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A Foundational Study of the Dehram River's Aquatic Ecosystem: Bridging Fresh and Brackish Water

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

In this study, we explore Dehram river system, focusing on its biological characteristics, in a hot arid region. This is a freshwater stream flowing over salt formations. We examined various ecological aspects of the river, including its benthic macroinvertebrates, zooplankton, fishes, as well as some physical and chemical factors in three selected stations. The river showed variations in physical and chemical properties, with salinity and conductivity levels being the most significant. Salinity, total dissolved solids, calcium ion concentration, and nitrate levels increased downstream in the study area. Our findings revealed 13 macroinvertebrate orders present in the river, including a new record for Fars Province - the hydrobiid gastropod *Ecrobia grimmi*. The discovery of the four fish species in the river marked a new addition to their known geographical distribution. Certain invertebrate families were unique to station 1 and/or 2, while families Dyticidae and Simuliidae were exclusive to station 3. Other families were found in all three stations. Fish groups in the river included four identified cyprinid species, revealing new distribution ranges for them. *Capoeta barroisi*, known for tolerating specific environmental conditions, was found to adapt to the higher

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temperature, EC, and pH ranges in the river, setting new ecological records. The river exhibited unique ecological conditions such as high temperature and extranormal conductivity levels, which may have led to specific adaptations in its biota. We recommend further detailed investigations to determine whether these are new species or highly adapted populations isolated geographically and physiologically.

Keywords: benthos; fish; Iran; Ecrobia grimmi; zooplankton.

1. INTRODUCTION

Aquatic ecosystems are subject to various disturbing agents that can impact their structure and function. These disturbances include thermal pollution, habitat destruction, dam construction, human-mediated dispersal of alien species, climate, and land-use changes [1,2]. Over the last few decades, freshwater ecosystems, known for their rich diversity of habitats have faced increasing threats and stressors [3]. River ecosystems, especially in developing countries, may be particularly vulnerable due to a lack of adequate data. Therefore, understanding the characteristic features of species is essential for predicting community responses to these stressors and to identifying the sensitive components of the community.

While most major rivers, wetlands, and lakes worldwide have been extensively studied, smaller streams, springs, and groundwater systems have mostly been neglected in many regions including Iran, with a few exemptions. Iran consists largely of arid or semi-arid zone**s** [4] and it is home to numerous small rivers with unique ecological conditions. Previous research has primarily focused on larger rivers, such as on the macroinvertebrates and water quality in Haraz [5], Tajan [6], and Sefid Rud rivers [7] in northern Iran, Zayandeh Rud river in Isfahan, central Iran [8], and the Karun river, Khuzestan [9], and Hajiabad river, Hormozgan [10] in south. Some studies have also examined zooplankton in the Karun [11] and Haraz river [12].

In Fars Province, Aazami et al. (2019) conducted an assessment of water quality in the Kor river in the north and west of the province [13]. Another recent study focused on the macroinvertebrate community of the upper Ghare-Aghaj river**,** where Shahradnia et al. (2020) recorded 20 families of macroinvertebrates [14]. Their findings showed a decrease in the number of recorded families from the middle to the lower parts of the river near the Persian Gulf. Additionally, Abbaspour et al. (2019) reported four gastropod mollusk species (*Physa acuta*, *Planorbis intermixtus*, *Radix persica*, and *Galba truncatula*) and a bivalve species *Pisidium casertanum* from Jubkhalle River, located in the catchment of the Kor river [15]. Another study investigated the macrobenthos of Behesht-e Gomshodeh river in a nearby region, revealing 25 families with the order Ephemeroptera displaying the highest diversity [16]. However**,** apart from these few works, limited research has been conducted on smaller aquatic ecosystems in Iran.

The Dehram river represents an exceptional riverine ecosystem that starts as fresh water but transitions to highly saline water. The rapid change in chemical and physical properties along the river's course could potentially influence its biological community. Understanding the responses of the living community to the dramatic changes from fresh to brackish water in the Dehram river will provide valuable insights for predicting how biodiversity may respond to future challenges such as human intervention, global warming, and drought. This paper presents the first comprehensive report on the physical, chemical, and biological properties of the Dehram river aiming to characterize its unique aquatic environment.

2. MATERIALS AND METHODS

2.1 Site Description

2.1.1 Statistical analyses

The Dahram River, a tributary of the Ghare-Aghaj River, is one of the longest rivers in southern Iran stretching approximately 125 km [17] (Fig. 1). The Ghare-Aghaj River originates from the Anar, Arjan, and Khanic Mountains in the northern parts and eventually flows into the Persian Gulf after a course of 765 km. While the main body of the river has been experiencing severe drought over the past decade, many of its tributaries remain active, particularly during the wet seasons.

The Dehram River undergoes a transition from fresh water to saline water as it passes over salt and gypsum formations and saline soils, starting from the south of the historical city of Firuzabad [18]. The Dehram River undergoes a transition from fresh water to saline water as it passes over salt and gypsum formations and saline soils, starting from the south of the historical city of Firuzabad [18]. The river is then referred to as Dehram from this section onwards. It eventually reaches the Farrashband County, where it merges with the Mond River in the Dezhgah plain. The maximum recorded temperature and precipitation in the district are 39°C and 164 mm [19].

The Dehram River is characterized by its shallow depth, mostly below 20 cm, with occasional depressions reaching approximately 100 cm deep. It flows through plains surrounded by the Zagros Mountains, resulting in a relatively flat area with a low gradient. The river widens in some areas and narrows in others, with a rocky riverbed consisting of varying sizes of gravel. In certain meander corners the riverbed is covered with eroded sediments of fine sands or mud. Aquatic plant aggregations are scattered along the riverbanks, and dense masses of the blanket weed are observed in some locations.

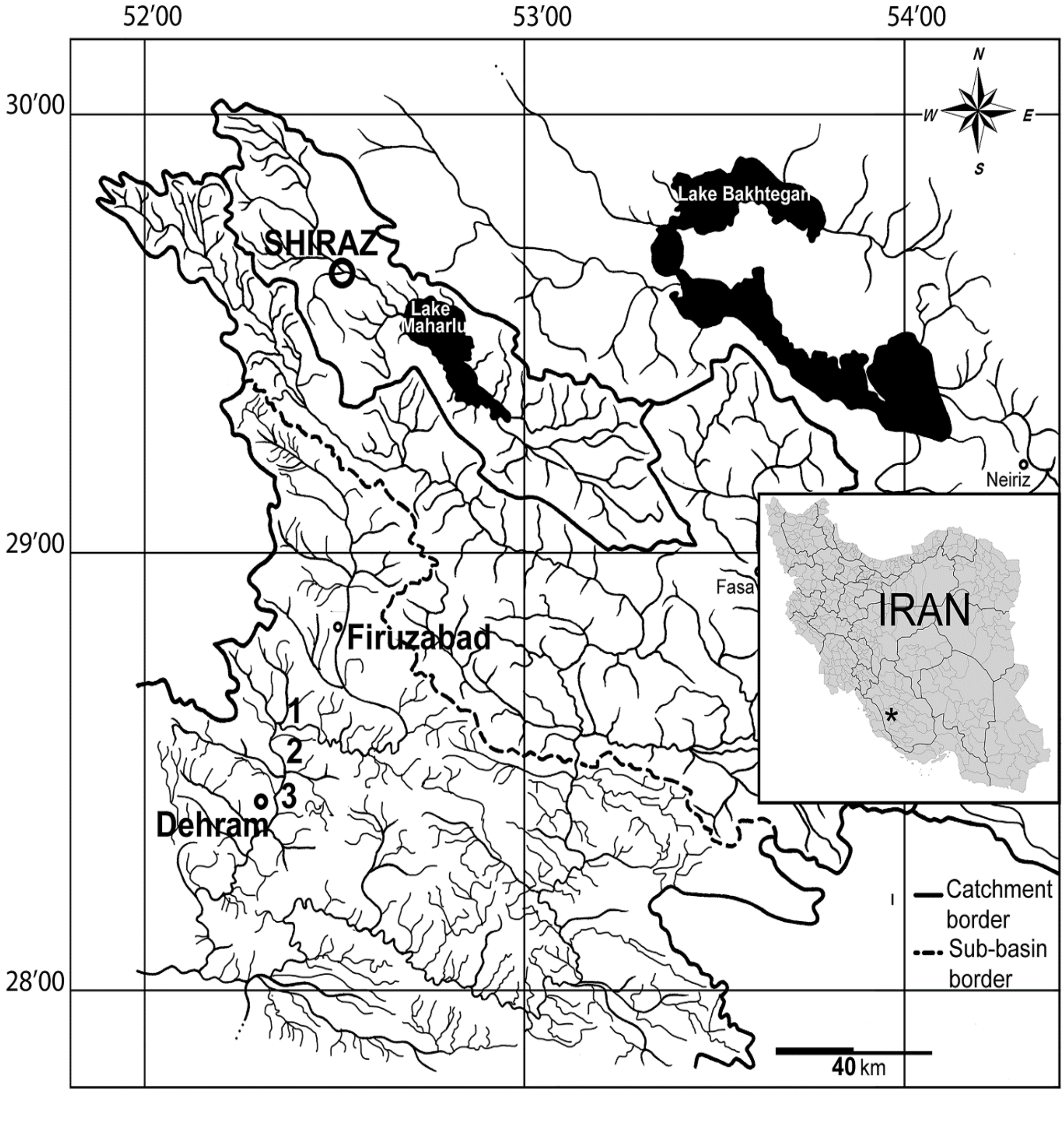

Fig. 1. Map of the Ghare Aghaj river catchment with the Dehram river in its southern sub-basin. Numbers indicate sampling stations

2.2 Sample Collection and Preparation

Three sampling stations (Figs. 1,2) were selected based on their geographical availability along the river's course (28°54'N52°36 'E; 28°45'N52°33'E; and 28°52'N52°34'E). Water sampling was conducted during three periods in 2012–2013 (September, March, and June) specifically on the 14th to 16th of each month. Various abiotic factors, including salinity, electrical conductivity, pH (measured using Hanna-HI 1281), temperature, and dissolved oxygen (measured using Hach HQ40d Multimeter) were measured at three locations: the corner, midpoint, and an intermediate point between them in each station. Additionally, current velocity, discharge, average depth, and river width were recorded. Three water samples were collected across the river width at the aforementioned points. The samples were stored in a cool box and transported to the laboratory within 2 – 6 hours. In the laboratory, total dissolved solids (TDS), [Ca^{2+}], [Mg^{2+}], total suspended solids (TSS), and onions and cations including [$PO43^-$], [$NO3^-$], [$NO2^-$], [$NH4^+$], [$SiO32^-$], as well as water quality factors biochemical and chemical oxygen demand (BOD and COD) were measured [20].

A Surber sampler (catching area: 625 cm^2, mesh size: 500 µm) was used for benthic invertebrate sampling in three locations among gravels or aquatic vegetation (where present), with a sampling duration of five minutes for each location to create a mixed sample. The contents were then preserved in 70% ethanol. Zooplankton was sampled with a 200µ plankton net. A volume of 50 L of water was collected from five points across the river width, starting from one corner, passing through the midpoint, and ending at the other corner. The water was filtered through the net, and the remaining content was transferred to the sampling glasses. A few drops of fixing solution (Lugol's iodine) were added to the sample. Zooplankton and macroinvertebrates were identified to the lowest possible taxonomic level [21,22], according to the availability of experts for each taxon.

2.3 Statistical Analyses

Data were tested for normality before applying parametric tests. One-way analysis of variance (ANOVA) followed by Duncan multiple comparison tests were conducted to determine the significant differences in physico-chemical variables among different months and stations. All statistical analyses were performed using SPSS 16.0., and differences were considered significant at the $P < 0.05$ level.

3. RESULTS

3.1 Physicochemical Parameters

The Dehram River exhibited variations in physicochemical parameters across different stations and seasons. The highest recorded water temperature in Dehram River was 33°C in station one during the summer, while the lowest temperature of 15°C was observed in station three during the winter. The concentrations of dissolved oxygen ranged from 5.7 mgL^{-1} to 14.2 mgL^{-1}, and pH ranged from 7.2 and 8.4. In December and March, the total dissolved solids of the three stations were significantly higher compared to September and June ($P < 0.05$). The trends of BOD5 and COD changes from September to March were decreasing, but in June, they reached a level similar to that of September ($P < 0.05$). The values of phosphate ions [PO_4^{3-}] showed a declining trend in March but increased in June ($P < 0.05$). The highest concentration of CO2 was recorded in September, while the lowest was in December. The concentration of silicate ion also varied significantly among seasons, with the highest value observed in September (Table 1).

Comparing the three stations, significant variations were observed in their physical and chemical properties, particularly in salinity and conductivity (Table 1). The salinity of the water increased from station 1 to station 3, with station 1 having the lowest salinity of 5.5 $g.L^{-1}$ (EC = 12350 $µS.cm^{-1}$) and station 3 having the highest salinity of 20.0 $g.L^{-1}$ (EC = 19410 $µS.cm^{-1}$). This trend of variation was also observed in other factors such as total dissolved solids, calcium ion concentration (both significant at $P < 0.05$), dissolved oxygen (both concentration and saturation), phosphate, and total suspended solids. In contrast, nitrate levels decreased significantly from station 1 to 3 (Fig. 3).

3.2 Macroinvertebrate Community

A total of 13 macroinvertebrate families from 5 orders and 3 classes were recorded in Dehram river (Table 2). The highest number of identified families was in station 1 (summer), while the lowest number was seen in station 2 (winter). The most taxonomic diversity was observed in Insecta with three orders and nine families, including a majority of families from the order

Diptera (four families). Gastropods were the next most diverse class with three families (Table 2).

The identified mollusks included *Melanoides tuberculatus* (dimensions: shell length (SL): 7.8± 0.09, shell greatest width (SW): 2.7 ± 0.36, aperture height (AH): 2. 4± 0.09, and aperture width (AW): 1.5± 0.05), *Ecrobia grimmi* (dimensions: SL: 3± 0.01, SW: 1.4 ± 0.02, AH: 1.18± 1.07, and AW: 0.85± 0.01), and *Planorbis intermixtus* (SL: 2.5, and SW: 2.1).

Some invertebrate families were exclusively present in station 1 and/or station 2, including families Caenidae, Ceratopogonidae, Thiaridae, Planorbidae, and Gammaridae. On the other hand, families Dyticidae and Simuliidae were found only in station 3. Other families were observed in all three stations (Fig. 4).

Fig. 2. Photographs of the Dehram river, Fars province, Iran. Top left: station 1, top right: station 2, middle left: station 3, middle right: general landscape of the region from above a nearby hill, bottom left and right: different locations along the river

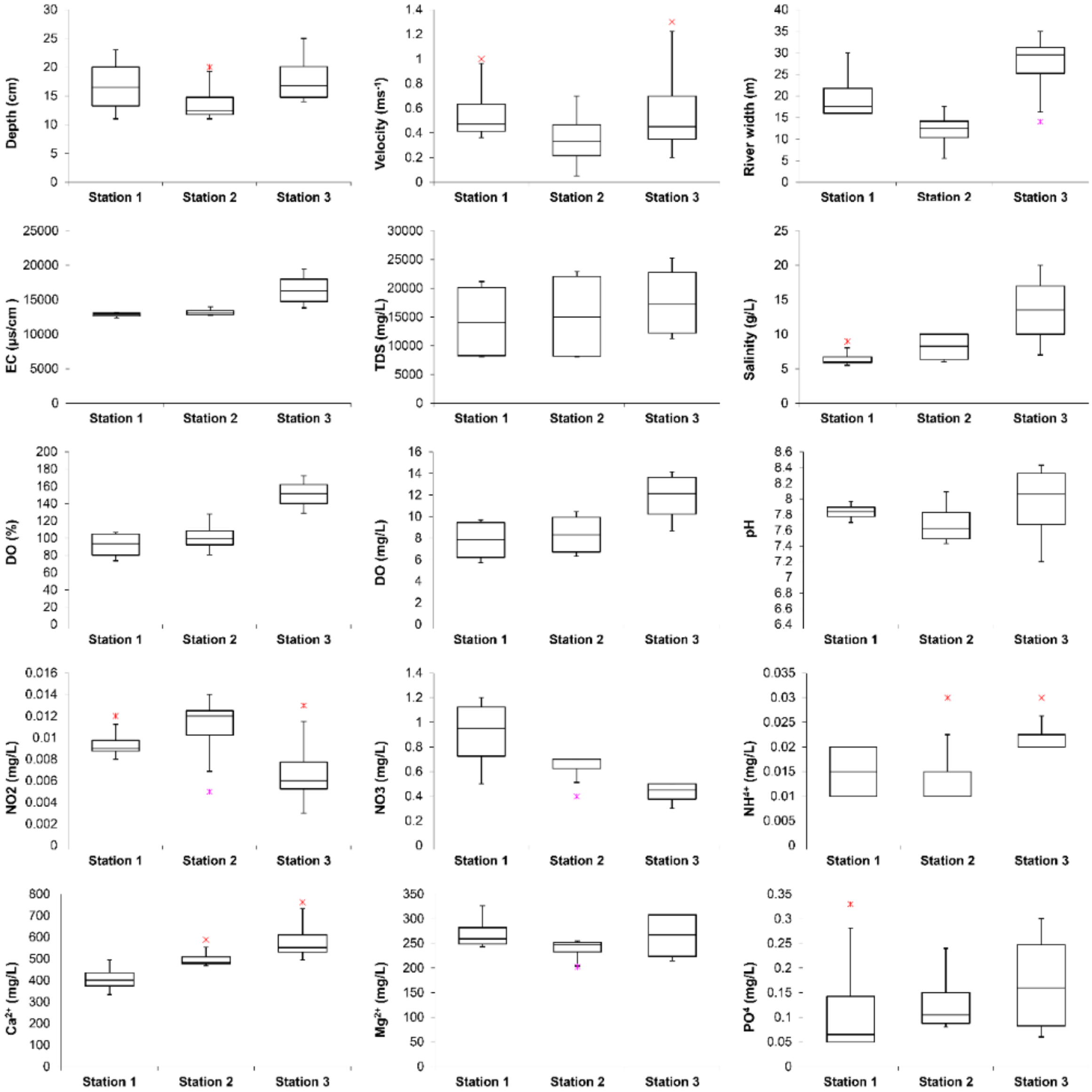

Fig. 3. Graph of selected physico-chemical parameters in the Dehram River

Four families, including Leptophebiidae, Hydraenidae, Chironomidae, and Hydrobiidae were present throughout the whole year. Families Caenidae and Hydrophilidae were not observed during the winter. Three families were exclusively observed in the spring, two families in the summer, and one family exclusively in the winter (Fig. 4).

The observed macroinvertebrate families contribute to various trophic functions with varying degrees of extent. The family with the most diverse trophic function in the river is Chironomidae which encompasses all trophic functions. The least diverse family in terms of trophic function is Simulidae, which consists only of filtering collectors. Other families have functions as predators, gathering collectors, and scrapers (Ceratopogonidae), or scrapers and shredders (Ephydridae).

3.3 Zooplankton Community

The examination of water samples revealed the presence of zooplankton populations consisting of three classes: Eurotatoria, Branchiopoda, and Hexanauplia. The identified taxa were included *Lecane* sp. (Class Eurotatoria: Lecanidae) with two unidentified species, one unidentified species of Trichocercidae (order *Ploima*), *Bosmina* (class Branchiopoda: Order Anomopoda: Bosminidae), and one unidentified species of Cyclopidae (Class Hexanauplia: Cyclopoida). All of these families were observed at station 1.

Family Trichocercidae was not observed in the lower parts of the river. Families Lecanidae and Cyclopidae extended their ranges to station 2, while in station 3, only one taxon, family Bosminidae, was present. In May, only family Cyclopidae were recorded, while all the taxa were present in August and February (Fig. 5).

Table 1. Environmental and physico–chemical parameters during sampling period in Dehram River

	Mean values (± SD)		
	Station 1	**Station 2**	**Station 3**
Depth (cm)	16.7± 4.6	14.0± 3.1	18.1±4.3
Width (m)	20.2±5.8	12.0±4.3	27.0±7.8
Current velocity ($cm.s^{-1}$)	0.6±0.20	0.35±0.23	0.60±0.41
Discharge ($m^3.s^{-1}$)	152±17.3	108.4±68.6	225.1±92
Water temperature (°C)	21±2.1	23.7±5.6	24.4±6.3
EC ($\mu S.cm^{-1}$)	12840±302.9^{a}	13225±467.8^{a}	16452.5±2163.9^{b}
DO ($mg.L^{-1}$)	7.8±1.6	8.3±1.8	11.8±2.2
pH	7.8±0.08	7.7±0.22	7.9±0.5
CO_2 ($mg.L^{-1}$)	0.6±.0.3	0.5±0.71	0.5±0.35
TDS ($mg.L^{-1}$)	14335.9±5490.8	15251.5±7076.4	17748.1±5993.2
TSS ($mg.L^{-1}$)	2.1± 0.09^{a}	1.8±0.13^{b}	2.03±0.13^{ab}
COD (($mg.L^{-1}$)	20.7±4.1	21.2±6.0	23.0±8.7
BOD ($mg.L^{-1}$)	6.4±1.1	7.0±2.0	7.7±3.5
[NO_2^-] ($mg.L^{-1}$)	0.009±0.001	0.01±0.003	0.007±0.003
[NO_3^-] ($mg.L^{-1}$)	0.9+0.2^{a}	0.62±0.11^{ab}	0.42±0.08^{b}
[NH_4^+] ($mg.L^{-1}$)	0.01±0.004	0.02±0.008	0.02±0.004
[PO_4^-] ($mg.L^{-1}$)	0.12±0.01	0.13±0.05	0.17±0.09
[SiO_3^{2-}] ($mg.L^{-1}$)	7.1±2.9	8±2.8	10.8±4.2
[Ca^{2+}] ($mg.L^{-1}$)	407.6±58.2^{a}	504.5±48.2^{ab}	580.9±102.0^{b}
[Mg^{2+}] ($mg.L^{-1}$)	271.8±29.0	237.8±18.6	264.0+43.9

Different superscript letters (a and b) represent statistically significant differences ($p < 0.05$)

Table 2. List of macroinvertebrates recorded in Dehram river

Order Ephemeroptera	**Family Caenidae Ulmer, 1920** **Family Leptophlebiidae Banks, 1900**
Order Coleoptera	Family Hydrophilidae Latreille, 1802
	Family Dyticidae Leach, 1815
	Family Hydraenidae Mulsant, 1844
	Hydraena farsensis Skale and Yaech, 2011
Order Diptera	Family Ceratopogonidae Newman 1834
	Family Simuliidae Newman, 1834
	Family Chironomidae Erichson, 1841
	Family Ephydridae Zetterstedt, 1837
Order Amphipoda	Family Gammaridea Latreille, 1802
	Gammurus loeffleri Zamanpoore et al. 2010
Class Gastropoda	Family Thiaridae Gill, 1871
	Melanoides tuberculata (O. F. Müller, 1774)
	Family Hydrobiidae Stimpson, 1865
	Ecrobia grimmi (Clessin & Dybowski, 1888)
	Family Planorbidae Rafinesque, 1815
	Planorbis intermixtus Mousson, 1874

	Station 1	Station 2	Station 3	August	February	May
Caenidae	●	●	○	●	○	●
Leptophebiidae	●	●	●	●	●	●
Hydrophilidae	●	●	●	●	○	●
Hydraenidae	●	●	●	●	●	●
Dyticidae	○	○	●	○	○	●
Ceratopogonidae	●	○	○	●	○	○
Chironomidae	●	●	●	●	●	●
Ephydridae	○	●	○	○	○	●
Simuliidae	○	○	●		●	○
Thiaridae	●	○	○	●	○	○
Hydrobiidae	●	●	●	●	●	●
Planorbidae	●	○	○	●	●	○
Gammaridae	●	○	○	○	○	●

Fig. 4. sapacial and temporal pattern of presence for macroinvertebrate families in the Dehram River

	station 1	station 2	station 3	August	February	May
Trichocercidae	●	○	○	●	●	○
Lecanidae	●	●	○	●	●	○
Cyclopidae	●	●	○	●	●	●
Bosminidae	●	●	●	●	●	○

Fig. 5. sapacial and temporal pattern of presence for zooplankton families in the Dehram River

3.4 The Fish Community

Various groups of fish, mainly fingerlings, were observed throughout the river during the sampling periods. However, only two identifiable cyprinid species were found in adult sizes: *Cyprinion tenuiradius* Heckel, 1847 and *Garra persica* Berg, 1914. Additionally, three other fish samples, caught by local people from inaccessible areas downstream, were examined. These included *Luciobarbus barbulus* (Heckel, 1849) and *Capoeta barroisi* (Lortet, 1894), both belonging to the Cyprinidae family, as well as one unidentifiable sample.

3.5 Macroalgae

The river was covered by a dense population of the blanket weed algae *Spirogyra condensata* (Vaucher) Dumortier 1822 in station 2, while they were also seen sparsely on some riversides in stations 1 and 3.

4. DISCUSSION

The results provide an overview of the ecological elements present in the Dehram river, an arid region streams in Iran. The river is influenced by geological salts, resulting in a transition from fresh to brackish water.

4.1 Physico-Chemical Variation

The most prominent feature along the course of the river is the increase of salinity, particularly in stations 3. Two main factors contribute to the elevated salinity in the Dahram River are the presence of salt domes in the region and the Gachsaran geological formations [18]. The study area is located in the folded and broken zone of

Zagros in the Persian Gulf basin. The salt basin of the Hormoz formation, dating back to the Cambrian, is the source of these unique geological features. Salt diapirism, a phenomenon commonly found in the folded Zagros, leads to the emergence of salt domes on the Earth's surface, scattered across the southern half of the basin [18]. Approximately 11 saltwater springs in the surrounding area contribute to the river's salt concentration, as they are affected by the salt domes. The physico-chemical parameters, including total dissolved solids, calcium ion concentration, phosphate, total suspended solids, and dissolved oxygen, also exhibit variations along the river (Fig. 3).

The water temperature and pH in the Dehram river range from 15 – 33 °C, and 7.2 – 8.4. These values fall within the ranges observed in rivers located in arid and semi-arid zones of the worldwide. For instance, rivers in the Auris region of Algeria show similar temperature ranges of 16 – 24 °C and pH ranges of 7.1 – 8.2 [23]. The Prianhas-Acu River in Brazil exhibits temperatures of 26 – 32 °C and pH values of 7.2 – 8.5 [24], while rivers of Burkina Faso, west Africa have higher temperatures ranging 23 – 35 °C and wider pH ranges of 5.7 – 11.6 [25]. On the other hand, the saline Salado River in Argentina shows lower temperature (18.1 – 18.9°C) and pH (8.6 – 9.3) ranges [26]. The oxygen concentration in these rivers varies, ranging from a limited range of 3.4 – 5.7 $mg.L^{-1}$ in Prianhas-Acu [24] and 8.7–9.1 $mg.L^{-1}$ in the Salado river [26], to a broader range of 1.5 – 10.7 $mg.L^{-1}$ in rivers of Burkina Faso [25], which is in the same range of the Dehram river (5.7 – 14.2 mgL^{-1}). However, it is important to note that the concentration of dissolved oxygen can vary significantly based on factors such as the presence of organic matter and the overall health of the aquatic ecosystem.

One notable characteristic of the Dehram River is its high electrical conductivity, which serves as an indicator of salinity. The river's conductivity ranges from 12,350 to 19,410 µS/cm, surpassing the values observed in most studied rivers, for example 140 – 265 $\mu S.cm^{-1}$ in Prianhas-Acu [24], 27 – 491 $\mu S.cm^{-1}$ in Burkina Faso rivers [25], and 421 – 921 $\mu S.cm^{-1}$ in rivers in the Auris region of Algeria [23]. Rivers with similar or higher conductivities are typically found in regions impacted by intensive agriculture or the inflow of saline groundwater. The Salado River in Argentina shows conductivities ranging from 934 to 5,910 µS/cm [26], which are still much lower than those recorded in the Dehram River.

4.2 Macroinvertebrates Distribution

The order Diptera, including families Ceratopogonidae, Simuliidae, Chironomidae, and Ephydridae, exhibited the highest family diversity among the benthic macroinvertebrates. These taxa are known for their broad tolerance to water conditions, especially salinity, and were present in all stations. However, the density of chironomids was relatively high in station 3, which showed the highest salinities. Chironomidae, the largest and most widespread freshwater dipteran, can be found in a variety of aquatic environments worldwide [27]. They are also known to tolerate saline waters, and have been found in hypersaline lakes with salinities up to 340 $g.L^{-1}$ [28]. Larval ephydrids, another family within Diptera, are known to tolerate extremely saline conditions through their remarkable osmoregulation physiology. They can be found in littoral zones, margins of lotic and lentic habitats, saline lakes and pools, and salt marshes [29]. Dytiscid species, belonging to the order Coleoptera, are also found in brackish water [30]. Chironomid larvae was described as the most abundant insect group in an intermittent stream in semi-arid Brazil [23], and Chironomidae, Baetidae, and Dytiscidae were the most common families in arid and semi-arid ecosystems of Peru [31]. Diptera, particularly Chironomidae, also showed high family diversity in the Haraz River [5], Zayandeh Rud River [8], and Behesht-e Gomshodeh River [16].

Caenidae and Leptophlebiidae, families within the order Ephemeroptera, were recorded from different stations along the Dehram river in this study. Leptophlebiidae is one of the most ecologically and taxonomically diverse groups of Ephemeroptera [32]. They have been previously reported from other ecosystems in Iran, such as the Tajan River where *Caenis* sp. (Caenidae) was also reported [33], and the Zayandeh Rud River in Isfahan, where Leptophlebiidae and Caenidae were found [8].

Among the gastropod species collected in the Dehram River, *Melanoides tuberculatus* and *Planorbis intermixtus* are relatively widespread in Iran [34]. The third species *Ecrobia grimmi* was reported from only one location, Hormozgan Province [34]. The distribution of *Ecrobia* species has been reported in its eastern borders in Issyk-Kul lake, Kyrgyzstan, southern Iraq, the Caspian

Sea region and narrow margins of the Persian Gulf [35]. Therefore, our finding extends the distribution of this species, and the whole genus, from the Persian Gulf coasts northward to the inland basins of the Fars Province.

The distribution of benthic macroinvertebrates may be affected by physical and chemical properties such as water temperature, pH, and total dissolved solids [23]. For example, diversity of benthic insects was correlated with water temperature in Walker River [36], and pH, conductivity, and total dissolved solids in streams of the Aurès arid region, Algeria [23]. Generally, limiting ecosystem conditions of streams in arid areas have caused not only different population size and habitat quality, but also lower diversity of macroinvertebrates compared to humid areas [23]. Diaz et al., (2008) showed that disturbance and human pressure during ecological history determine the community structure of evolving macroinvertebrates in streams [37]. In contrast, in rivers that receive high pollution inputs, biodiversity has a significant correlation with physical and chemical variables such as oxygen saturation, nitrate and phosphate concentrations, total suspended solids, conductivity, and various chemical components [13,38,39].

Macroinvertebrates are a crucial component of the Dehram River ecosystem, representing a wide array of trophic functions. For instance, a study conducted in the Walker River, located in the semi-arid regions of Nevada, USA, revealed that collector-gatherers dominated the macroinvertebrate community, while shredders were mostly absent downstream [36]. Similarly, intermittent desert streams in the arid Colorado Plateau exhibited a scarcity of certain trophic groups like scrapers, filtering-collectors, and shredders, with gathering-collector taxa being dominant [40]. In the Chubut River, located in the arid regions of Argentina, collector-gatherers and scrapers/grazers were the predominant macroinvertebrate groups, while shredders were less abundant [41].

The diversity of zooplankton in the Dehram River showed an inverse relationship with salinity levels. The reduction in the number of taxa from station 1 to 3 indicates the susceptibility of zooplankton to the existing ecological stressors. Different species exhibit varying adaptations to cope with the changes in environmental salinity. For example, certain species of Cyclopidae family can thrive in high salinity environments [42]. while others may not tolerate higher salinity levels and are limited to less saline areas.

4.3 The Fish Community

The fish community in the Dehram River includes four species that are new records for the region. These findings are ecologically significant, considering the more saline conditions of the river. One notable species is *Cyprinion tenuiradius* (Ghareh-Aghaj Botak), an endemic fish found in various parts of Fars Province and the Persian Gulf basin [43,44]. Another species, *Garra persica* (Persian stone lapper), is an endemic cyprinid fish found in southern parts of Iran [43,45,46]. It is found in flowing waters at various altitudes, feeding mainly on detritus, periphyton, and algae [43], which is the consistent with the situation in the Dehrm River. *Luciobarbus barbulus* (Heckel, 1847) is widely distributed in Asia, and has been found in Mond, Helleh, Tigris, Karun, and Zohreh River catchments, and the Shadegan Wetland in Iran. Additionally, *Capoeta barroisi* is an economically important fish species found in different river basins in Iran [43]. These fish species exhibit diverse feeding habits, including phytoplankton, filamentous algae, aquatic insects, and benthic organisms. It is consumed considerably by local people in Iran, Iraq, and Turkey due to its good taste [46–48]. They feed on algae and aquatic insects. *Capoeta barroisi* is reported to live in habitats with temperatures up to 29°C, ECs up to 1353 µS/cm, DO of 6.1–11.7 mg/l, and pH of 6.4–6.8 [43]. In our study, the maximum recorded temperature was 33°C, which is the highest recorded temperature for this species. The highest EC recorded in the Dehram river was 19410 µS/cm, 14 times higher than the recorded range for the species. The pH was also in a higher range, up to 8.4. According to these values, this is apparently a new ecological record for *C. barroisi* which proves its much higher tolerable conditions.

5. CONCLUSIONS

The high range of fundamental environmental factors in the Dehram River indicates an extraordinary habitat, situated in an arid climate and influenced by salinization agents. Such environments are extensively prevalent in the southern regions of Iran, which have largely been overlooked in research. However, the biodiversity in the Dehram River suggests that each taxon has developed a sufficient set of adaptations, making the river environment tolerable. A more detailed study on their taxonomy is needed to determine the species/subspecies categories and to clarify whether they represent new taxa or are merely highly adapted, physiologically isolated populations.

This report is the first to describe the ecology of the Dehram River, detailing aspects of its biodiversity and recording physicochemical parameters. We are reporting the presence of *Ecrobia grimmi* in the Fars Province for the first time, and the exceptional ecology of the river suggests the existence of other new taxa. The Dehram River is a unique ecosystem with high salinity downstream of the extensive freshwater river, Ghare-Aghaj, located in a hot arid area. We have also reported a new ecological record for *C. barroisi* in a much higher tolerable salinity conditions. Careful conservation of these unique aquatic environments is critically important given the threats faced by biodiversity in arid regions under climate change.

Continued longitudinal monitoring of the river's physicochemical parameters and biodiversity over time would help track potential impacts of increasing salinization and other environmental changes in this sensitive ecosystem. The intention of this paper is to draw attention to the significance of this area. It is hoped that more comprehensive information will enhance our understanding of the value of aquatic ecosystems in arid zones and further the cause of biodiversity conservation.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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