistical Computing. R Foundation for Statistical Computing, Vienna, Austria. Available at: <https://www.R-project.org/>. Accessed 10 Jan. 2024.
- Rakhmatullaev S, Huneau F, Celle-Jeanton H, Le Coustumer J, Motelica-Heino M et al. 2013. Water reservoirs, irrigation and sedimentation in Central Asia: a first-cut assessment for Uzbekistan. Environ Earth Sci 68:985–998. doi:10.1007/s12665-012-1802-0.
- Rakhmatullaeva GM. 1998. Morpho-ecological characteristics of family Daphniidae of the Uzbekistan fauna. Candidate Thesis, Institute of Zoology, Uzbekistan. (in Russian)
- Rakhmatullaeva GM. 2007. Cladocera of Uzbek fauna. Available at: <https://uznix.narod.ru/sci/hyd/splist.html>. Accessed 09 Jan. 2025. (in Russian)
- Rakhmatullaeva G, Khurshut E. 2001. Aydar-Arnasay Lake System. In: 9th International Conference on the Conservation and Management of Lakes, Shiga, Japan, 22 Mar. 2001.
- Rakhmatullaeva G, Mirabdullayev I. 1998. Record of the tropical *Simocephalus mesorostris* Orlova-Bienkowskaja, 1995 (Crustacea, Cladocera) in Central Asia and first description of its male. Int Rev Hydrobiol 83:435–438.
- Rasdi NW, Arshad A, Ikhwannuddin M, Hagiwara A, Yusoff FM et al. 2020. A review on the improvement of cladocera (*Moina*)

- nutrition as live food for aquaculture: using valuable plankton fisheries resources. *J Environ Biol* **41**:1239–1248. doi:10.22438/jeb/41/5(SI)/MS_16.
- Richard J. 1892. Sur la distribution géographique des Cladocérés. *In*: Congrès International de Zoologie, Deuxieme Session, Moscow, Russia, pp. 22–30 Aug. 1892.
- Rogers DC. 2003. Revision of the thamnocephalid genus *Phallocryptus* (Crustacea: Branchiopoda: Anostraca). *Zootaxa* **257**:1–14. doi:10.11646/zootaxa.257.1.1.
- Rogers DC. 2013. Anostraca Catalogus (Crustacea: Branchiopoda). *Raffles Bull Zool* **61**:525–546. doi:10.5281/zenodo.5352398.
- Rogers DC. 2020. Spinicaudata Catalogus (Crustacea: Branchiopoda). *Zool Stud* **59**:45. doi:10.6620/ZS.2020.59-45.
- Rogers DC, Chang TC, Wang YC. 2017. A new *Eocyzicus* (Branchiopoda: Spinicaudata) from Taiwan, with a review of the genus. *Zootaxa* **4318**:254–270. doi:10.11646/zootaxa.4318.2.2.
- Rogers DC, Kotov AA, Sinev AY, Glagolev SM, Korovchinsky NM et al. 2019. Arthropoda: Class Branchiopoda. *In*: Rogers DC, Thorp JH (eds) Keys to Palaearctic Fauna: Thorp and Covich's freshwater invertebrates, vol. 4. Academic Press, Elsevier, Kidlington, Oxford. doi:10.1016/B978-0-12-385024-9.00018-6.
- Rosen MR, Crootof A, Reidy L, Saito L, Nishonov B et al. 2018. The origin of shallow lakes in the Khorezm Province, Uzbekistan, and the history of pesticide use around these lakes. *J Paleolimnol* **59**:201–219. doi:10.1007/s10933-016-9914-2.
- Saparov AD, Kuzmetov AR, Ergashev KB, Erdanova GM. 2019. Zooplankton in the ponds of the Scientific Research Institute of Fish Farming. *In*: Khismatullin DR (ed) Nauchnye razrabotki: Evraziyskii Region: materialy mezhdunarodnoi nauchnoi konferentsii teoreticheskikh i prikladnykh razrabotok, Ufa, Russia. (in Russian)
- Shao Y, Zhao W, Wei J, Wang S, Wang Y et al. 2021. Growth and reproduction effects and transgenerational effects of nonylphenol in *Moina mongolica* Daday (Crustacea: Cladocera). *Environ Sci Pollut Res* **28**:29221–29230. doi:10.1007/s11356-021-12592-8.
- Sheveleva NG, Ayushsuren C, Tuvshinzhargal N, Zaitseva EP, Sukhanova LV. 2023. Modern fauna of the Cladocera and copepod crustaceans (Crustacea: Cladocera, Copepoda) of Lake Dood Tsagaan (Darhad Basin, Mongolia). *Inland Water Biol* **16**:821–833. doi:10.1134/S1995082923050139.
- Sibirtseva LK, Afanasyeva LI, Ledyeva AI, Nikolaenko VA. 1972. Hydrobiological characteristic of South-Surkhan Reservoir. *In*: Mukhamediev AM, Gurvich FV (eds) Scientific basis of directed formation of feed invertebrates and fish in water bodies of Uzbekistan. FAN, Tashkent, Uzbekistan. (in Russian)
- Sinev AY. 2001. Separation of *Alona cambouei* Guerne and Richard, 1893 from *Alona pulchella* King, 1853 (Branchiopoda: Anomopoda: Chydoridae). *Arthropoda Sel* **10**:5–18.
- Sinev AY. 2014. A comparative morphological analyses of four species of *Camptocercus* Baird, 1843 (Cladocera: Anomopoda: Chydoridae). *Zootaxa* **3895**:183–207. doi:10.11646/zootaxa.3895.2.3.
- Sinev AY. 2015. Revision of the *pulchella*-group of *Alona* s. lato leads to its translocation to *Ovalona* Van Damme et Dumont, 2008 (Branchiopoda: Anomopoda: Chydoridae). *Zootaxa* **4044**:451–492. doi:10.11646/zootaxa.4044.4.1.
- Sinev AY, Dadykin IA, Đinh CN. 2024. A new species of the genus *Ovalona* Van Damme & Dumont, 2008 (Cladocera: Anomopoda: Chydoridae) from South-East Asia, related to Australian *Ovalona archeri* (Sars, 1888). *Zootaxa* **5448**:273–282. doi:10.11646/zootaxa.5448.2.7.
- Sinev AY, Karabanov DP, Kotov AA. 2020. A new North Eurasian species of the *Alona affinis* complex (Cladocera: Chydoridae). *Zootaxa* **4767**:115–137. doi:10.11646/zootaxa.4767.1.5.
- Smirnov NN. 1974. Chydoridae. Fauna of the USSR, Crustacea, vol. 1, iss 2. Keter Publishing House Jerusalem Ltd., Jerusalem, Israel.
- Smirnov NN. 1976. Macrothricidae and Moinidae of the world fauna. Fauna of the USSR, Crustacea, vol. 1, iss 3. Nauka, Leningrad, USSR. (in Russian)
- Smirnov SS. 1949. A new species of genus *Eulimnadia* Pack. (Crustacea, Conchostraca) from Uzbekistan. *Dokl AN SSSR* **67**:1159–1162. (in Russian)
- Sokolov II. 1931. To the investigation of Old Bukhara and its vicinity water body fauna. *Tr SAGU* **12a**:11–15. (in Russian)
- Stamou G, Kourkoutmani P, Michaloudi E. 2022. The inland Cladocera and Copepoda fauna in Greece. *Divers* **14**:997. doi:10.3390/d14110997.
- Stepanova NA, Ledyeva AI. 1957. Materials to hydrobiology of Andijan Province rice fields. *In*: Stepanova NA, Ledyeva AI (eds) Hydrobiology of the Fergana Valley irrigational system. Izdatelstvo AN RUz, Tashkent. (in Russian)
- Telesh IV, Ojaveer H. 2002. The predatory water flea *Cercopagis pengoi* in the Baltic Sea: invasion history, distribution and implications to ecosystem dynamics. *In*: Leppäkoski E, Gollasch S, Olenin S (eds) Invasive aquatic species of Europe. Distribution, impacts and management. Springer, Dordrecht. doi:10.1007/978-94-015-9956-6_7.
- Temirbekov R, Mirzambetov N, Musaev A, Israilova I, Kaipov I et al. 2023. Current state of biodiversity and hydrological-hydrochemical regime of the Mezhdurechensk Reservoir of the Republic of Karakalpakstan. *IOP Conf Ser Earth Environ Sci* **1284**:012007. doi:10.1088/1755-1315/1284/1/012007.
- The Government Portal of the Republic of Uzbekistan. 2024. Local authority. Available at: <https://old.gov.uz/en/organizations/kind/local>. Accessed 09 Jan. 2025.
- Turemuratova G, Nagmetov K, Abdreymova M. 2024. Qualitative composition and species diversity of Saikul Lake zooplankton. *BIO Web Conf* **130**:03020. doi:10.1051/bioconf/202413003020.
- Turemuratova GI, Kosymbetova MB. 2024. Structure and dynamics of zooplankton communities in Karakalpakstan. *In*: Proceedings of International Educators Conference, Rome, Italy, 25 Apr. 2024.
- Turemuratova GI, Kurbatova AI, Nagmetov HS, Kurbanov UI. 2022. Hydrobiological studies of zooplankton Lake Karateren. *Eurasian Med Res Period* **4**:27–32.
- Turemuratova GI, Kuzmetov AR. 2016. The qualitative composition of zooplankton of the Nukus fishery. *Econ Soc* **9**:471–473. (in Russian)
- Turemuratova GI, Madumarov MD, Kuzmetov AR, Zaripov EZ. 2021. Representatives of Cladocera order in the lakes of the Republic of Karakalpakstan. *IT Industr* **9**:987–990.
- Turemuratova GI, Nagmetov HS. 2021. Development indicators and dynamics of zooplankton. Lake Karateren. *Centr Asian J Med Nat Sci* **2**:83–90.
- Turemuratova GI, Urazymbetova NP, Esenbekova AA. 2018. Representatives of species diversity of zooplankton and zoobenthos of Lake Akchakul. *In*: Forum Molod Uchen **3**:660–664. (in Russian)
- Ulyanin VN. 1875. Journey of A.P. Fedchenko to Turkestan, vol. 2. Zoogeographic studies. Crustacea. *Izv Imp Obshch Lyub Estestvozn Antropol Etnogr* **11**:1–63. (in Russian)
- Ustaoglu MR. 2015. An updated zooplankton biodiversity of Turkish inland waters. *J Limnol Freshw Fish Res* **1**:151–159. doi:10.17216/LimnoFish-5000151941.
- Utemuratova FJ, Kim SI, Kamilov BG, Yuldashov MA, Mustafaeva ZA. 2022. Biometrical study of *Artemia* cysts harvested from the Aral Sea in Uzbekistan. *IOP Conf Ser Earth Environ Sci* **1068**:012030. doi:10.1088/1755-1315/1068/1/012030.

- Van Damme K, Dumont H. 2008. Further division of *Alona* Baird, 1843: separation and position of *Coronatella* Dybowski and Grochowski and *Ovalona* gen. n. (Crustacea: Cladocera). *Zootaxa* **1960**:1–44. doi:10.11646/zootaxa.1960.1.1.
- Walseng B, Hessen DO, Halvorsen G, Schartau AK. 2006. Major contribution from littoral crustaceans to zooplankton species richness in lakes. *Limnol Oceanogr* **51**:2600–2606. doi:10.4319/lo.2006.51.6.2600.
- Walsh JR, Lathrop RC, Vander Zanden MJ. 2017. Invasive invertebrate predator, *Bythotrephes longimanus*, reverses trophic cascade in a north-temperate lake. *Limnol Oceanogr* **62**:2498–2509. doi:10.1002/lno.10582.
- Walter A. 1888. Transcaspische Binnencrustaceen. I. Entomostraca. *Zool Jahrb Abteil Syst Ökol Geogr Tiere* **3**:987–1014. (in German)
- WoRMS. 2025. Branchiopoda. Available at: <https://www.marinespecies.org/aphia.php?p=taxdetails&id=1069>. Accessed 03 June 2025.
- Xiang XF, Ji GH, Chen SZ, Yu GL, Xu L et al. 2015. Annotated Checklist of Chinese Cladocera (Crustacea: Branchiopoda). Part I. Haplopoda, Ctenopoda, Onychopoda and Anomopoda (families Daphniidae, Moinidae, Bosminidae, Ilyocryptidae). *Zootaxa* **3904**:1–27. doi:10.11646/zootaxa.3904.1.1.
- Zadereev E, Lipka O, Karimov B, Krylenko M, Elias V et al. 2020. Overview of past, current, and future ecosystem and biodiversity trends of inland saline lakes of Europe and Central Asia. *Inland Water* **10**:438–452. doi:10.1080/20442041.2020.1772034.
- Zuykova EI, Bochkarev NA, Taylor DJ, Kotov AA. 2019. Unexpected endemism in the *Daphnia longispina* complex (Crustacea: Cladocera) in Southern Siberia. *PLoS ONE* **14**:e0221527. doi:10.1371/journal.pone.0221527.

Supplementary materials

Table S1. Database of Branchiopoda records in the samples collected in 2023–2024 by the authors. (download)

Table S2. Local Cladocera faunas of Uzbekistan and some regions of Eurasia. (download)

Table S3. Sorensen-Dice similarity coefficients for local faunas of several Eurasian regions. (download)

Appendix. Annotated checklist of Branchiopoda in Uzbekistan. (download)