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Moina micrura species in Water Bodies of Fergana Valley

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ABSTRACT

Species of the genus *Moina* Baird (Cladocera: Moinidae) are commonly found in temporary freshwater ponds. Some species of moinas are used in aquaculture as valuable protein-rich feed for fish in ecological monitoring of water bodies, and as biological objects in many scientific studies. The aim of this research was to describe the biodiversity of moinas, in particular, species belonging to the genus *Moina* Baird in some water bodies of the Fergana Valley, in particular, the distribution area, growth, development dynamics, and morpho-biological properties of *Moina micrura* Kurz 1874. Our results revealed that the aforementioned species can be found in fish farms and some rice fields in Andijan and Fergana regions of Fergana Valley. The biological and ecological characteristics of the mentioned species and aspects of economic importance were addressed from 2021 to 2023.

INTRODUCTION

Crustaceans (Crustacea; Cladocera) are diverse animals in terms of their external structure, forming the plankton, benthos and neuston in all types of inland waters of the continents on Earth **(Forró *et al.*, 2008; Damme & Kotov, 2016)**. The species of the order Anomopoda Sars, 1865, which are part of them, are not only rich in species **(Błędzki & Leszek, 2016)** but also have great economic importance in some aspects and arouse great interest in science. The order Anomopoda Sars, 1865 (*Moina* Baird, 1850) has a large number of species **(Baird, 1850; Bekker, 2016)**. Moins form the basis of freshwater microscopic animals living in temporary water bodies **(Goulden, 1968; Smirnov, 1976)**. Sexual demorphism is observed, which is clearly expressed in specific morphological characters, size, and structure. The carapace of parthenogenetic females with a wide body forms a pointed corner at the back. Antennae I of both males and females are developed and mobile, with males possessing 3 to 6 aristae at the tip. Antennae II are covered with large, dark setae. The faceted eyes of the male are large and occupy the entire front of the head. There are typically 5 pereiopods. The ephippius contains 1- 2 wintering eggs **(Smirnov, 1976; Korovchinsky *et al.*, 2021)**. Some representatives of zooplankton are used in industrial aquaculture as feed for fish spawns

due to their rapid reproduction **(Goulden, 1968; Abdinazarov & Madumarov, 2022; Dumont & Negrea, 2002)**. In addition, in ecological monitoring of water bodies, they play the role of standard test objects **(Wong *et al.*, 1995; Smirnov, 2014)**. In particular, the ways of using these organisms as bioindicators in the ecological monitoring of Fergana Valley water bodies have been researched **(Abdinazarov, 2018)**.

Despite that the genus Moina has been comprehensively studied systematically **(Goulden, 1968; Smirnov, 1976)**, there are still uncertainties in its taxonomy. Moina populations are morphologically highly variable, and the taxonomy of the genus is still incomplete **(Petrusek *et al.*, 2004; Chatterjee *et al.*, 2013)**. However, early molecular studies have begun to shed light on the systematics of the moinas **(Petrusek *et al.*, 2004)**. It turned out that the populations of *Moina micrura* collected from Europe and Australia belong to different species, while the populations of *Moina macrocopa* found in the Czech Republic and Uganda were assumed to belong to the same species **(Petrusek *et al.*, 2004; Eugeniya, 2016)**. A number of scientists have carried out DNA barcoding studies of moina genera **(Elías-Gutiérrez *et al.*, 2008; Nicholas *et al.*, 2011; Sean *et al.*, 2013)**. For the first time, the identification of the mitochondrial genome of *Moina macrocopa* (Straus, 1820), a representative of the Moinidae family, forms a great importance in the future phylogenetic research of moinas **(Sang-Eun Nam *et al.*, 2022)**.

The Moinidae family includes more than 25 species according to some data **(Forró *et al.*, 2008; Eugeniya *et al.*, 2016)**, and even 36 species in current electronic resources, such as the taxonomic browser BOLD systems. The ICZN list of nominal taxa of the species group includes 78 formal names in the genus *Moina* **(International Commission on Zoological Nomenclature, 2000)**. Such discrepancies indicate that there are still unresolved obstacles in the taxonomic assessment of this family.

The study of *Cladocera* species in the water bodies of Central Asia, in particular, Uzbekistan, has its own history. In the second half of the 20th century, academician A.M.Mukhammadiev's research has dramatically improved the science of hydrobiology in Uzbekistan. According to A.M.Mukhammadiev, it was known that, 5 families, 24 genera and 65 species of *Cladocera* can be found in the Fergana valley alone **(Mukhamediev, 1981; Mukhamediev, 1986)**.

Countless species of *Cladocera* belonging to the genus *Moina* Baird, 1850 have been identified in the water bodies of Uzbekistan. *Moina micrura* was represented in the works of A.M.Mukhammadiev (1964), and *Moina dubia* species were described in the works of S.V.Krinev (1992) **(Muhamediev, 1981; Muhamediev, 1986)**. At the end of the last century, the researches of I.M.Mirabdullaev further expanded our knowledge about the generation of moinas. They described the species *Moina weismani*, *Moina gouldeni*, *Moina mukhamedievi* **(Mirabdullaev, 1992; Mirabdullaev, 1993; Mirabdullaev, 1998)**. According to Urazova, there are 8 species of moinas in the fauna of Uzbekistan: *Moina macrocopa* (Straus), *M. rectirostris* Leydig, *M. micrura* Kurz, *M. weberi* Richard, *M. microphthalma* Sars, *M. mongolica* Daday **(Urozova & Mirabdullaev, 2006)**. Later it became known that *Moina weberi* is considered a synonym of *Moina micrura*. *M. rectirostris* is usually referred to as *Moina micrura* or *M. brachiata* **(Goulden, 1968; Smirnov, 1976; Urozova & Mirabdullaev, 2006)**, *Moina mongolica* and *M. microphthalma* can be considered synonyms of *Moina salina* Daday, 1888 **(Negrea, 1984)**.

The researches described that species of the genus *Moina* Baird 1850, such as *Moina brachiata, M. micrura, M. macrocopa,* and *M. weismani* are found in the reservoirs of the Fergana Valley **(Abdinazarov *et al.*, 2019)**.

MATERIALS AND METHODS

The Ferghana Valley is rich in water bodies, which have different ecological conditions. Our research aimed at studying the morphology, changes in numbers during the season, reproduction dynamics of the species *Moina micrura* Cruz 1874, which belongs to *Moina* Baird, 1850 in the fisheries located in the Fergana Valley.

Specimens were taken from the open, middle and littoral zones of the water bodies using a Djedai net, which filters zooplankton organisms from 50- 100 liters of water. The distribution of moidas in the water body mainly depends on the water temperature, illumination level, the amount of oxygen, carbon dioxide and other substances in the water. In addition, the development of benthic algae in the water environment has a great impact on the quantity of moinas.

Zooplankton specimens were taken from the fisheries of Kolgandarya in Fergana and Andijan regions (Table 1).

Table 1. Features of the studied area and water

№	Area	Width		Water		Number of specimens
		N`	E`	Depth, meter	pH	
1.	A	40°32`10	70°30`59	1.1	7.6	45
2.	A	40°32`16	70°30`88	1.3	7.6	23
3.	A	40°32`24	70°31`04	1.1	7.6	45
4.	A	40°32`30	70°31`30	1.3	7.5	30
5.	A	40°32`64	70°31`62	1.0	7.6	28
6.	A	40°32`78	70°32`20	1.3	7.6	24
7.	A	40°33`04	70°32`40	1.2	7.4	36
8.	A	40°32`24	70°32`89	0.9	7.6	46
9.	A	40°32`33	70°33`10	0.8	7.6	34
10.	B	40°46`34	71°35`59	1.3	7.3	40
11.	B	40°46`36	71°36`04	1.4	7.2	43
12.	B	40°46`36	71°36`00	1.4	7.4	39
13.	B	40°46`38	71°35`56	1.6	7.5	40
14.	B	40°46`37	71°35`54	1.5	7.3	40
15.	B	40°46`43	71°36`07	1.6	7.4	46
16.	B	40°46`42	71°36`19	1.3	7.6	48
17.	B	40°46`50	71°36`04	1.2	7.5	35
18.	B	40°46`51	71°35`09	1.3	7.4	47
19.	B	40°46`59	71°35`59	1.2	7.5	41

RESULTS AND DISCUSSION

In recent years, sudden changes in limnic ecosystems in Uzbekistan, particularly in the Fergana Valley, have been reflected in the regime of water bodies and hydrobionts living in it. As a result of the water shortage in the valley, multitudinous water bodies have shifted to a different source of nutrition. Previously, the system of lakes around the Syrdarya was formed due to the flow of fresh water from the river. Changes in the species composition of these water bodies, which have significantly lost their self-cleaning properties due to the change of the hydrological regime and excessive introduction of biogenic elements, were observed.

Studies have shown that the species *Moina micrura* Cruz 1874, belonging to the genus *Moina* Baird (Cladocera: Moinidae), occurs in almost all the studied water bodies. It first appeared from May of the studied year and was observed until October. The highest numbers and biomass occurred in the May- June and September- October months of the season.

In the Fergana Valley, researches on the diversity of species in *Moina* Baird (Cladocera: Moinidae), their morpho-biological characteristics, distribution areas of their population, seasonal reproduction dynamics have not been conducted for a long time. Studying the current situation of the moinas in the valley, which are of great practical importance due to their rapid increase, is not only practical but also expands our fundamental knowledge about them.

As a result of the conducted research, it was found that, *Moina micrura* can be found in the lakes of Sarikamish, Kolgandaryo, in the rice fields of Buvayda district, and in the fisheries in Andijan and Namangan regions (Fig. 1).

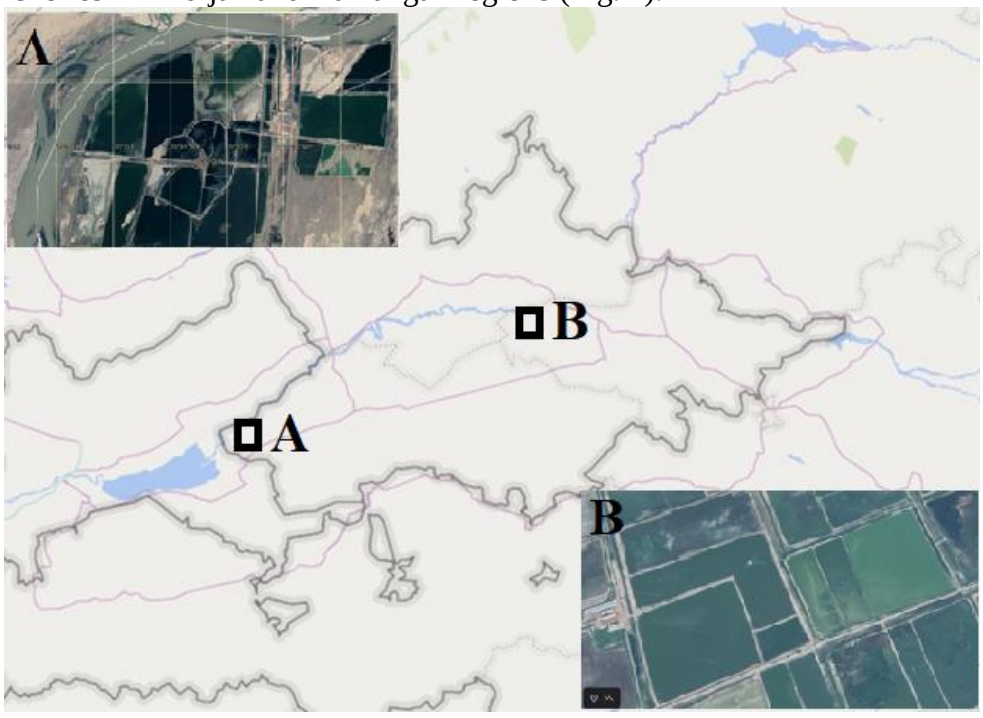

Fig. 1. Map of the Fergana Valley, the studied areas are in the black rectangle, as well as the fisheries A-Beshariq district, B-Ulughnor district (original copies of the maps were obtained through Google Earth (https://earth.google.com/web/search) and processed by Paint program

There is no border on the head and carapace. The head of females has a depression above the eyes typical to the younger generation: the tip of the shell has 12-18 large setae: the setae at the ventro- posterior end are united in groups of 6- 8 and scattered. There are 6- 7 denticles of mandibular apparatus on the postabdomen. The posterior setae at the lateral tip are divided into two groups: the basal group has 15- 20 setae, which do not differ in size from the setae of the proximal group. The postabdomen part consists of 7- 9 ventral setae. Prothorax has a pair of joined legs called maxillipeds; they are used for swimming and feeding. The maxillipeds are covered with small setae that help the animal to move through the water (Fig. 2). The last thoracic joint, known as the telson, is shorter than the other two thoracic joints. The setae of the back end of the notch are grouped. The antennae is without a seta or has a weakly expressed setae. The setae of the ventral end of the slit are 15- 25. The length of the antennules is less than 5 times the width. The ephippium consists of 1- 3 ovules. The scape, which is the first segment of the three-segmented antennae is 1.2- 1.3 times longer than the second (Fig. 2).

Comparison of postabdominal claw morphology, which serves as an important diagnostic structures warrants future revision of all previously described species of the genus Moina **(Semenova & Tchougounov, 2018)**. In addition, the suggestion that a definitive taxonomic analysis should be based on the characters of males and ephippial characters of females is noteworthy **(Korovchinsky *et al.*, 2021)**. The systematics of Moina are often subject to ambiguities. Of the 78 formal names that can be assigned to this genus according to the ICZN definition, 11 belong to the *micrura* group **(International Commission on Zoological Nomenclature 2000)**. In addition to the morphological characters used, it is also necessary to take into account the size of the setea on the abdominal claws and the location of the lateral setea on antenna I (Fig. 2).

Table 2. Analysis of the species *Moina micrura* in fisheries

Name of the studied area	**Time of the first encounter**	**Total length, mm**	**Ratio in the species composition, %**	**Encounter during the year**							
				April	**May**	**June**	**July**	**August**	**September**	**October**	**November**
Lake Sarikamil (Fergana)	20-30 May	3-4	16,5	+	+	+	+	-	+	+	-
Fishery “Kolgandarya” (Fergana)	15-25 May	3-4	18,3	+	+	+	+	-	+	+	-
Fishery “Ulugnar” (Andijan)	25-30 April	2-3	8,9	-	+	+	-	-	+	+	-
Fishery “Mingbulak” (Namangan)	15-25 April	2-3	7,4	-	+	+	+	-	+	+	-

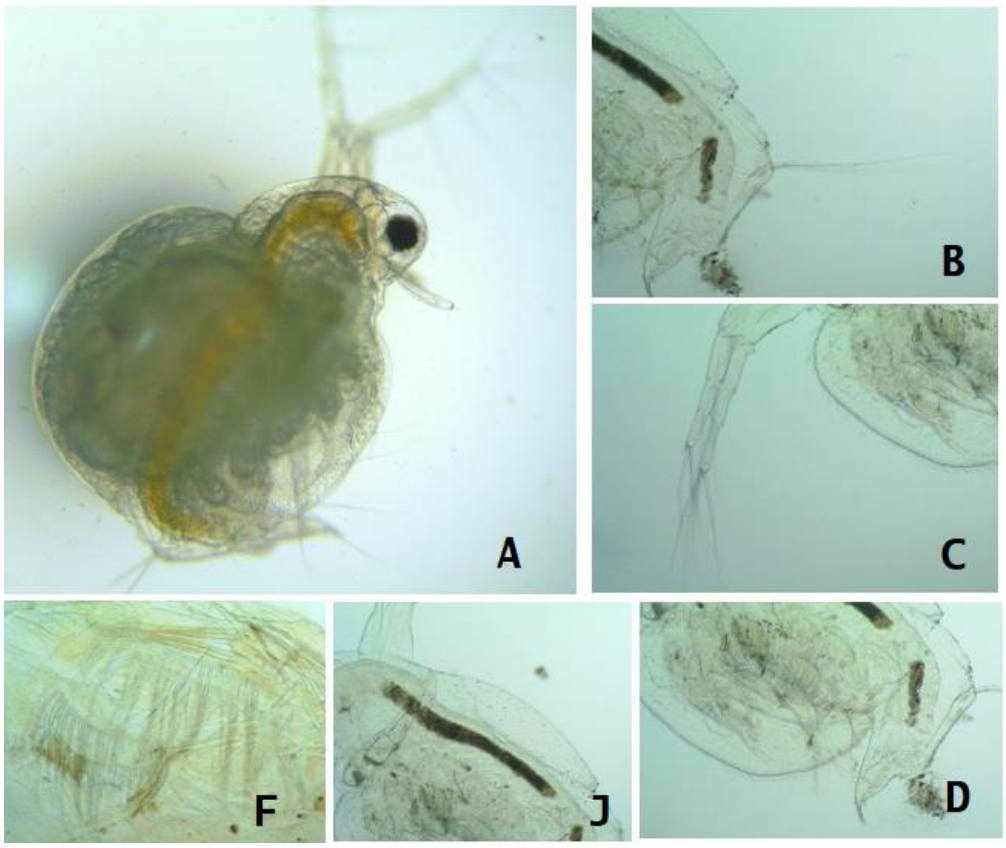

Fig. 2. (A) General, **(B)** Postabdomen, **(S)** Antennae, **(D)** Dorsal, **(J)** Ventral, **(F)** Thoracic organs of *Moina micrura* Kurz under a microscope (picture taken by M. Madumarov)

In the course of our research, *Moina micrura* was detected in April 2023 in Lakes Sarikamish and Kolgandarya, and in May in the fisheries of Andijan and Namangan regions.

Females holding parthenogenetic eggs with a length of 1- 2mm were found in the obtained specimens. The share of the species in the composition of zooplankton is about 15%. *Moina micrura* became the dominant species in Sarikamish and Kolgandarya, and in the sampled collection, it made up 7.4 to 16.5% of the total amount of zooplankton. *Moina micrura* prefers stagnant lakes rather than temporary bodies of water. Hence, it was found that there is a little less biomass in rice fields and fisheries, and more biomass in Lake Sarikamish.

During the season, changes in the annual dynamics of the number and biomass of *Moina micrura* were observed in the studied water bodies. The data obtained indicate that the increase in the proportion of *Moina micrura* in the zooplankton community coincided with a water temperature of around 25°C. The reason for this can be explained in connection with the increase of the feeding algae of *Moina micrura* during this period and the decrease of cyanobacteria.

Although the fecundity of *Moina micrura* is low (lays 4- 6 eggs, up to 20 in other species), the egg-laying period is very short and less than 1 day is enough for its development. This allows the population to quickly increase its density under optimal

conditions. We consider this phenomenon to be of an economic importance and one of the main factors in the formation of a natural feed source for fish by breeding this species in fish farms.

According to information from **Gulden (1968)**, **Wilhelm Kurtz (1875)** and **Smirnov (1976)**, who later made a complete revision of the genus, the representatives identified in Sarikamish, Kolgandarya reservoirs of the Fergana Valley, rice fields of Buvayda district, and fisheries of Andijan and Namangan fully corresponds to the description of *Moina micrura*.

The reaction of *Moina micrura* to salinity appears to vary significantly, with different data reported in various literatures **(Alam *et al.*, 1993; Jones *et al.*, 2016)**. However, these data can be explained by the genetic diversity of morphologically distinct cryptic species **(Nédli *et al.*, 2014)**.

Moina weberi is probably recognized as a synonym of *Moina micrura* **(Goulden, 1968)**.

CONCLUSION

Since molecular-phylogenetic studies on *Moina micrura* have not been conducted in the territory of Uzbekistan, including in the Fergana Valley, thus it is necessary to clarify the species *Moina micrura* distributed in our region. Looking at the map in the BOLD systems taxonomic browser, it is observed that not a single specimen belonging to the genus *Moina* from Central Asia is presented. This shows that it is necessary to conduct extensive molecular research on representatives of this generation in Uzbekistan.

In general, studies have shown that *Moina micrura* prefers warm, permanent bodies of water. A decrease in the quantity of this species was observed in water bodies with a slightly higher salinity index. Salinity was considered an important ecological factor for moinas.

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