__Original Research Article__

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

Abstract

In this study, we explore Dehram river system, focusing on their biological characteristics, in a hot arid region. This is a freshwater stream flowing over salt formations. We examined various aspects of the river's ecology, including its benthic macroinvertebrates, zooplankton, fishes, and some physical and chemical factors. The river showed variations in physical and chemical properties, with salinity and electrical conductivity 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 Dehram 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 temperature, EC, and pH ranges in the Dehram 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

Introduction

Aquatic ecosystems are subject to various disturbing agents which may affect their structure and function, including thermal pollution, habitat destruction, dam construction, human-mediated dispersal of alien species, climate, and land-use changes (Crook et al., 2015; Worthington et al., 2015). Freshwater ecosystems with their rich diversity of habitats have been under threat due to stress in the last few decades (Mantyka-Pringle et al., 2014). River ecosystems, particularly in developing countries may be more susceptible to these conditions because of the lack of adequate data. It is also essential to know characteristic features of species to predict community responses to these stressors and to recognize the sensitive parts of the community.

Most major rivers, wetlands, and lakes of the world have been extensively studied, while springs, groundwater systems, and smaller streams have mostly been neglected in many areas including Iran, aside from a few exemptions. A large part of Iran is located in the arid or semi-arid zone (Raziei, 2016) with numerous small rivers having specific ecological conditions. As an example of works on large rivers, research was on macroinvertebrates and water quality in Haraz (Banagar et al., 2018), Tajan (Aazami et al., 2019), and Sefid Rud rivers (Ghane et al., 2017) in northern Iran, Zayandeh Rud river in Isfahan, central Iran (Varnosfaderany et al., 2010), and the Karun river, Khuzestan (Babaahmadi, 2015), and Hajiabad river, Hormozgan (Khosravani et al., 2014) in south of the country. Zooplankton have been studied in Karun (Neisi et al., 2019) and Haraz river (Jafari et al., 2011).

In Fars Province, Aazami et al. (2019) worked on the assessment of water quality in the Kor river in the north and west of the province. In a recent study focused on the macroinvertebrate community of the upper Ghare-Aghaj river Shahradnia et al. (2020) recorded 20 families of macroinvertebrates. Their result showed that the number of recorded families decreased from the middle to the lower parts of the river behind the Persian Gulf. Four gastropod molluscan species *Physa acuta*, *Planorbis intermixtus*, *Radix persica*, and *Galba truncatula* as well as a bivalve species *Pisidium casertanum* were reported from Jubkhalle River, in the catchment of the Kor river (Abbaspour et al., 2019), and macrobenthos of Behesht-e Gomshodeh river in a nearby region were studied, revealing 25 families with the order Ephemeroptera having the most diversity (Karami et al., 2015). Apart from these and probably a few other works (mainly on larger rivers), not much research has been conducted on smaller aquatic ecosystems in Iran.

Dehram river is an exceptional riverine ecosystem which is fresh in outset but continues as highly saline. Shortly after originating, the water turns brackish with a sharp gradient of chemical and physical properties, which could have affected the river's biological community. Understanding the responses of the living community to the strict changes in the transition from fresh to brackish water in this river will provide valuable information for predicting how biodiversity will react in the possible future caused by human intervention, global warming, and drought. This paper is the first to report the physical, chemical, and biological properties of the Dehram River to recognize its unique aquatic environment.

MATERIALS AND METHODS

Site description

Dahram River is a tributary of Ghare-Aghaj, one of the longest rivers (ca. 125 km) in the south Iran. The Ghare-Aghaj originates from the Anar, Arjan, and Khanic Mountains in the northern parts, and eventually reaches the Persian Gulf after passing 765 km (Pourghasemi et al., 2021) (Fig. 1). The main body of the river has been under severe drought for the last decade, but many of its tributaries remain alive, at least during the wet seasons.

From the headquarters to the south of the historical city of Firuzabad, the river has fresh water, but afterwards the it runs over the salt and gypsum formations and saline soils, thus turns to saline (Moayrei and Ahmadinezhad, 2006). Then the river enters the plain of Dehram and takes branches from Mount Padana. From this section it is called Dehram. The river finally arrives in the Farrashband County and flows into the Mond River in the Dezhgah plain. Maximal recorded temperature and precipitation in the district are 39°C and 164 mm (Ajam Zadeh and Mollaeinia, 2016).

Dehram is a shallow river mostly below 20 cm depth. There are occasional depressions where the depth reaches ca. 100 cm. The river lies in plains among the outskirts of the Zagros Mountains, so it flows in a relatively flat area with a low gradient. In these areas it spreads and gets wide, but its width decreases in some places. The riverbed is almost rocky, with gravels of varying sizes, but in some meander corners the bed is covered with eroded sediments of fine sands or mud. Aggregations of aquatic plants are scattered along the riversides, and dense masses of the blanket weed are seen in some locations.

Sample Collection and Preparation

Three stations (Figs. 1, 2) were selected due to geographical availability along the river path (28°54′N52°36 ′E; 28°45′N52°33′E; and 28°52′N52°34′E). The river was sampled from 2012-2013 (September, March, and June). Abiotic factors were measured locally including salinity, electrical conductivity, pH (by using Hanna-HI 1281), temperature, and dissolved oxygen (Hach HQ40d Multimeter) in three locations at the corner, at the midpoint of the river, and between them. Current velocity, discharge, average depth, and the river width were also recorded. Three water samples were taken from the above metioned points across the river width. Samples were kept in a cool box prior to be brought to the lab after 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 BOD and COD were measured (APHA, 2017).

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

A Surber sampler (catching area: 625 cm2) was used for benthic invertebrate sampling in three locations among gravels or aquatic vegetation (where present), five minutes for each to make a mixed sample. The contents were subsequently preserved in 70% ethanol. Zooplankton was sampled with a 200μ plankton net. A 50 L volume of water taken from 5 points across the river width, from corner to the midpoint to the other corner was passed through the net and the remaining content was transferred to the sampling glasses; a few drops of fixing solution (Lugol's iodine) were added. Zooplankton and macroinvertebrates were identified to the lowest possible taxonomic level (Elliott et al., 1988; Kriska, 2013), according to the availability of experts for each taxon.

Statistical Analyses

Data were tested for normality before the application of parametric tests. One-way analysis of variance followed by Duncan multiple comparison tests were conducted to test the significant differences of the physico-chemical variables among different months and stations. All statistical analyses were performed using the SPSS 16.0.

RESULTS

Physicochemical parameters

The highest and lowest recorded water temperature in Dehram River were 33°C in station one, summer, and 15°C in station three, winter. Dissolved oxygen concentrations and pH were between 5.7 mgL^{-1} and 14.2 mgL^{-1}, and 7.2 and 8.4, respectively. In December and March, the total dissolved solids of the three stations were significantly higher than in 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 close to that of September ($P < 0.05$). Values of [PO_4^{3-}] showed a declining trend in March but increased in June ($P < 0.05$). The highest value of CO2 concentration was recorded in September and the lowest one in December. Silicate ion showed significant differences in seasons, so that the highest value was recorded in September (Table 1).

Figure 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.

In comparison of the three stations, they demonstrated variations in their physical and chemical properties, most significant in salinity and electrical conductivity (Table 1). The trend of water salinity change was increasing from stations 1 to 3. Station 1 had the lowest salinity of 5.5 $g.L^{-1}$ (EC = 12350 $\mu s.cm^{-1}$) compared to station 3 with the highest salinity of 20.0 $g.L^{-1}$ (EC = 19410 $\mu s.cm^{-1}$). This variation trend was aslo observerd in other factors such as total dissolved solids and calcium ion concentration (all significant at $P < 0.05$), as well as in dissolved oxygen (both concentration and saturation), phosphate, total suspended solids. Meanwhile, nitrate levels significantly decreased from station 1 to 3 (Figure 3).

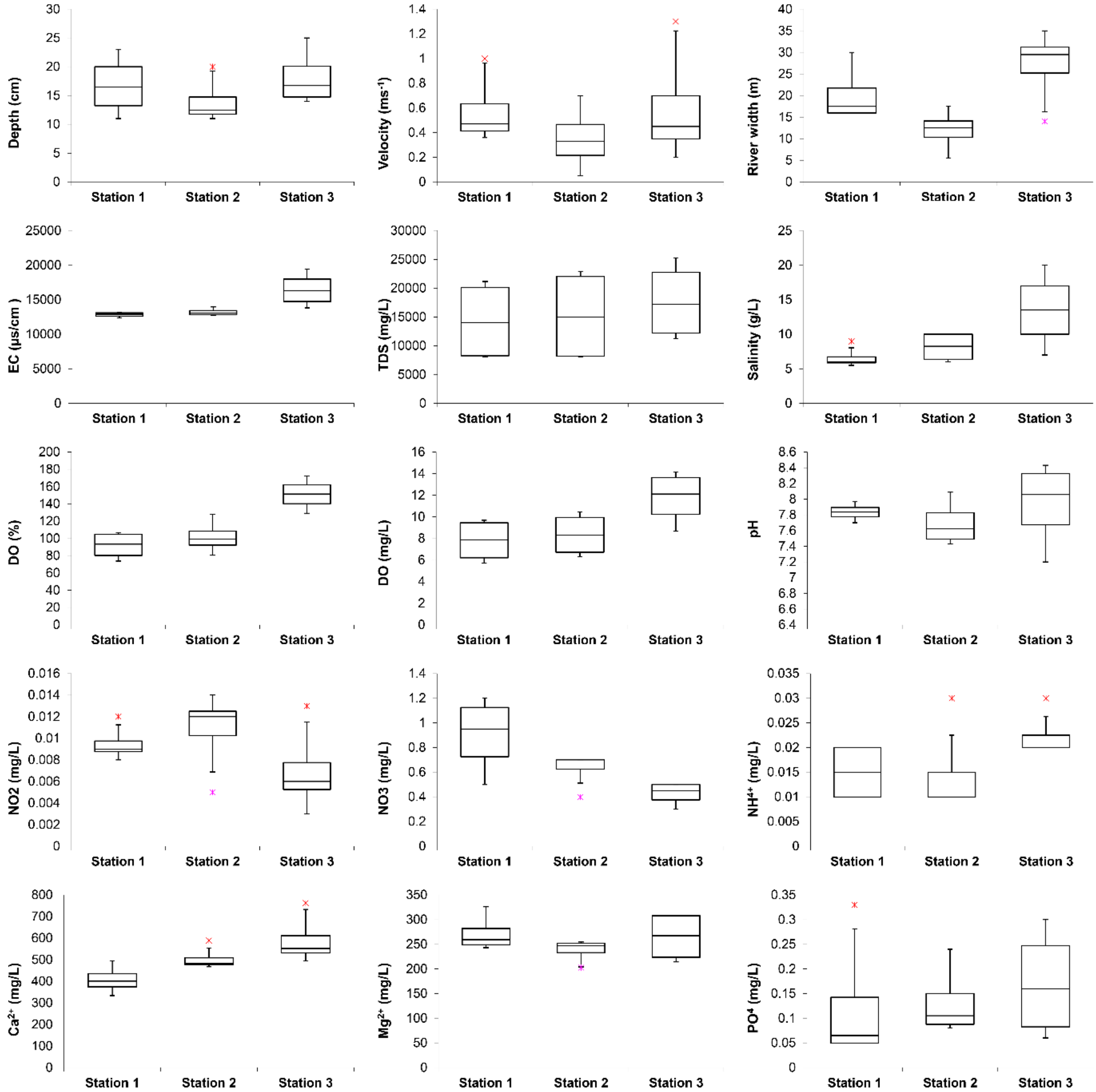

Figure 3. Graph of selected physico-chemical parameters in the Dehram River.

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)	0.6±0.20	0.35±0.23	0.60±0.41
Discharge (m^3/s)	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 (µS)	12840±302.9^{a}	13225±467.8^{a}	16452.5±2163.9^{b}
DO (mg/L)	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)	0.6±.0.3	0.5±0.71	0.5±0.35
TDS (mg/L)	14335.9±5490.8	15251.5±7076.4	17748.1±5993.2
TSS (mg/L)	2.1± 0.09^{a}	1.8±0.13^{b}	2.03±0.13^{ab}
COD ((mg/L)	20.7±4.1	21.2±6.0	23.0±8.7
BOD (mg/L)	6.4±1.1	7.0±2.0	7.7±3.5
[NO_2^-] (mg/L)	0.009±0.001	0.01±0.003	0.007±0.003
[NO_3^-] (mg/L)	0.9+0.2^{a}	0.62±0.11^{ab}	0.42±0.08^{b}
[NH_4^+] (mg/L)	0.01±0.004	0.02±0.008	0.02±0.004
[PO_4^-] (mg/L)	0.12±0.01	0.13±0.05	0.17±0.09
[SiO_3^{2-}] (mg/L)	7.1±2.9	8±2.8	10.8±4.2
[Ca^{2+}] (mg/L)	407.6±58.2^{a}	504.5±48.2^{ab}	580.9±102.0^{b}
[Mg^{2+}] (mg/L)	271.8±29.0	237.8±18.6	264.0+43.9

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

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 highest taxonomic diversity was seen in Insecta with three orders and nine families, among them most families were from Diptera (four families). Gastropods were the next with three families (Table 2).

Identified molluscs 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 of the invertebrate families were present exclusively in station 1 and/or station 2, including family Caenidae, Ceratopogonidae, Thiaridae, Planorbidae, and Gammaridae. In contrast, families Dyticidae and Simuliidae were found only in station 3. Other families were observed in all three stations (Figure 4).

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

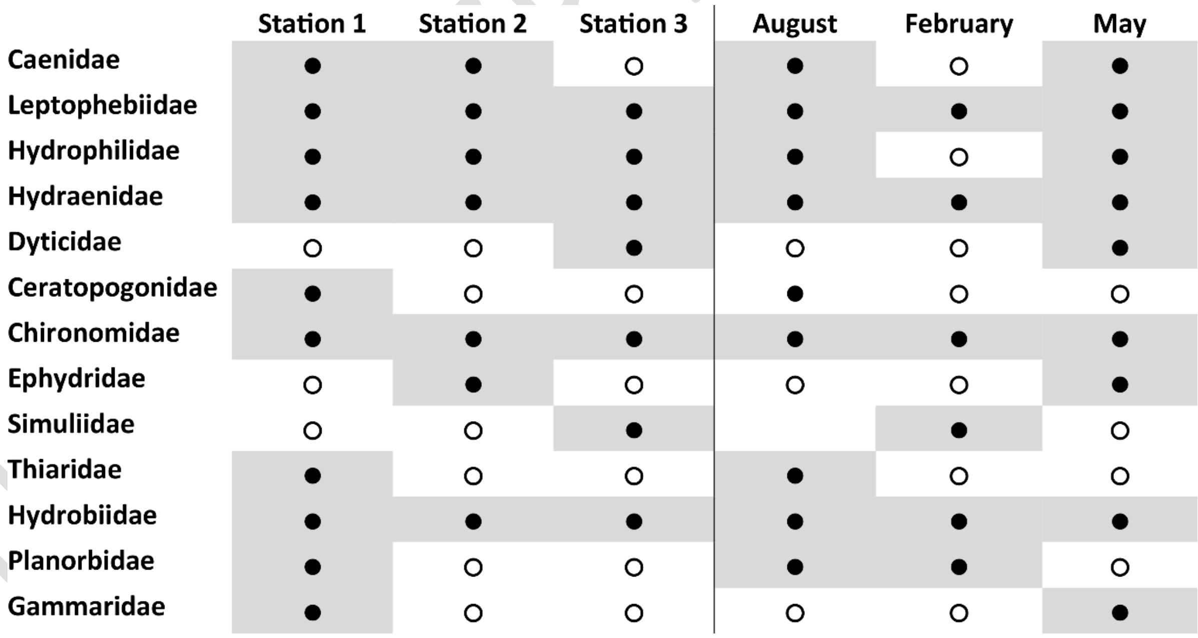

Figure 4. sapacial and temporal pattern of presence for macroinvertebrate families in the Dehram River.

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

The observed families of the macroinvertebrates are contributed to various trophic functions with different degrees of extent. The family with the most diverse trophic function in the river is Chironomidae having all trophic functions, and the least diverse family is Simulidae, only filtering collectors, while other families have functions as predators, gathering collectors, and scrapers (Ceratopogonidae), or scrapers and sgredders (Ephydridae) .

Zooplankton community

Examination of water samples revealed zooplankton populations consisting of three classes: Eurotatoria, Branchiopoda, and Hexanauplia. Samples were identified as *Lecane* sp. (Class Eurotatoria: Lecanidae) with two unidentified species, one unidentified species of Trichocercidae (order *Ploima*), *Bosmina* (class Branchiopoda: Order Anomopodao: Bosminidae), and one unidentified species of Cyclopoidae (Class Hexanauplia: Cyclopoida). All families were seen at station 1.

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

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

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

The Fish community

Groups of fish (mostly fingerlings) were seen all over the river during the sampling periods. However, only two cyprinid species *Cyprinion tenuiradius* Heckel, 1847 and *Garra persica* Berg, 1914 were found in adult and identifiable sizes. Three other fish samples, caught by local people from inaccessible areas downstream, were also examined. These included *Luciobarbus barbulus* (Heckel, 1849) and *Capoeta barroisi* (Lortet, 1894), both from the Cyprinidae family, as well as one unidentifiable sample.

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.

DISCUSSION

The results demonstrate a general image of the ecological elements of the Dehram river, an example of arid region streams of Iran, which is affected by the impact of geological salts, and the resulting conditions in transition from fresh to brackish water.

Physico-chemical variation

The increase of salinity in stations 3 might be the most prominent feature in the course of the river. Two main reasons for the increased salinity of the Dahram River are repoted to be the salt domes of the region and the Gachsaran geological formations (Moayrei and Ahmadinezhad, 2006). The study area lies in the folded and broken zone of Zagros in the Persian Gulf basin, and their source is the salt basin of the Hormoz formation, dated back to the Cambrian. One of the most unique features of the geology of the folded Zagros is the phenomenon of salt diapirism, producing salt domes in the earth surface, scattered in the southern half of the basin (Moayrei and Ahmadinezhad, 2006). About 11 salt water springs in the surroiunding which bring underground water to the river are affected by the salt domes, and increase its salt concentration as well. Other factors including total dissolved solids, calcilum ion concentration, phosphate, total suspended solids, and dissolved oxygen demonstrated this variation as well (Figure 3).

Water temperature and pH in the Dehram river were in the ranges of 15 – 33 °C, and 7.2 – 8.4. In arid and semi-arid zones of the world, rivers demonstrate various ranges of temperature and pH, like similar values in rivers of Auris region, Algeria, with T = 16 – 24 °C and pH = 7.1 – 8.2 (Ghougali et al., 2019), Prianhas-Acu River, Brazil with T = 26 – 32 °C and pH = 7.2 – 8.5 (Rocha et al., 2012), or higher temperatures (23 – 35 °C) and wider pH ranges (5.7 – 11.6) in rivers of Burkina Faso, west Africa (Kaboré et al., 2016). On the other hand, the saline Salado River, Argentina, has lower temperature (18.1 – 18.9°C) and pH (8.6 – 9.3) ranges (Gabellone et al., 2005). Oxygen concentration in these rivers might be in limited range of 3.4–5.7 $mg.L^{-1}$ in Prianhas-Acu (Rocha et al., 2012) and Salado river 8.7–9.1 $mg.L^{-1}$ (Gabellone et al., 2005), or broader range of 1.5 – 10.7 $mg.L^{-1}$ in Burkina Faso rivers (Kaboré et al., 2016), which is more consistent with Dehram (5.7 – 14.2 mgL^{-1}). However, most studied rivers are fresh waters with low electrical conductivities, for example of 140 – 265 $\mu S.cm^{-1}$ (Rocha et al., 2012), 27 – 491 $\mu S.cm^{-1}$ (Kaboré et al., 2016), and 421 –

921 µS.cm^{-1} (Ghougali et al., 2019), which are far lower than Dehram. On the other hand, high conductivities (934 – 5910 µS cm^{-1}) were recorded in regions under the impact of intensive agriculture or the inflow of saline groundwater, for example in Salado River, Argentina (Gabellone et al., 2005), but still much lower than Dehram (12350 – 19410 µS cm^{-1}), which is an extraordinary value for conductivity of a river.

Macroinvertebrates distribution

The highest family diversity of benthic macroinvertebrates was in the order Diptera, including families Ceratopogonidae, Simuliidae, Chironomidae, and Ephydridae. Reported taxa are among those that have broad tolerance to the water conditions, especially to salinity. They were present in all stations, but the density of chironomids was relatively high in station 3, which showed highest salinities. Chironomidae, the largest and most widespread freshwater dipteran, which some of its species can be found in a vast variety of environments through the aquatic ecosystems in the world (Armitage et al., 2012), are also known to tolerate saline waters, as they have been found in hypersaline lakes with salinities up to 340 g.L^{-1} (Belyakov *et al*., 2018). Larval ephydrids are known to tolerate extremely saline conditions as well, with the power of their remarkable osmoregulation physiology, in littoral zones, margins of lotic and lentic habitats, saline lakes and pools, and salt marshes (Williams & Feltmate, 1992). Dytiscid species are also found in brackish water (Yee, 2014). In a study of intermittent stream of semi-arid Brazil, chironomid larvae was described as the most abundant insect group (Rocha et al., 2012) and Chironomidae, Baetidae, and Dytiscidae were the most common families in arid and semi-arid ecosystems of Peru (Arana Maestre et al., 2021). According to Banagar et al. (2018), Diptera had the most family diversity in the Haraz River. Chironomidae was also reported as the first dominant taxa in the Zayandeh Rud and Behesht-e Gomshodeh River (Karami et al., 2015; Varnosfaderany et al., 2010).

Caenidae and Leptophlebiidae were also recorded from different stations along Dehram river in the present study. Leptophlebiidae is one of the most ecologically and taxonomically diverse groups of Ephemeroptera (Godunko et al., 2022). They have been previously reported from other ecosystems in Iran. Shokri et al. (2014) reported 5 families of Ephemeroptera from the Tajan River, north of Iran, including *Caenis* sp. (Caenidae). Leptophlebiidae and Caenidae were also reported from Zayandeh Rud River, Isfahan (Varnosfaderany et al., 2010).

Of the gastropod species which we collected in Dehram, *Melanoides tuberculatus* and *Planorbis intermixtus* are relatively widespread in Iran (Glöer and Pešić, 2012). The third species *Ecrobia grimmi* was reported from only one location, Hormozgan Province (Glöer and Pešić, 2012). Distribution of species of the genus *Ecrobia* was reported in its eastern borders in Issyk-Kul lake, Kyrgyzstan, southern Iraq, the Caspian Sea region and narrow margins of the Persian Gulf (Vandendorpe et al., 2019). 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 (Ghougali et al., 2019). Diversity of benthic insects was correlated with water temperature in Walker River (Mehler et al., 2015), and with pH, conductivity, and total dissolved solids in streams of the Aurès arid region, Algeria (Ghougali et al., 2019). Generally, it has been stated that 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 (Ghougali et al., 2019). Diaz et al., (2008) showed that disturbance and human pressure during ecological history determine the community structure of evolving macroinvertebrates in streams. In contrast, in rivers which receive high amounts of pollution inputs, where environmental factors may raise above their natural values, biodiversity has a significant correlation with physical and chemical variables. Examples are correlation with oxygen saturation in Zayanderud River (Varnosfaderany et al., 2010), with nitrate and phosphate concentrations in Tajan river (Aazami et al., 2015), TSS and conductivity in Langat river (Azrina et al., 2006), and with all of EC, [TSS], [O_2], COD, BOD, [$NH4^+$], and [$PO4^-$] in Lepenci river basin in Kosovo (Etemi et al., 2020).

Altogether, these invertebrates represent ecological groups with a wide variety of trophic functions. In comparison, all trophic groups were seen in Walker River, in a semi-arid watershed area of Nevada, USA, but collector–gatherers were dominant group in the macroinvertebrate community, and shredders were absent through most of the downstream habitats (Mehler et al., 2015). In the intermittent desert streams in the semi-arid Colorado Plateau, no scraper taxa and very few filtering-collectors or shredders were seen, while gathering-collector and filtering-collector taxa were dominant with few predatory taxa in the perennial desert streams (Miller and Brasher, 2011). On the other hand, in the Chubut River, a large river in arid regions of Argentina all trophic groups were present, but collector-gatherers and scrapers/grazers were predominant groups at most studied sites, with regard to their relative abundance. Shredders were almost absent at middle and lower basin sites, and less abundant in the upper sites (Miserendino, 2007).

The trend of zooplankton diversity was opposite to that of salinity. Reduction of the number of the present taxa from station 1 to 3 shows that they are more susceptible to the existing ecological streesors. Dofferent species may have different individual adaptations to cope with the environmental salinity changes. Some species of Cyclopidae are found in environments with high salinity levels (Anufriieva, 2015). Some others may have not be tolerant enough to expand their habitats to more saline localities.

The fish community

The four fish species identified in Dehram river are new records for their geographical distribution range. This is a new finding as well, from an ecological point of view due to the more saline conditions of the river. The genus *Cyprinion* Heckel, 1843 includes four native and one endemic species in Iran. *Cyprinion tenuiradius* (Ghareh-Aghaj Botak) is the only endemic species of the genus distributed in different parts of Fars Province in Maharlu Lake, Kor, and Rudbal river basins, as well as in the Persian Gulf basin in Mond river (Keivany et al., 2016). It feeds on phytoplankton, filamentous algae, and aquatic insects (Keivany et al., 2016; Tabatabaii et al., 2020). Genus *Garra* is widely distributed from East Asia to Africa, 12 species of which have been identified and reported in Iran's inland waters (Zamani Faradonbe and Keivany, 2021). *Garra persica* (Persian stone lapper) is an endemic cyprinid fish distributed in southern parts of the country like the Sarbaz River (Hormuz and Makran basins), Hamun-e Jaz Murian basins, Halilrud and Bampur rivers in Sistan and Jazmurian basins (Coad, 2016; Keivany et al., 2016). It is found in flowing waters at various altitudes, feeding mainly on detritus, periphyton, and algae (Keivany et al., 2016). *Luciobarbus barbulus* (Heckel, 1847) is widely distributed in Asia, and has been found in Mond, Helleh, Tigris, Karun, and Zohreh River chatchments, and the Shadegan Wetland (Keivany et al., 2016). It feeds on benthic organisms (insects, plant remains, and detritus), but larger fish can also feed on other fish (Keivany et al., 2016). The distribution range of *C. barroisi* Lortet, 1894 includes the Tigris Basin, Lake Zarivar in the north of the country, the Jarrahi and Karun rivers in the south-east, and the Mond and Dasht-e Palang rivers in the south. It has been considered an economic fish species, so locals are in great demand of it as food. It is consumed considerably by local people in Iran, Iraq, and Turkey due to its good taste (Aral et al., 2007; Parmaksız and Eskici, 2018). 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 (Keivany et al., 2016). 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.

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. 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 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 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.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request

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