

Biodiversity in Qanats (The Case study of Kerman County, Iran)

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Received: 11 June 2008; Received in revised form: 28 October 2008; Accepted: 14 November 2008

Abstract

Qanat is one of the important inland aquatic ecosystems commonly containing freshwater in arid and semi-arid regions. There are 37 qanat chains in Kerman County in the Kerman province of Iran. During past years, some of them have been dried as a result of deep wells digging in their vicinities. The present study used morphomeristic analysis to characterize fishes and invertebrate fauna in the qanats of Kerman County. Seven fish species and seven invertebrate genres were identified. All fishes were from the Cyprinidae family except for the mosquito fish (Poeciliidae family). *Capoeta aculata* was the most common fish species in the Kerman county qanats. From the insect identified species, the *Hydropsyche* genus was found in all qanats and *Simolium* genus was found in more qanats. The incidence of insect species *Rhithrogena* sp., *Liponeura* sp. and *Ecdyonurus* sp. was related to the incidence of organic pollution. They were only found in high discharge water qanats such as Farmin and Goharriz. This indicates that the high discharge water is necessary to provide adequate water quality for settlement of these species. The results showed that more biodiversity is observable in qanats having higher water volumes.

Keywords: Kerman; Qanat; Fish; Invertebrate; Ecosystem

1. Introduction

A qanat is a water supply system consisting of an underground tunnel connected to the surface by regular openings along its length (Behnia, 2000). In recent decades, it has become evident that groundwater is one of the most important and most vulnerable natural resources. It has been demonstrated that ancient methods of groundwater management, such as the qanat system, provide good examples of human ingenuity to cope with water scarcity in a sustainable manner.

The climate of Iran's central basin is arid and semi-arid. There are no perennial rivers in these regions. Despite the anthropogenic degradation of the aquatic ecosystems and the exploitation of deep wells in their vicinities, qanats remain one of the most important sanctuaries for aquatic animals. Iranian qanats are home to 25 species of fish, including about 40% of the fish

on the Iranian plateau (Abdoli, 2002). In recent years, studies have examined the qanats of the Iranian central basin. Mashkani and Pourkasmani (2004) identified 3 fish species from the Cyprinidae family in 31 qanats in the Birjand central basin. In Bajestan basin qanats, six fish species have been identified from the Cyprinidae, Cyprinodontidae and Balitoridae families (Malek, 2002).

The county of Kerman (44570 km²) is located in southeastern Iran. There are 37 qanats in the county, although some have run dry in recent years because of sustained drought and the increase in deep wells dug in their vicinity (Siadat, 2002). The catastrophic earthquake in Kerman has drawn the attention of researchers to the great human heritage of sustainable management of groundwater in arid zones and the development of a sophisticated culture of rational resource allocation.

Groundwater has a number of key advantages over surface water. It is usually of higher quality, better protected from direct pollution, less subject to seasonal and perennial fluctuation, and more uniformly spread over

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large regions of the world (Siadat, 2002). In present day Iran, there are about 32164 active systems with a total discharge of about 9 billion m³. Since Iran has few perennial rivers and surface water resources, many of its communities have depended on qanats for thousands of years. A significant proportion of fish habitat comprises the small streams, springs, and qanats of Iran. Qanats are an unusual habitat for fish in Iran. Coad and Abdoli (2000) have provided an account of qanat fish with an extensive bibliography. The different fish species in these qanats that have high biodiversity value for these ecosystems (Coad 2000; Mashkani and Pourkasmani, 2004). Ebrahimi (2005) identified 4 fish species in qanats in the Zarand and Sirjan regions of Kerman province, but there is no documented information about aquatic animals in the qanats of Kerman County. The present study identified the fish and invertebrate species of qanats in Kerman County to provide a framework for better management of this important aquatic ecosystem.

2. Material and methods

There are 27 qanats in Kerman County; their hydrological characteristics are shown in Table

1. The sampling methods used in this study were designed based on standard sampling methods for fish and invertebrates and carried out in September 2007. The 3 locations sampled were the water exit point, and at points 100 m and 200 m downstream from the water exit point for both fish and invertebrate sampling (Dale, 1996; Andrew et al., 2001).

The fish were caught using an electro-shocker (AG230/Iran) and spoon net; the fish samples (n=216) then were fixed in 10% formalin and identified at the Kerman research station laboratory. The morphometric characteristics of total length, standard length, body depth, head length, snout length, interorbital width, orbital length, mandible length, body width, width of mouth, barbels, scales on lateral line, dorsal fin spines and soft rays, pharyngeal teeth were recorded (Ebrahimi, 2001; Abdoli, 2002; Toraji and Vosoughi, 2006). The invertebrates were collected using a Surber square-foot sampler (400 cm²) with a 250 µm screen from selected sampling points in the qanats. After screening, the samples were fixed in 4% formalin. The invertebrate samples were then identified using standard identification keys at the Kerman research station laboratory (Ahmadi and Nafisi, 2002; Gorjipour and Asadi, 2007).

Table 1. Hydrological information of Kerman county qanat

<i>Native Qanat name</i>	<i>Location name</i>	<i>Qanat Length (M)</i>	<i>Discharge (L/s)</i>	<i>Water flow point location (U.T.M)</i>
Goharriz	Joupar	4000	242	510211 3322342
Kosarkhiz	Joupar	6000	71.4	511493 3322456
Abgarmoo	Abgarmoo	250	22	531623 3310790
Roghanoo	Roghanoo	200	17	532625 3311119
Aliabad	Aliabad	400	7	533036 3312658
Vakilabad	Mahan	6000	27	534857 3323538
Dastjerd	Dastjerd	950	34	530675 3337731
Neizar	Hoseinabad	11000	38.5	532276 3343022
Koushk langar	langar	2000	9	526794 3317820
Yasaei	Allahabad	3000	17.5	525251 3354173
Ghanateghestan	Ghanateghestan	1500	76.5	520532 3321279
Terooteh	Sarasiab	1000	54	521400 3353891
Amirabad	Joupar	4000	16	519048 3320748
Dehonorari	Dehonorari	3000	4	516176 3321675
Pirzang	Pirzang	4000	38	512433 3324420
Akhlaghi	Hoseinabad	8000	32	411718 3324854

Table 1. Hydrological information of Kerman county qanat

Native Qanat name	Location name	Qanat Length (M)	Discharge (L/s)	Water flow point location (U.T.M)
Karimabad	Karimabad	1800	14	510824 3325417
Ghaderabad	Ghaderabad	3500	12	510704 3325382
Ghasemabad	Ghasemabad	2000	6	510233 3325969
Mohiiabad	Mohiiabad	5000	25.5	510908 3329962
Kohanchenar	Kohanchenar	800	3	509516 3321066
Esmailabad	Esmailabad	6000	42	509642 3322914
Hojatabad	Hojatabad	6000	69	509452 3323159
Hashoueih	Baghein	3000	27	496758 3330842
Ebrahimabad	Ebrahimabad	1800	5	493864 3337542
Tavakkoli	Sekonj	4000	73.5	543701 3317428
Farmintan	Mahan	6000	243	538935 3314922

3. Results

The present study identified 7 fish species (Table 2) and 7 invertebrate genera (Table 3). All fish identified were from Cyprinidae family except for the mosquito fish (Poeciliidae family). *Capoeta aculata* was the most common fish species in the Kerman county qanats (Table 2). The insect species were from *Hydropsyche* genus in all qanats studied and the *Simolium*

genus was most commonly observed (Table 3). The insect species of *Rhitrogena* sp., *Liponeura* sp. and *Ecdyonurus* sp. have been affected by organic pollution in the area and were only observed in Farmintan, Kosarkhiz and Goharriz qanats (Table 3). All qanats provide fresh water for both drinking and agriculture; the physico-chemical properties of the water in these qanats are shown in Table 4 (Kerman Water Research Organization, 2003).

Table 2. Fish identified in Kerman County qanats

Qanat	<i>Gambusia affinis</i>	<i>Alburnoides bipunctatus</i>	<i>Pseudorasbora parva</i>	<i>Garra persica</i>	<i>Capoeta fusca</i>	<i>Capoeta damascina</i>	<i>Capoeta aculata</i>
Goharriz	+	+	+	+	+	+	+
Kosarkhiz	+	—	+	—	—	+	+
Abgarmoo	+	—	—	—	—	—	+
Roghanoo	—	—	—	—	—	—	+
Aliabad	—	—	—	—	—	—	—
Vakilabad	+	—	—	—	+	—	+
Dastjerd	+	—	—	—	+	+	+
Neizar	+	—	—	—	+	—	+
Koushk langar	—	—	—	—	—	—	+
Yasaei	—	—	—	—	—	—	+
Ghanateghestan	+	—	+	—	+	+	+
Terooteh	+	—	—	—	+	—	+
Amirabad	—	—	—	—	—	—	+
Dehhonari	—	—	—	—	—	—	—
Pirzang	+	—	—	—	—	+	+
Akhlaghi	+	—	—	—	+	+	+
Karimabad	—	—	—	—	—	—	—
Ghaderabad	—	—	—	—	—	—	—
Ghasemabad	—	—	—	—	—	—	—
Mohiiabad	+	—	—	—	+	—	+
Kohanchenar	—	—	—	—	—	—	—
Esmailabad	+	—	—	—	+	+	+
Hojatabad	+	—	—	—	+	+	+
Hashoueih	—	—	—	—	—	—	+
Ebrahimabad	—	—	—	—	—	—	—
Tavakkoli	+	—	+	—	+	—	+
Farmintan	+	+	+	+	+	+	+

Table 3. Invertebrates in Kerman County qanats

Qanat	Leech <i>Erpobdella</i> sp.	Snail <i>Limnaea</i> sp.	Insect <i>Ecdyonurus</i> sp.	Insect <i>Rhithrogena</i> sp.	Insect <i>Liponeura</i> sp.	Insect <i>Simolium</i> sp.	Insect <i>Hydropsyche</i> sp.
Goharriz	+	+	+	+	—	+	+
Kosarkhiz	+	+	—	+	+	+	+
Abgarmoo	+	+	—	—	—	—	+
Roghanoo	—	+	—	—	—	—	+
Aliabad	—	+	—	—	—	—	+
Vakilabad	+	+	—	—	—	—	+
Dastjerd	+	+	—	—	—	—	+
Neizar	+	+	—	—	—	+	+
Koushk langar	+	+	—	—	—	—	+
Yasaei	+	+	—	—	—	+	+
Ghanateghestan	+	+	—	—	—	+	+
Terooteh	+	+	—	+	—	+	+
Amirabad	+	+	—	—	—	—	+
Dehonorari	—	+	—	—	—	—	+
Pirzang	+	+	—	—	—	+	+
Akhlaghi	+	+	—	—	—	+	+
Karimabad	+	+	—	—	—	—	+
Ghaderabad	—	+	—	—	—	—	+
Ghasemabad	—	+	—	—	—	—	+
Mohiiabad	+	+	—	—	—	+	+
Kohanchenar	—	—	—	—	—	—	—
Esmailabad	+	+	—	—	—	+	+
Hojatabad	+	+	—	+	—	+	+
Hashoueieh	+	+	—	—	—	+	+
Ebrahimabad	—	+	—	—	—	—	+
Tavakkoli	+	+	—	+	—	+	+
Farmintan	+	+	+	+	+	+	+

Table 4. Physico-chemical properties of water in Kerman County qanats

Qanat	So ₄ (ppm)	Na (ppm)	Mg (ppm)	Ca (ppm)	Cl (ppm)	Hco ₃ ⁻ (ppm)	TDS (ppm)	PH
Goharriz	3±0.4	3.3±0.5	2.7±0.2	4.5±0.6	1.6±0.2	3.2±0.2	842±67	7.9±0.2
Kosarkhiz	3.3±0.3	3.3±0.2	2.6±0.5	4.6±0.7	0.9±0.1	2±0.3	824±52	7.9±0.1
Abgarmoo	2±0.2	1.2±0.1	2.2±0.3	4.3±0.5	1.4±0.2	1.4±0.3	682±104	7.6±0.1
Roghanoo	2.1±0.5	1.8±0.2	2.3±0.3	3.2±0.5	0.8±0.2	1.1±0.2	538±55	7.7±0.1
Aliabad	0.3±0.1	0.8±0.2	0.5±0.1	3.5±0.3	0.6±0.1	1.4±0.3	462±61	7.5±0.2
Vakilabad	3.5±0.4	2.3±0.3	3.2±0.6	2.8±0.2	1.7±0.3	1.6±0.1	750±92	7.5±0.1
Dastjerd	3.5±0.6	5.3±0.5	2.6±0.3	4±0.6	0.7±0.2	1.1±0.2	809±62	7.8±0.1
Neizar	3±0.3	5.3±0.7	2.9±0.4	3.9±0.2	1.8±0.3	2±0.5	703±51	7.7±0.2
Koushk langar	3±0.1	2.2±0.1	3±0.5	4.2±0.9	1.3±0.4	1.8±0.6	704±104	7.6±0.3
Yasaei	3.2±0.9	1.7±0.2	3±0.3	4.4±0.7	1.4±0.2	1.6±0.2	805±38	7.6±0.1
Ghanateghestan	3.5±0.5	2.2±0.4	3.8±0.4	3.8±0.5	1.2±0.1	2±0.2	856±116	7.7±0.2
Terooteh	4±0.7	2.8±0.4	3.1±0.2	3.7±0.9	1.8±0.3	1.6±0.3	849±71	7.5±0.2
Amirabad	4.5±0.7	2.2±0.3	4.3±1.1	5.5±0.8	1.4±0.4	1.6±0.2	887±54	7.7±0.2
Dehonorari	6±1.2	2.8±0.5	4±0.3	7.6±1.7	1±0.2	1.4±0.1	917±122	7.7±0.1
Pirzang	1.5±0.3	0.9±0.1	2±0.1	3.6±0.6	1.2±0.1	1.6±0.1	490±68	7.9±0.2
Akhlaghi	1±0.2	0.8±0.1	1±0.1	3.7±0.4	1.1±0.3	1.9±0.3	375±23	7.8±0.3
Karimabad	3.4±0.5	1.5±0.4	3.6±0.3	5±1.2	1.5±0.3	1.3±0.2	905±144	7.6±0.2
Ghaderabad	2.5±0.7	3.3±0.2	3.3±0.4	4±0.6	1.4±0.2	1.7±0.1	942±103	7.9±0.1
Ghasemabad	9.1±2.3	3.8±0.5	3.9±0.6	3.6±0.2	0.9±0.1	1.2±0.2	947±136	7.5±0.1
Mohiiabad	3.4±0.2	1.6±0.3	3.6±0.5	1.7±0.2	0.9±0.1	1.6±0.1	482±74	7.4±0.3
Kohanchenar	3.8±0.6	2.5±0.5	4.3±1.1	3.5±0.8	1.7±0.5	1.8±0.4	929±88	7.8±0.1
Esmailabad	0.8±0.3	0.4±0.1	0.4±0.1	1.8±0.3	1.6±0.5	1.2±0.1	454±57	7.8±0.1
Hojatabad	2.8±0.5	1.1±0.3	2±0.4	3.4±0.8	1.4±0.3	1.2±0.2	703±118	7.7±0.2
Hashoueieh	3.3±0.8	0.5±0.1	2.3±0.6	5.2±1.3	1.2±0.1	1.2±0.3	717±45	7.8±0.1
Ebrahimabad	2.5±0.4	2.1±0.2	1.5±0.4	4.5±0.6	1.5±0.1	2±0.1	927±122	7.7±0.1
Tavakkoli	1.7±0.2	2.4±0.4	0.9±0.1	8±1.7	0.9±0.1	1.7±0.3	765±71	7.8±0.1
Farmintan	2.7±0.4	0.7±0.2	3.3±0.6	4.5±0.8	1.6±0.4	1±0.3	804±97	7.8±0.2

4. Discussion

The fish in the qanats of Kerman County comprised 25 species of the species found in Coad's study and 40% of the fauna on the Iranian plateau (Coad, 1991). The fauna is

dominated by Cyprinidae, which comprises 76% of the ichthyofauna. In recent years, 3 fish species have been reported in qanats of Zarand and Sirjan regions near Kerman county qanats (Ebrahimi, 2005). The results of the present study show 7 fish species in Kerman county

qanats (Table 2). This may be related to the high water discharge level of qanats in Kerman County.

Ebrahimi (2005) also reported the presence of *Nemachilus sargadensis* in some qanats in Sirjan Qanats, but this fish species was not identified in Kerman County (Table 2). This is probably a result of the physico-chemical properties of the water in the region that influence natural habitat selection. The Kerman and Sirjan basins have different geological formations (Mahdavi, 2005). Qanat fauna are a subset of the basin in which the qanat occurs and include small species and broadcast spawners that do not require specialized food and are non-migratory and widely tolerant of environmental conditions. The results of this study show that the qanats of this county have higher water volumes and more fish biodiversity than in other regions (Tables 1 and 2).

All identified fish, except the mosquito fish (Poeciliidae family) belong to the Cyprinidae family. *Capoeta aculata* had the highest population and was the prevailing fish species. *Gambusia affinis* and *Capoeta fusca* were also found in many qanats. *Alburnoides bipunctatus*, *Pseudorasbora parva* and *Garra persica* were observed only in the qanats with high discharge water (Goharriz and Farmantin). This indicates that high discharge water established adequate water quality for settlement of these species.

Qanats are now rapidly being replaced by pump-wells, which are faster and easier to excavate but do not provide fish habitat. Schemes to restrict water flow from qanats for conservation reasons will also presumably affect available habitat for fish. It is only possible to identify long term methods of rational groundwater use and protection of these species by consideration of the interaction between the groundwater and other environmental components.

All the qanats studied provide fresh water for both drinking and agriculture. The physico-chemical properties of the water in these qanats (Table 4) are similar because they all originate in the quaternary lime formation of Kerman (Mahdavi, 2005). Based on universal standard classification, the concentrations of all physico-chemical factors are in the range for fresh water (EPA, 2001). Because all the fish species and invertebrates are fresh-water, the physico-chemical properties of the water do not significantly influence the distribution of the fish and invertebrates.

Acknowledgments

The authors are grateful to Dr. M. Jafari, Director, to Dr. H. Ahmadi, Deputy of Research, and to Dr. M.K. Reyhan, Head of the Department of Arid Regions Management, of the International Desert Research Center (IDRC) at the University of Tehran. This research was supported by a research grant from the International Desert Research Center (IDRC) at the University of Tehran.

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