JJBS

Volume 12, Number 4,September 2019
ISSN 1995-6673
Pages 495 - 502

Jordan Journal of Biological Sciences

An Update on Freshwater Fishes of Saudi Arabia

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Received November 5, 2018; Revised January 9, 2019; Accepted February 4, 2019

Abstract

In this study, freshwater fishes of Saudi Arabia were surveyed between April and May of 2013 in twenty-two different sites. These sites were selected based on the known published historical distribution. New localities where freshwater fish were known to occur based on local knowledge were also visited. The fish sampling was performed using battery-powered, back-mounted electric fishing gear, and cast nets when deep water was sampled. All the previously recorded species were confirmed except *Carasobarbus apoensis*. *Acanthobrama hadiyahensis* was recorded for the first time after being described almost thirty years ago. The results of this work contribute to the regional assessment of freshwater fishes of Arabia and provide data from the region in particular concerning Saudi Arabia. *Acanthobrama hadiyahensis* was assessed as critically endangered, and *Garra buettikeri* as vulnerable, while all others are considered as least- concern species. Challenges to the viability of freshwater fish populations are increasing, including water extraction and impoundment and the subsequent habitat loss. Invasion by alien species was recorded too (e.g *Oreochromis mossambicus*) and could increase if water extraction and impoundment continue.

Keywords: Arabian Peninsula, Impoundment, Conservation assessment, *Acanthobrama*, *Arabibarbus*, Invasive species

1. Introduction

Freshwater fishes of the Arabian Peninsula are distinguished by their high level of endemism (Krupp, 1983). Out of the twenty-one known species from the Arabian Peninsula, fifteen species are endemic to Arabia, and six species are of a wider distribution (Freyhof *et al*., 2015). The endemics include species that are distributed in three freshwater ecoregions in Arabia (Abell *et al*., 2008). These ecoregions are the Southwest Arabia Coast (fifteen species), Oman Mountains (five species), and the Arabian Interior (ten species), noting that some species may occur in more than one ecoregion. The unique endemism in such an arid region has attracted the attention of ichthyologists since 1870 when Playfair reported a record of *Disconganthus lamtus* from Aden in southern Yemen. Trewavas (1941) described three new endemic species including *Barbus arabicus* (=*Arabibarbus arabicus*), *Garra tibanica* and *Garra britooni* (=*Garra longipinnis*) based on materials brought by the first systematic zoological collections in southwest Arabia, which was performed by the British Natural History Museum between 1937 and 1938. In 1956, Fowler and Steinitz described *Garra barreimiae* from Oman.

In 1977, Banister and Clarke published the most comprehensive revision of the Arabian freshwater fishes in which they added four new species, namely *Barbus apoensis* (=*Carasobarbus apoensis*), *Barbus exulatus* (=*Carasobarbus exulatus*), *Cyprinion acinaces*, and *Garra longipinnis*, in addition to one new subspecies, *Garra barreimiae shawkahensis.* In 1983 Krupp published the second updated taxonomical review of freshwater fishes of Arabia based on the revision of museum materials of previous collections, and frequent field trips to Arabia. Krupp added three new other species of *Garra* to the previously known species of Arabia including *Garra buettikeri*, *Garra mamshuqa*, and *Garra sahilia* in addition to two new subspecies, namely *Cyprinion acinaes hijazi* and *Garra shailia gharbia.*

In the same year, *Acanthobrama hadiyahensis* was described (Coad *et al*., 1983) as a new species of a Levantine origin in Arabia. Alkahem and Behnke (1983) reported "*the first comprehensive scientific collection of freshwater fishes from Saudi Arabia*", based on collections made in 1977 and 1981. A new species was described as *Cyprinion mhalensis*, and notes were given to the unusual specimens of *Garra*, *Cyprinion*, and *Burbus* which indicated the occurrence of other undescribed species.

After these reviews, only a few freshwater fish research has been published throughout Arabia in general and in Saudi Arabian in particular. Additional species were added to the list of Arabian freshwater fishes such as *Garra dunsirei* and *Garra lautior* (Banister 1987), and subspecies such as *Garra barreimiae gallagheri* (Krupp, 1988) which was up levelled in 2016 to *Garra gallagheri* (Lyon *et al*., 2016). In 1998, Ghamdi and Abu-Zinadah published their work on freshwater fishes of the Mid-Western Region of Saudi Arabia, in which they recorded four species; two in the low lands, namely *Aphanius dispar* and *Cyprinion acinaces* and two in the highlands, namely *Garra buettikeri* and *Cyprinion mhalensis*.

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Due to the scarcity of up-to-date data on freshwater fishes of Arabia, the issue of the conservation of freshwater fishes was discussed for the first time at the regional level in the Conservation Assessment and Management Planning (CAMP) workshop in Sharjah, United Arab Emirates in 2002. Ichthyologists from the region and abroad met to analyse the situation of freshwater fishes in Arabia (EPAA, 2002). The lack of updated data and the shortage of national experts in the field of ichthyology were regarded among the top conservation priorities (EPAA, 2003). A few actions were achieved on the ground based on the CAMP recommendations including a field survey to Yemen (Krupp, 2008.), and an analysis of the status of *Garra ghorensis* in sourthern Jordan (Hamidan and Mir, 2003), in addition to the conservation project of Azraq Killifish *Aphanius sirhani* in eastern Jordan, but no updates took place regarding fishes of Saudi Arabia.

The aim of this work is to narrow the gap of knowledge in regard to the recent status of freshwater fishes in Saudi Arabia in the frame of CAMP workshop recommendations (EPAA 2002, and 2003), and to identify the threats that pose challenges to the conservation of these native and endemic populations in light of water shortage and the water harvesting projects in Saudi Arabia.

2. Materials and Methods

2.1. Study Area

This survey covered the western part of Saudi Arabia along the Hijaz Mountains (= Sarawat Mountains) and the Red Sea coastline, with maximum extension north to the last known water bodies in Wadi al-Disi [27°38'0.80"N, 36°32'29.85"E] in Tabouk, and south to Jizan near the Yemeni border [17°17'0.00"N, 43° 6'0.00"E]. The historical distribution of freshwater fishes was reviewed based on Banister and Clarke, 1977, Krupp, 1983, and Alkahem and Behnke, 1983. The authors visited the majority of the sites (Figure 1) listed in the three references except for the eastern side of Arabia along the Gulf coast. New localities where freshwater fishes were known to occur based on local knowledge were also visited (Figure 1, Table 1).

Table 1: Comparison of the results of the present study with previous published research (Coordinates in Degrees and Decimal Minutes)

Species	Study	Location	Coordinates Lat		Lon	
Barbus apoensis = *Arabibarbus apoensis*	Banister and Clarke (1977)	Khamis Mshait	18	17	42	34
		Wadi Turbah	22	56	40	54
		Wadi Adama	19	53	41	57
	Alkahem and Behnke (1983)	Wadi al Mahallah	17	58	43	24
		Stream near Khamis Mushayt				
		Wadi hediah	25	42	39	31
	Krupp (1983)	Wadi turbah	20	29	41	9
		Wadi Turbah	20	30	41	17
		Wadi Turbah	20	29	41	12
		Wadi shuqub	20	39	41	13
		Khamis Mushyat	18	17	42	34
		Wadi Adamah	19	53	41	57
Barbus arabicus = *Arabibarbus arabicus*	Krupp (1983)	Wadi Jufa	17	20	42	8
	Hamidan and Shobrak, present study	Wadi Damad	17	20	43	02
Cyprinion acinaces	Banister and Clarke (1977)	near Ta'if	21	20	40	30
	Krupp (1983)	Wadi Hediah	34	0	39	0
		near Jeddah	25	42	39	12
		WadiSulaym	25	36	39	16
		closed swimming pool nearJeddah				
	Alkahem and Behnke (1983)	Ain al bhair,Khaibar				
		Ain salaleem, Khaibar				
		Ain ali, Khaibar				
	Hamidan and Shobrak, present study	Ain Al-Hammah - Khaibar	25	47	39	26
		Wadi Khadrah	23	06	39	42
Cyprinion incertae sedis	Banister and Clarke (1977)	Khamis Mushyat	18	17	42	34
		WadiHediah	24	0	39	0

Cyprinion mhalensis	Krupp (1983)	Wadi Turabah	20	29	41	9
		Wadi Turabah	20	29	41	12
		Wadi Turabah	20	30	41	17
		Wadi Turbah	20	29	41	9
		Wadi Afrak	19	48	41	18
		Wadi Adama	19	41	42	4
		Wadi Shuqub	20	39	41	13
		Wadi Buwah	20	47	41	12
		WadiShumrukh	20	26	41	18
		Wadi noaman	18	14	42	35
		Asir				
		near Ta'if	21	20	40	21
		Wadi Habayaba between Taif and Sarfa				
	Alkahem and Behnke (1983)	Wadi al Mahallah				
	Hamidan and Shobrak, present study	Wadi Tarj and Tarjes	19	07	42	29
		Wadi Shumrukh	20	45	41	32
		Wadi Al-Arj	21	23	40	45
		Wadi Turabah	20	54	41	28
		Wadi Buwah	37	04	36	14
Garra tibanica	Alkahem and Behnke (1983)	Wadi al Mahallah				
		Ain al Jmyma Khaibar				
		WadiHediah				
		WadiNejran Dam				
	Banister and Clarke (1977)	near Ta'if				
		Khibar				
		Wadi North Jizan	17	32	42	25
		WadiDaga - Tihama coastal plain				
	Krupp (1983)	Hijaz Mountain				
		Wadi Fatima				
		Wadi near Jizan				
		near Jadah, Farag				
		Khaibar	25	42	39	12
		Wadi Ayban				
		Wadi Hesu'a	18	5	42	21
		WadiDamad	17	17	43	6
	Hamidan and Shobrak, present study	Ain Al-Hammah - Khaibar	25	47	39	26
		Wadi Damad	17	20	43	2
		Wadi Khadrah	23	06	39	42
Garra buettikeri	Krupp (1983)	WadiTurabah	20	29	41	12
		Wadi Turabah	20	30	41	17
		Adama, Asir	19	26	42	3
		Adama, Asir	19	41	42	4
		WadiNoval	20	23	41	19
		WadiShumrukh	20	27	41	19
		Abalah 7km from Athnen, Asir	18	51	42	13
		WadiNoaman	18	14	42	35
		Abha, Asir	18	13	42	29
	Hamidan and Shobrak, present study	Wadi Buwah	37	4	36	14
		WadiShumrukh	20	45	41	32
		Wadi Al-Arj	21	23	40	45
		Wadi Turabah	20	54	41	28
		Wadi Al-Bagarah	18	77	41	98
Garra sahilia gharbia	Krupp (1983)	WadiMinsah	20	31	40	40
		Wadi Daga				
		Wadi north of Jizan	17	32	42	25
		Bani Sharfa	19	42	41	24
		WadiGaanah	18	26	41	53
	Hamidan and Shobrak, present study	Alein Al-Harrah	20	46	40	46
		Wadi Kudais	19	15	41	82
		Wadi Al-Gassah	18	72	41	99
		Wadi Al-Bagarah	18	77	41	98
		Wadi Haroub	17	46	42	88

Aphanius dispar	Banister and Clarke (1977)	WadiDaga Tihama coastal plain				
		Khiber north Hejaz				
	Krupp (1983)	al Qatif	26	33	50	0
		al Hufuf	25	24	49	28
		al Hasa Oasis.artesian well	25	29	49	27
		Ghoria spring,al Hasa Oasis				
		Bataliah,al Hasa Oasis				
		Khodod spring,al Hasa Oasis				
		Khaibar, Hijaz				
		Wadi fatima near Jeddah				
		Wadi Daga				
		al Qatif	26	23	50	0
		al Khari	24	21	47	11
	Hamidan and Shobrak, present study	Wadi Khulab	16	76	43	12
		Wadi Al-Bagarah	18	77	41	98
		Ein Al-Buhairah	25	72	39	26
		Wadi Kudais	19	15	41	82
		Wadi Khadrah	23	06	39	42
Acanthobrama hadiyahensis	Coad *et al* (1983)	Wadi Hadiyah	25	33	38	44
	Hamidan and Shobrak, present study	Sad Al-Bint	25	29	39	21
Wadi was dry	Hamidan and Shobrak, present study	Wadi Al-Oshar	19	80	41	60
Wadi was dry		Wadi Olaib	20	03	40	83
No fish were found		Wadi Aqabat Sal'a	17	87	42	38
No fish were found		Wadi Shougab	20	66	41	24
No fish were found		Wadi al Disi	27	60	36	43

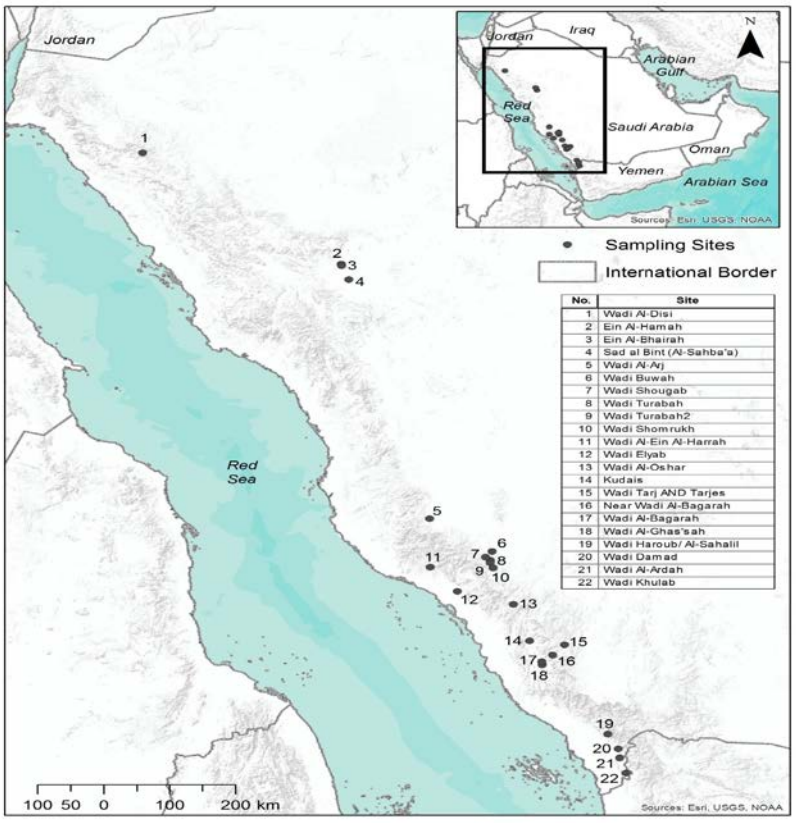

Figure 1. Sampling sites along the Red Sea coast in Saudi Arabia and the Hijaz Mountains.

2.2. Fish Sampling

Fishes were sampled between April and May, 2013 from twenty-two sampling sites (Figure 1). The sampling sites elevation varied from 1935 metres above mean sea level (amsl) at Wadi Tarj-Tarjes in the Tanoumah area, down to 177 metres amsl at Wadi al-Lieth in the Lieth governorate. The sampling involved the use of battery-powered, back-mounted electric fishing gear. At deep sampling sites (e.g. Wadi Al Ghassah) where electric fishing was not possible, cast nets of 18 mm mesh size were used. The sampled fishes were identified up to the species level based on Banister and Clarke, 1977, Krupp, 1983, and Alkahem and Behnke, 1983 for those species with clear morphological features that enable their field

identification (e.g. *Cyprinion*), while others (e.g *Garra*) were transferred to the laboratory for further identification. The identified fishes were released back to their sampling sites except for representative specimens that were taken to establish a reference collection at the Al-Taif University. All specimens were processed in the field before being taken to the laboratory in an over anaesthetised clove oil (Soto, 1995) followed by preservation in 76 % ethanol, after which each specimen was assigned a reference number. Living specimens were photographed on site in a small aquarium (8″ wide, 8″ height, 2″ depth).

3. Results

Eight native species were recorded in this study (Table 1), in addition to one introduced Cichlid species (*Oreochromis mossambicus*). The survey confirmed the survival of two species that had never been sampled for the past thirty years; these species included *Acanthobrama hadiyahensis* in al-Thamad area in Khaibar, and *Arabibarbus arabicus* in Wadi Damad in Jizan. The two common species collected were *Cyprinion mhalensis* in and around Taif, and *Garra sahilia gharbia* along the southern Red Sea coastline west of the Hijaz Mountains.

Acanthobrama hadiyahensis Coad, Alkahem & Behnke, 1983

This species (Plate 1.A) was caught in the pond behind the ancient Qusaiba'a Dam (Plate 1.B) in Al-Thamad area of Khaiber city about 30 km southwest of the type locality in Wadi Hadiyah. The dam is located within the basalt desert (Al-Harra) of a coastal drainage basin. The dam impounds runoff water that may stay mostly all year around. One specimen of a standard length (*LS*) 80.08 mm and one juvenile of 12 mm (*LS*) were the only fish that were caught from the lake of the dam. The juvenile was caught by an aquatic invertebrate net.

The larger specimen was kept as a sample while the juvenile was released alive back to the water. Despite the fact that the species is threatened, having one specimen was of critical importance to act as a voucher and to promote further conservation and research. Thus the larger specimen was deposited in the collection of the Natural History Museum in London with the reference number BMNH 2013.10.1.2

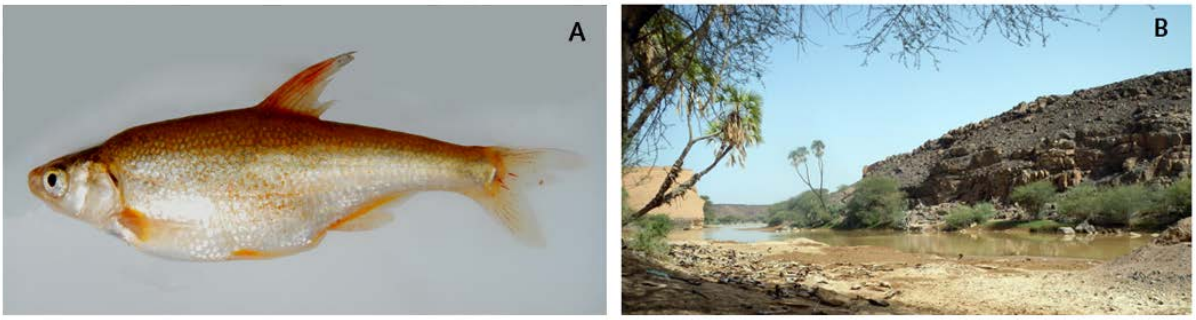

Plate 1. A: *Acanthobrama hadiyahensis* the large specimen of 80.08 mm standard Length, **B**: The Qusaiba'a Dam (Locally known as Sadd Al-Bint) in Al-Thamad area of Khaiber where *A. hadiyahensis* was sampled [Lat: 25.485373°, Long: 39.363197°].

Arabibarbus arabicus (Trevawas, 1941)

This species (Plate 2.A) was collected from Wadi Damad in southern Jizan. The wadi contains fast flowing waters, with a narrow width that reaches up to approximately 10 metres in some locations. Five specimens of *Arabibarbus arabicas* were caught as specimens. This species was in association with the endemic *Garra tibanica*.

Cyprinion acinaces Trevawas, 1941

This species (Plate 2.B) was collected only from Ein al-Hamah near Khaiber. The species coexisted with *Garra tibanica*, and *Aphanius dispar*. The sampling site was a slow running stream with shallow ponds along the stream. In the ponds, *C. acinaces* and *G. tibanica* were found actively feeding, while *A. dispar* was found in the slow-running stream. (Plate 2.B).

Cyprinion mhalensis Alkahem & Behnke, 1983

This species (Plate 2.C), which was abundant in Taif, was collected from four locations around Taif in Wadi al-Arj (1585 m amsl), Wadi Turabah (1365 m amsl), Wadi Shumrokh (1554 m amsl), and Wadi Buwah (1371 m amsl). However, it was also collected at higher elevations (1935 m amsl) in the confluence of Wadi Tarj and Wadi Tarjis in Tanomah area. The density of this species was higher than the co-inhabitant *G. buettikeri* in Wadi Turabah, and Wadi Shumrokh (98 % of total catch). While it was the only species found in Wadi Tarj, and Wadi Tarjis, it was found to coexist with *G. tibanica* in Wadi Buwah.

Plate 2. A. *Arabibarbus arabicus*, B. *Cyprinion acinaces*, C: *Cyprinion mhalensis*

Garra buettikeri Krupp, 1983

This *Garra* species was sampled around Taif in Wadi al-Arj (three specimens), Wadi Turabah (two specimens), and Wadi Shomrukh (one specimen) in low numbers compared to *C. mhalensis*. In Wadi Shomrukh, the largest specimen (Plate 3.A) was collected (17 cm in *Ls*). This species was found to share habitats with *C. mhalensis.*

Garra sahilia gharbia Krupp, 1983

This was the most common *Garra* (Plate 3.B) found at the western part of southern Hijaz Mountain. It was the only species found in the south in Wadi Haroub in Jizan, and Wadi al-Ghassah. It was a predominant species compared to the Arabian cypriniodont *Aphanius dispar* in the wadi al-Lieth hotspring (Ein al-Harrah), Wadi Kudais, and Wadi al-Bagarah.

Garra tibanica Trewavas, 1941

The species (Plate 3.C) was found in three localities. It was collected from the south in Wadi Damad in the Jizan region with *Arabibarbus arabicus*, and in Wadi al-Bagarah in association with *G. s. gharbia* and *A. dispar*. It was also collected from the north at Khaibar in Ein al-Hamah in association with *C. acinaces* and *A. dispar*.

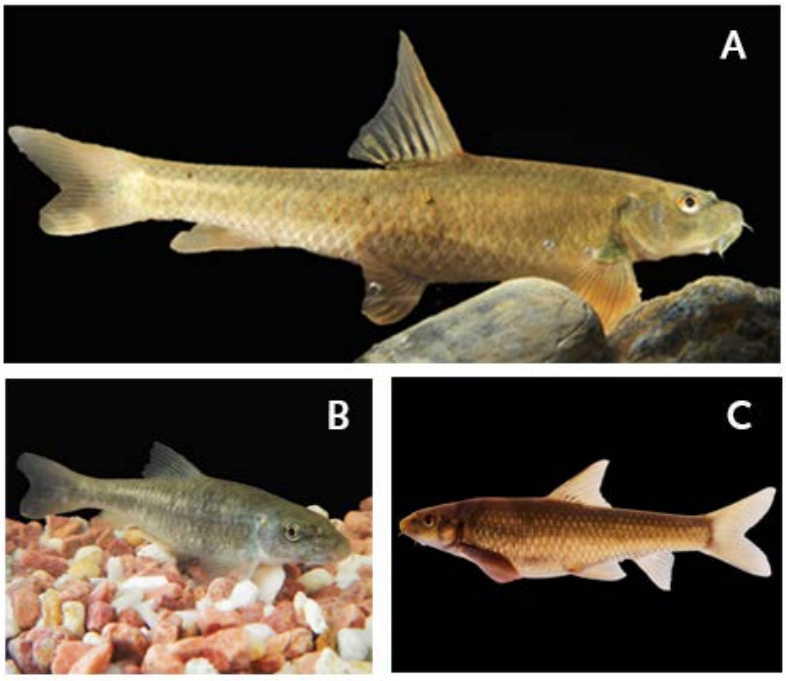

Plate 3. A: *Garra buettikeri*. B: *Garra sahilia gharbia*, C: *Garra tibanica*

Aphanius dispar (Rüppell, 1828) Plate 4

This was a common species sampled from seven localities. It was collected from Wadi Khulab where no other species were sampled, in Wadi al-Bagarah in association with *G. s. gharbia* and *G. tibanica*, and Wadi Kudais and Ein al-Harrah in association with *G. s. gharbia*. In Khaibar it was sampled from Ein al-Hammah and Wadi Khadrah in association with *G. tibanica* and *C. acinaces*, and in Ein al-Buhairah with the introduced *Oreochromis mossambicus.*

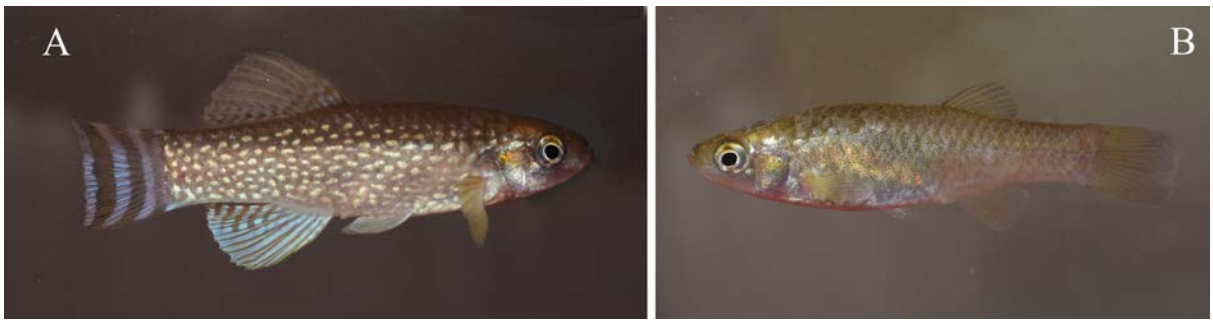

Plate 4. *Aphanius dispar* male (A), *Aphanius dispar* female (B), both from Wadi Khadrah, Al-Madinah al Munawwarah.

4. Discussion

This work identifies the survival of all known freshwater fishes of Saudi Arabia except for *Arabibarbus apoensis* that was regarded as common in the available literature (Banister and Clarke, 1977, Krupp, 1983, and Alkahem and Behnke, 1983), but was not found in this survey. Both *Acanthobrama hadiyahensis* (Hamidan and Al-Aoufi 2014) and *Arabibarbus arabicus* were collected after thirty years of their last published collection (Krupp, 1983). Although the fieldwork did not cover all known localities of freshwater fish distribution known in the literature, it, nonetheless, explored sites where both permanent/seasonal water habitats and endemic species are known to occur (Table 1). The survey confirmed the viability of freshwater systems to host those endemic species such as Wadi Tarj-Tarjes that are not impacted, while other freshwater systems are heavily impacted, especially those systems around Taif area such as Wadi Turbah, Buwah, and Shomrukh, which is previously known to be one of the major freshwater ecosystems in the Taif region (Krupp, 1983). A recent sampling of freshwater fishes in Saudi Arabia was carried out in 2013 in Wadi Buwah (Zubair, *et al*., 2013) where the authors collected *C. mhalensis* from the wadi for food analysis. However, they did not record any notes regarding the density of fish, species assemblage, or the impact on this wadi, which did not allow the comparison of the status of *A. apoensis*. The escalating demands for water in arid regions have resulted in the substantial physical modification of many river systems through the construction of dams for instance, and activities, including water extraction (Propst *et al.,* 2008). The resulting disturbed river environments, with losses of lateral and longitudinal connectivity, and degraded key habitats for specific fish life stages raise concerns over the consequences which may hinder the sustainability of populations of native and endemic species, particularly those that are already under threat (Kingsford 2000). This was addressed in the CAMPs meeting as a potential coming threat, and precipitated the idea of updating the freshwater fish status in one of the three major freshwater eco-regions in the Arabian Peninsula (Abell *et al*., 2008).

Disturbed environments are often more vulnerable to the invasion of non-native species, because they possess more generalist traits and show high adaptability to different environments which enables them to take advantage of all modified conditions (McKinney 1997; Marvier *et al*., 2004). Whilst this combination of habitat disturbance and invasion increases the risk for local native fish populations to be extirpated and endemic fishes to become extinct (Olden and Poff 2005), this risk varies among species according to their traits and their ability to adapt to the modified environment and coexist with invasive species (Olden *et al*., 2006, 2008; Hamidan and Britton 2015a, b).

Freyhof *et al*. (2015) summarized the threats facing freshwater fishes in the Arabian Peninsula in general saying that water extraction and impoundment and the consequent habitat loss come first. In Saudi Arabia, the construction of the large-scale project of Wadi Turabah Dam, for example, was found to change the nature of the wadi by creating a deep and large pool, and reducing the flow in the habitats of the freshwater fishes of the wadi. This setting can control the flow of water that is a determining factor in the reproductive success of native species in regulated rivers (Brown and Ford, 2002), and flush out the juvenile and fry fishes from their habitats in the event of unexpected artificial flood during summer for cleaning (Asadollah, 2011, Hamidan, 2014). On the other hand, the dam lake promotes an "invasive friendly receiving environment" for non-native and/or non-indigenous species such as *Oreochromis mossambicus.* Pollution was also reported as an existing threat (Frehhof *et al*., 2015) although no comprehensive data are available concerning chemical or biological pollutions. Potential threats including climatic impact, harvesting, and introduction were also mentioned. This survey revealed that the introduction of alien species is minimal, but may increase as a result of potential habitat changes or losses and due to the construction of dams.

In conclusion, Saudi Arabia still hosts the eight Arabian endemic species with different status, despite the fact that threats, facing freshwater fishes in particular, and water habitats in general, are increasing. The results of this work had contributed to the regional assessment of freshwater fishes of Arabia (Freyhof, *et al*., 2015) which is characterized by scarcity of data from the region, in particular regarding Saudi Arabia and Yemen. Only *A. hadiyahensis* was assessed as critically endangered, while *G. buettikeri* was regarded as vulnerable and all others were considered as least-concern species.

Acknowledgements

The researchers deeply appreciate the generous financial and logistic support of the Deanship of Academic Research at Taif University. Thanks are also extended to the Saudi Wildlife Authority which has facilitated the research work and provided the needed permissions. The authors would like to express their gratitude to Mr Yehya Khalid the general manager of the Royal Society for the Conservation of Nature (RSCN) for his support in this research and allocating RSCN's resources for this purpose. The Environment and Protected Areas Authority in Sharjah/ UAE are acknowledged for the CAMP initiative that guided the researchers to narrow the gap of knowledge about the current status of freshwater fishes in Arabia. We would like to thank Dr Abdul Hadi Al Aoufi for his companion and guidance in the Northern areas, and in Madina al Munawwarah. The authors are also grateful to Dr Robert Britton for his directive inputs in the planning stage, Drs. Christopher R. Boland and Christopher Goldspink for their critical comments on the original manuscript.

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