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SPECIES STRUCTURE AND SPATIAL DISTRIBUTION OF FISH IN THE MARMARIK RIVER

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The Marmarik River is the largest tributary of the Hrazdan River. However, it is heavily isolated from the main course of the river by the Aghbyurak dam. Considering low density of population and lack of pollution sources in the basin, the Marmarik River valley is a well-known biodiversity area within Armenia. As in many small tributaries, there is a limited knowledge about the ichthyofauna and its spatial distribution in the drainage basin. Thus, the aim of the study was to reveal the species structure and spatial distribution of fish in the Marmarik River. The results show five species of fish permanently dwelling the river where the most abundant one is the Kura chub and the rarest species is Khramicarp. Limited distribution was revealed also for Brown trout and Berg loach.

Hrazdan River – hydrobiological monitoring – ichthyofauna – abundance – diversity

Մարմարիկը Հրազդան գետի ամենախոշոր վտակն է: Այնուամենայնիվ, այն մեծապես մեկուսացված է Հրազդան գետից Աղբյուրակի ջրամբարով: Հաշվի առնելով Մարմարիկի ավազանում սակավաբնակությունը և աղտոտման աղբյուրների սակավությունը՝ գետավա-զանը հայտնի է որպես ՀՀ կենսաբազմազանության թեժ կետերից մեկը: Ինչպես այլ փոքր վտակ-ների պարագայում, Մարմարիկի ձկնաշխարհի կազմի և տեսակների տարածական բաշխման առանձնահատկությունների վերաբերյալ գիտելիքները սահմանափակ են: Այսպիսով, աշխատանքի նպատակն է բացահայտել Մարմարիկ գետի ավազանում ձկների տեսակային կազմը և դրա տարա-ծական բաշխման առանձնահատկությունները: Հետազոտությունների արդյունքում բացահայտվել են ձկան հինգ տեսակներ, որոնք մշտապես բնակեցնում են գետի տարբեր հատվածները: Դրանցից ամենատարածվածը արևելյան տառեխիկն է, իսկ ամենահազվադեպը՝ կարմրախայտը: Կուրի կողակը և Բերգի լերկածուկը ևս ունեցել են սահմանափակ տարածվածություն:

Հրազդան գետ – ջրակենսաբանական մշտադիտարկում – ձկնաշխարհ – առատություն – բազմազանություն

Река Мармарик – крупнейший приток реки Раздан. Однако, Мармарик изолирован от реки Раздан Агбюракской дамбой. Учитывая малонаселенность и отсутствие крупных очагов загрязнения в бассейне, долина реки Мармарик считается одним из очагов биораз-нообразия в Армении. Как и для остальных малых рек Армении, в бассейне реки Мармарик

также существуют пробелы в знании видового состава и его территориального распределения. Таким образом, целью исследования являлось выявление видового состава и распределения рыб в бассейне реки Мармарик. Результаты исследований выявили пять видов рыб, постоянно обитающих в реке. Самым распространенным видом из них была Восточная быстрянка, а самым редким – Куринская храмуля. Ограниченное распространение имели также ручьевая форель и голец Берга.

Река Раздан – гидробиологический мониторинг – ихтиофауна – обилие – разнообразие

The role of small mountain tributaries in maintaining aquatic biodiversity is huge [10] considering low density of population and lack of economic pressures in their drainage basins [9]. Thus, they serve as refuge for many hydrobionts [6, 13]. From the ichthyological perspective they also provide with spawning ground as well as lurking for smolt and fry fish. In some cases, they provide with essential migration and invasion corridors too. However, in small tributaries the ecosystems' self-sustaining and self-regulating potential is weak, thus they transforming rapidly under the pressure. Thus, fish species living in small tributaries also very sensitive towards anthropogenic pressures and natural phenomena. Considering lack of regular ichthyological studies in small mountain tributaries of Armenia, the aim of the current work is to investigate the species structure and pattern of spatial distribution of fish in the Marmarik River drainage basin as a base for the establishment of a proper hydrobiological monitoring there.

In general, hydrobiological monitoring system in Armenia has been launched after the adoption of the decree N° 927-N from 11.06.2011 and the establishment of six River Basin Management Areas (RBMAs) in Armenia. The established system is highly inspired by the principles of EU Water Framework Directive [7], thus tends to adopt the use of the following four Biological Quality elements (BQEs) – benthic macroinvertebrates, fish, macrophytes and phytobenthos in hydrobiological monitoring activities. However, there is no attempts to use fish in such works yet which mainly comes from the knowledge gaps in local typology of rivers, reference hydrobiological conditions in each river type [3] along with specific studies of fish species and their spatial distribution in the reference areas. Thus, this work tends to fill these gaps for the Hrazdan RBMA and particularly Marmarik subbasin which is highly isolated from the remaining watercourse of the Hrazdan River by the system of dams.

Also, the results of study have a potential to support the estimation of aquatic ecosystem services in the subbasin as fish is an important component in the overall circulation of energy and matter as well as in provision of food and recreation activities.

Materials and methods. *Study area and sampling sites*. The Marmarik River is the largest tributary of the Hrazdan River and entirely flows in the territory of Kotayq marz (region). The length of the river is 37 km and the drainage basin area is 427km^2 . The river head locates in Tsaghkunyats mountain chain at an altitude of about 2500 m above sea level. The Marmarik River feeds on meltwater (55%), rain (18%) and ground waters (27%) [12]. Only about 7000 people live in the drainage basin and most of them at the lower course part [15]. Waters of the Marmarik River are mainly used for irrigation, hydro energy, municipal and sanitary services as well as industrial purposes. It completely isolated from the Hrazdan River by the Aghbyurak Dam.

One of the most dangerous natural phenomenon for hydrobionts is mudflow that been registered regularly for the small tributaries of the Marmarik River [5]. Thus, we studied only some small tributaries where mudflow risk is missing. Considering high mobility of fish and only

slight changes in the long-term hydro-chemical data along the river course [11], the sampling sites network has consisted only from five stations distributed along all the course of the river (fig. 1). However, when selecting sampling sites, we take into consideration the location of Marmarik dam which is the only serious impediment for fish migration in the basin. Thus, study involves also Erkarget and Gomurget tributaries.

Material collection and processing. Studies were conducted in May and July of 2021. Fish were caught by electrofishing gear SUM following the requirements for salmonid and cyprinid fish species [8]. 20 replicates of pulse were conducted along about 100m of a stream and following zigzag pattern to cover all major biotopes. Caught fish was separated and placed in different aerated buckets alive. Species was identified using the Key [17] where necessary. After identification of species all fish was released back into the river. All the names of fish in English were brought from the manuscript of Pipoyan et al. (2018) [18].

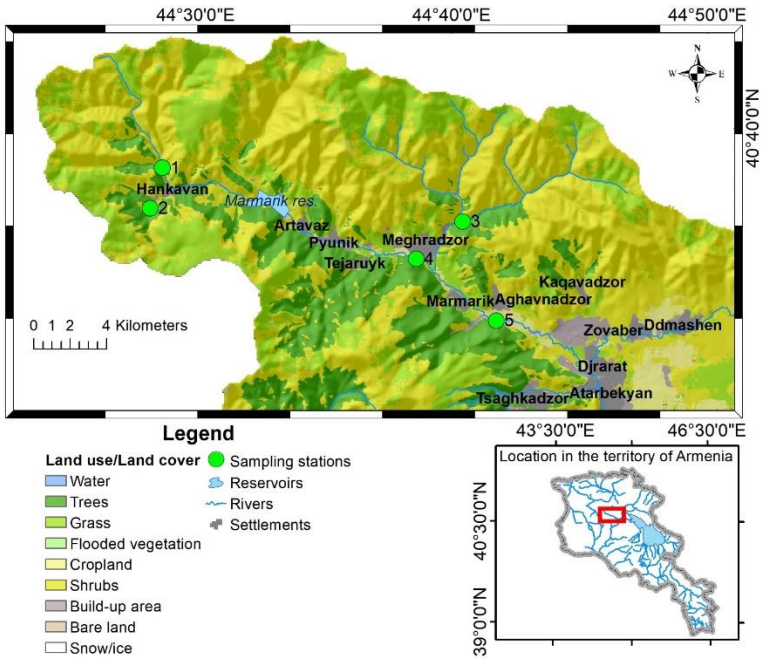

Fig. 1. Study area and sampling sites

Along with the fish sampling some supporting hydro-morphological and hydro-physical parameters were measured *in situ*. A substratum of the sampling reach was studied empirically using the classification of the AQEM system [2]. Then, for the higher accuracy, we carried out random measurement of the 50 samples' maximum diameter by the ruler [4]. Velocity measurements were carried out using a floating object by three replications: one in the central part and two at banks. Then, the average velocity was calculated. Channel width was measured directly by the ruler and average depth was measured by calculating the mean of all measurements along five transects made at each 0.5 m by the meter-stick.

Calculation of metrics. Abundance of each taxa was calculated for every sampling site. To map species distribution in different sites according to their abundance, we used the classification of Tereschenko and Nadirov (1996) [16]: rare species (< 0,1 %), small share species (0,1-1,0 %), common species (1,1-5,0 %), subdominant species (5,1-10,0 %), dominant species (> 10 %), super dominant species (> 50 %).

Diversity metric was measured by the Shannon index [14] (1).

$$H = -\sum_{j=1}^{N} pi \log_2 pi \quad (1)$$

where pi is the proportion of i^{th} species by the number and N is the total number of species in the catch

The dominance metric of species was estimated through Ferster's index [1] (2)

$$R = -\left(\sum_{j=1}^{N} pi \log_2 pi\right) / \log_2 N \quad (2)$$

where pi is the proportion of i^{th} species by the number and N is the total number of species in the catch.

Results and Discussion. In total, five species of fish from three families were recorded from the Marmarik River and its tributaries within our study.

Salmonidae

Brown trout - *Salmo trutta fario* Linnaeus 1758

Cyprinidae

Kura chub - *Alburnoides eichwaldii* De Filippi 1863

Kura barbel - *Barbus cyri* De Filippi 1865

Khramicarp - *Capoeta capoeta* Güldenstädt 1773

Nemachelidae

Berg loach - *Oxynoemacheilus bergianus* Derjavin 1934

The results of diversity assessment (table 1) show that ichthyofauna at different parts of Marmarik River is rather poor. The highest diversity (H=1,5) was measured in the lower course part of the river. Although there was no a single specimen of brown trout caught in the lower course part, we cannot neglect its presence here during autumn season. The same is true for the other parts of the river too. However, as study proved, brown trout is more typical for the upper course parts of the Marmarik River and only a small and isolated population could exist downstream from the Marmarik reservoir as long as the small tributaries maintain its reproduction. During our study no specimen of brown trout was recorded anywhere in the lower and the middle course parts.

Table 1. The results of metric calculation for fish in the Marmarik River

Sampling station	Name	Season	Number of species, N	Diversity, H	Dominance, R
1	Erkarget tributary	Spring	2	0,2	0,8
		Summer	3	0,5	0,7
2	Marmarik upper course part	Spring	2	1,0	0,0
		Summer	2	1,1	2,1
3	Gomur tributary	Spring	2	1,1	2,1
		Summer	2	0,5	0,5
4	Marmarik middle course part	Spring	1	0,0	1,0
		Summer	3	0,7	0,6
5	Marmarik lower course part	Spring	4	1,5	0,3
		Summer	4	1,5	0,3

The lowest diversity was observed in the middle course part in spring (H=0). Considering that here in summer we caught three species which are not migrating for long distances throughout the year it can be just assumed that during high water period the effectiveness of the sampling method was quite low. Thus, for the hydrobiological monitoring purposes either method should be revised or high water season should be avoided.

Like the Brown trout, Khramicarp has also had a very narrow geographical distribution in the basin. It feeds with periphyton and spawn in sandy substratum. Thus, based on the results of hydro-morphological studies (Table 2) we find that while both the lower and the middle course parts of the Marmarik River provide with enough conditions for Khramicarp to feed, the spawning ground is limited to the lower course part strictly. Another factor influencing the distribution of this species in the middle and lower course parts is the hydropeaking due to release of water from Marmarik reservoir. Probably, Khramicarp has preferring to stay all the year at the limited refuge where we caught him.

Table 2. Supporting hydro-physical and hydro-morphological parameters

Sampling station	Average width (m)	Depth (m)	Velocity (m/sec)	Temperature (°C)	Substratum
1	10/9	0.3/0.3	0.8/0.7	11/20	Mesolithal (60%), macrolithal (20%), megalithal (20%)
2	2/2	0.2/0.1	0.4/0.4	12/19	Mesolithal (50%), macrolithal (30%), megalithal (20%)
3	5/3	0.4/0.2	0.8/0.4	11/20	Megalithal (50%), macrolithal (30%), mesolithal (10%), sand (10%)
4	9/8	0.5/0.3	1.2/0.7	12/19	Mesolithal (50%), macrolithal (20%), microlithal (20%), sand (10%)
5	12/11	0.7/0.5	1.2/0.8	12/20	Mesolithal (60%), macrolithal (30%), sand and mud (10%)

The distribution of Berg loach in the basin was constricted to the main course of the river and it was recorded strictly from the lower and the middle course parts. By the same pattern as Kura barbell, Berg loach abundance decreasing towards upstream parts. Although a little known about the ecology of this species yet, it's obvious that any impediment will definitely constrain further migration of this fish. Thus, it can't be expected to find this species in wider geographical area in the drainage basin and particularly in the Gomur tributary upstream from Meghradzor village.

Kura barbel have been recorded everywhere aside the station 2 in the upper course part. However, as there are no specific impediments for the survival of Kura barbel in this part, we assume that it should be encountered there too.

Kura chub have the highest tolerance towards environmental conditions among all recorded species and it's not surprising that it colonized almost all the parts of the river. Moreover, it definitely spawns in Gomur tributary and like Kura Barbel also in the lower course part as both mature and fry specimens were caught there simultaneously.

The assessment of species abundance (fig. 2) shows that in general, Kura chub was super dominant species not only in the lower and in the middle course parts, but also

in the Erkarget tributary. At the same time, in both remaining stations it was dominant species which speak about lack of predator fish like brown trout in the basin.

In the Gomur tributary Kura barbel was superdominant, in the lower and the middle course parts – dominant while in the upper course part – common or subdominant species depending on the season.

Berg loach was dominant species in the lower course part while in the middle course part it was a common species.

Brown trout was strictly encountered in the headwaters and according to classification was dominant in the upper course part of the Marmarik River and common species in the Erkarget tributary.

However, considering low range of hydro-physical and hydro-morphological parameters among the stations, we assume that the only serious constrain for the wider distribution of species found is the Marmarik dam. Local impediments in the small tributaries like little falls or channels beneath roads could constrain mostly the movement of Berg loach which ecology is poorly studied yet.

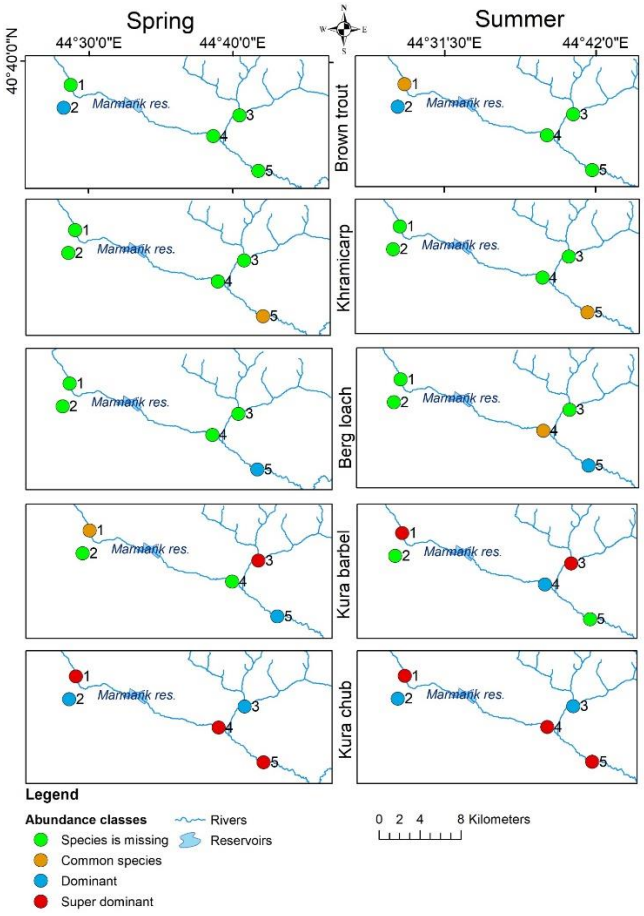

Fig. 2. Species abundance in spring and summer seasons

Five species of fish are permanently inhabiting the Marmarik River and Kura chub is the most widely distributed species there while Khramicarp and Brown trout were encountered only in some isolated areas. Although hydro-physical and hydro-morphological parameters vary slightly among the stations, the presence of Marmarik dam is constraining wider distribution of some species in the basin strongly. It's been also concluded that monitoring in the basin is quite ineffective during the high water period and thus the only knowledge gap recently for setting the appropriate monitoring season is the distribution patterns of species in the basin during autumn season.

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