

Structure and ecological indices of fish assemblages in the recently restored Al-Hammar Marsh, southern Iraq

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Abstract

The aim of the present study is to determine the species composition, the structure of the fish assemblages, and to develop ecological indices in the restored east Al-Hammar Marsh. Fish were collected from October 2005 to September 2006 at two stations (Mansoury and Burkah). Fish samples contained freshwater species, both native and alien, and marine species. Thirty-one species were collected, eleven of them marine, the rest freshwater. Native species numbered 14 (45%), alien species 6 (19%) and marine species 11 (36%). Resident species formed 32.2%, seasonal species 16.0% and occasional species 51.6% of the fauna. The abundance of species varied, *Liza abu* being the most dominant species, with *Carassius auratus* ranking second and *Acanthobrama marmid* ranking third, comprising 35.8%, 23.6% and 10.6% respectively. Ecological indices were as follows: diversity ranged from 1.07 in November to 2.01 in July, richness ranged from 0.74 in December to 2.83 in July, and evenness ranged from 0.48 in November to 0.84 in December. The highest monthly similarity was in May at 77% and lowest in December at 29%. Water temperature showed medium correlations (0.62 and 0.58) with both the number of species and the total catch, respectively, while salinity exhibited weak positive correlations (0.05 and 0.26) with both the number and the total catch of species, respectively. Temperature is related to species number, presumably as a surrogate for many other seasonal changes.

Keywords

Species composition, fish assemblage, ecological indices, tidal marsh diversity, Mesopotamian marshes, alien species, Iraq

Introduction

The marshes of southern Iraq were the largest wetlands in south-western Asia, covering more than 15,000 km² and representing about 44% of the inland freshwater bodies of Iraq. These marshes were a natural refuge for many aquatic organisms, especially fish and waterfowl. The environmental, hydrological and physiographical setting formed a unique ecosystem, allowing high biodiversity and richness of the aquatic biota. The marshes were also characterized by their productivity (Al-Hilli 1977, Al-Hilli et al. 2009, Al-Zubaidy 1985, Al-Mayah 1992) and consequently were the richest and rarest biotope in the region. The Mesopotamian marshes were considered by FAO (1999) as the major source of inland fisheries (60%) in Iraq, estimated at 23,600 tonnes (Partow 2001). They were the permanent habitat for millions of waterfowl and a flyway for millions more migrating between Siberia and Africa (Evans 2002).

Al-Hammar Marsh is situated south of the Euphrates River and extends from Nasiriyah City in the west of Iraq to the outskirts of Basrah City on the Shatt al-Arab River in the east. To the south is the saline-brackish Main Outfall Drainage (MOD) channel, sabkhas and the sand dune belt of the southern desert. The marsh area comprises 2800 km² of permanent marsh, expanding to over 4500 km² during the period of spring flooding and temporary inundation (Iraq Foundation 2003).

The formation of Al-Hammar Marsh was due to the deposition of the suspended load of the Tigris-Euphrates rivers and resulted in a shift from brackish lagoon and coastal marsh to inland marsh, occupied by fresh to brackish water (Aqrawi 1993, Aqrawi and Evans 1994).

Al-Hammar Marsh is the largest southern marsh extending through two provinces (Basrah and Nasiriyah). It is approximately 120 km long and 25 km wide. Maximum water depth in the marsh ranges from 1.8 m to 3.0 m. The marsh narrows about its middle, and consequently can be divided roughly into two parts, west and east, connected by a shallow channel (Fig. 1).

Planned drainage processes started in the early 1990s to divert the riverine water of the Tigris, Euphrates and Shatt al-Arab rivers away from the southern marshlands, resulting in a catastrophic loss of the native aquatic flora and fauna. In 2002, 93% of the permanent marshes defined in 1973 had been destroyed. Only 14.5% of the Al-Hammar Marsh remained (Richardson and Hussain 2006). Since 2003, great efforts have been made to restore the marshes and revive the wetlands environment. As of August 2007, the marshes had recovered almost 58% of their former area in 1972 according to UNEP/IMOS (2007).

After reflooding in April 2003, the west part of Al-Hammar Marsh was fed primarily from tributaries of the Euphrates, but the eastern part received a considerable amount of water from the Shatt al-Arab River, and groundwater recharge was another source of replenishment. The eastern part of Al-Hammar is a tidal marsh affected by the semi-diurnal tide from the Arabian Gulf, with well oxygenated oligohaline water, grey mud-silt sediments with low total organic carbon (TOC), and an alkaline pH (Hussain and Taher 2007, Tahir et al. 2008).

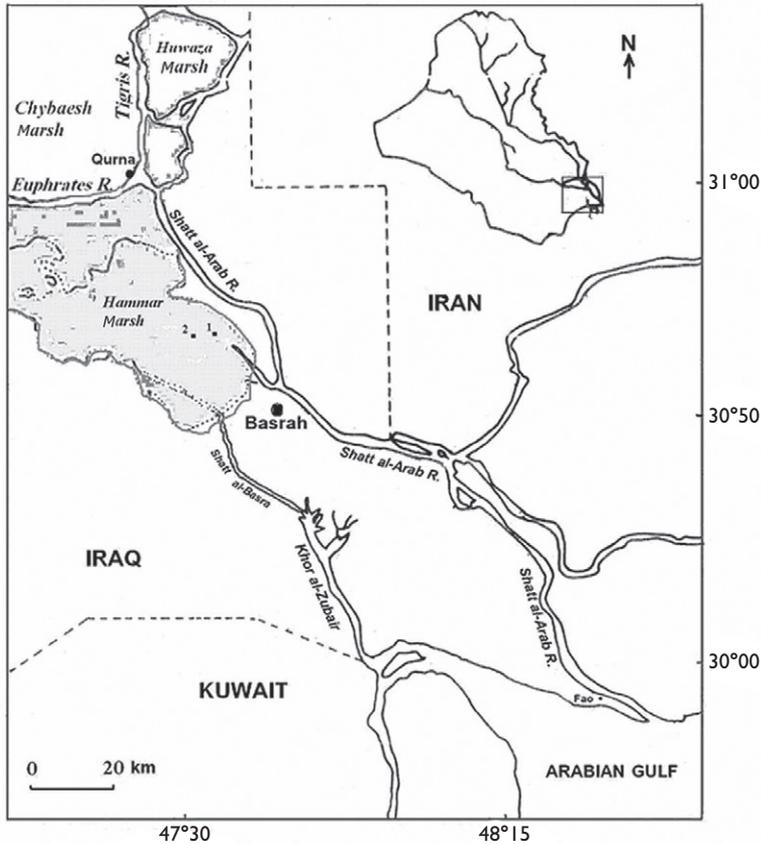


Figure 1. Map of southern of Iraq, showing the location of Al-Hammar Marsh (1 Mansoury Site, 2 Burkah Site).

The structure of the fish assemblage in the southern marshes has not been studied. A few taxonomic works refer to the marshes in passing (Khalaf 1961, Mahdi 1962, Coad 1991) and recently reports on the environmental restoration of the southern marshes have appeared (e.g., IMRP 2006, ARDI 2006) along with articles concerned with the occurrence and biology of marine and diadromous fish (Mohamed et al. 2009). Most previous studies have focused on biological aspects of some of the fresh-water fishes in Al-Hammar Marsh (Barak and Mohamed 1983, Dawood 1986, Jasim 1988, Al-Sayab 1989, Al-Kanaani 1989).

The aim of the present study is to determine the structure of the fish assemblage and the species composition in the restored Al-Hammar Marsh. Previously, no studies were conducted on the diversity of the fishes, taking into consideration their relative abundance, the monthly changes in ecological indices, and the similarity between sampled months coupled with the effects of environmental factors like water temperature and salinity.

Material and methods

From October 2005 to September 2006, fishes were collected monthly from two selected sites, both in east Al-Hammar: (1) Mansoury (30°40'32"N 47°37'21"E), environmentally considered as a tidal channel marsh and desiccated freshwater station, and (2) Burkah (30°40'22"N 47°33'03"E), a tidal open water marsh and desiccated station (Fig. 1). Sampling was carried out using a seine net (20 m long with a 2.5 cm mesh), fixed gill nets (50 m to 100 m long with 2.5 cm to 10 cm mesh size), and electro-fishing gear. Specimens were immediately transported to the laboratory on crushed ice. Water temperature and salinity were measured to determine the relationships of these two factors with the number of species and total catch of species. Fishes were identified to species by using Khalaf (1961), Mahdi (1962), Beckman (1962) and Coad (1991).

The ecological indices of the fish assemblage in east Al-Hammar Marsh, namely relative abundance, diversity, evenness, richness and similarity were calculated monthly according to Odum (1970), Shanon and Weaver (1949), Pielou (1977), Margalef (1968) and Boesch (1977), respectively. Fish species were divided into three categories according to their temporal occurrence in the monthly samples following Tyler (1971).

Results

Effects of abiotic factors

The monthly fluctuations in air and water temperatures and salinity in east Al-Hammar Marsh are illustrated in Fig. 2. Air temperature ranged from 15°C in February to 33°C in June and water temperature changed from 12.5°C in February to 29°C in July. The minimum value of salinity was 1.2 mg/l in August and the maximum value was 2.0 mg/l in May and July.

The relationships of water temperature and salinity with the total catch of individuals and the number of species in Al-Hammar Marsh are shown in Fig. 3. Water temperature showed a significant positive correlations with the number of species ($r = 0.620$, $p < 0.05$) and the total catch of fish individuals ($r = 0.578$, $p < 0.05$), while the salinity showed very weak positive correlations with both of them, $r = 0.056$ and $r = 0.262$, $p < 0.05$, respectively.

Species composition and temporal occurrence

The overall number of fish species caught from the marsh was 31, belonging to 14 families (Table 1). Cyprinidae, the dominant family in terms of number of species was represented by 12 species: *Aspius vorax*, *Carassius auratus*, *Barbus luteus*, *B. sharpeyi*, *B. xanthopterus*, *B. grypus*, *Cyprinus carpio*, *Ctenopharyngodon idella*, *Acanthobrama*

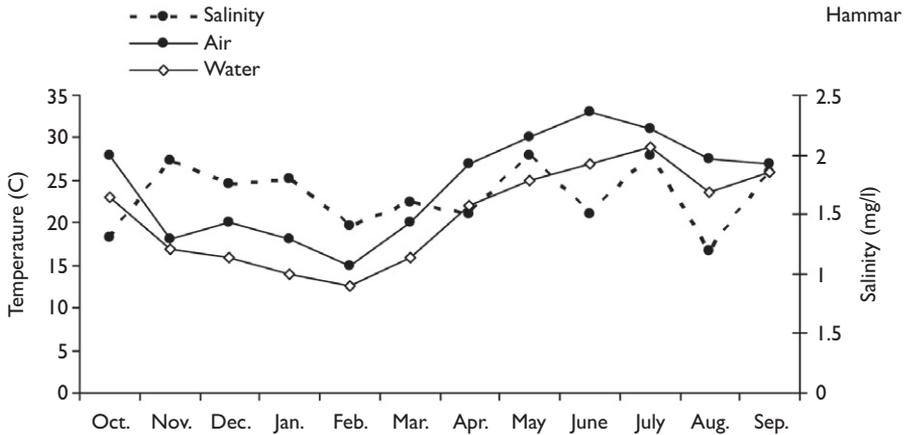


Figure 2. Monthly fluctuations in air, water temperature and salinity in east Al-Hammar Marsh (2005–2006).

marmid, *Cyprinion macrostomum*, *Alburnus mossulensis*, and *Alburnus* sp. Other species belonged to the families Mugilidae (*Liza abu*, *L. subviridis* and *L. klunzingeri*), Sparidae (*Acanthopagrus latus* and *A. berda*), Cyprinodontidae (*Aphanius dispar* and *A. mento*), Poeciliidae (*Gambusia holbrooki* and *Poecilia latipinna*), Gobiidae (*Bathygobius fuscus* and *Boleophthalmus dussumieri*), Clupeidae (*Tenulosa ilisha*), Siluridae (*Silurus triostegus*), Mastacembelidae (*Mastacembelus mastacembelus*), Heteropneustidae (*Heteropneustus fossilis*), Engraulidae (*Thryssa whiteheadi*), Scatophagidae (*Scatophagus argus*), Hemiramphidae (*Rhynchorhamphus georgii*), and Soleidae (*Brachirus orientalis*).

The fish fauna of eastern Al-Hammar Marsh may be broadly classified into three groups: native freshwater, alien and marine fish species. Fourteen native freshwater species (*Aspius vorax*, *Barbus luteus*, *B. sharpeyi*, *B. xanthopterus*, *B. grypus*, *Acanthobrama marmid*, *Alburnus mossulensis*, *Alburnus* sp., *Cyprinion macrostomum*, *Liza abu*, *Aphanius dispar*, *A. mento*, *Silurus triostegus* and *Mastacembelus mastacembelus*) constituted 45.1% of the total number of species. Six alien freshwater species (*Cyprinus carpio*, *Heteropneustus fossilis*, *Gambusia holbrooki*, *Carassius auratus*, *Ctenopharyngodon idella* and *Poecilia latipinna*) formed 19.4% of the total number of species. Eleven marine species (*Tenulosa ilisha*, *Liza subviridis*, *L. klunzingeri*, *Acanthopagrus latus*, *A. berda*, *Boleophthalmus dussumieri*, *Thryssa whiteheadi*, *Scatophagus argus*, *Bathygobius fuscus*, *Rhynchorhamphus georgii* and *Brachirus orientalis*) comprised 35.5% of the total number of species.

The monthly variations of native, alien and marine species in Al-Hammar Marsh are illustrated in Fig. 4. The highest numbers of total, native and marine species were in July and the lowest in December. There was a slight variation in the number of alien species throughout the year.

Species occurring temporally in the Al-Hammar Marsh were classified into three groups. The resident species were ten. Four of them appeared in all 12 months (*Liza abu*, *L. subviridis*, *Carassius auratus* and *Acanthobrama marmid*), one in 11 months

(*Barbus luteus*), four in 10 months (*Cyprinus carpio*, *Aspius vorax*, *Alburnus mossulensis* and *Heteropneustus fossilis*) and one in nine months (*Silurus triostegus*). The resident species, forming 32.3% of the total number, consisted of native, alien and marine species. Of the five seasonal species, *Thryssa whiteheadi* was captured in eight months and *Tenualosa ilisha* and *Barbus sharpeyi* in seven months, and the remaining two in six months (*Bathygobius fuscus* and *Aphanius dispar*). The seasonal species comprised 16.1% of the total number of species and the occasional species 51.6%. Sixteen species were categorized as occasional, two of them appeared in three months (*Aphanius mento* and *Cyprinion macrostomum*), two in two months (*Barbus xanthopterus* and *Acantho-*

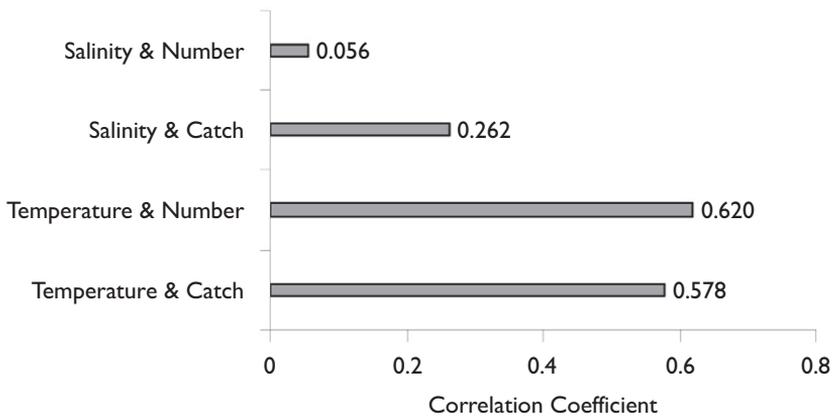


Figure 3. The relationships of water temperature and salinity with the total catch of individuals and the number of species in Al- Hammar Marsh

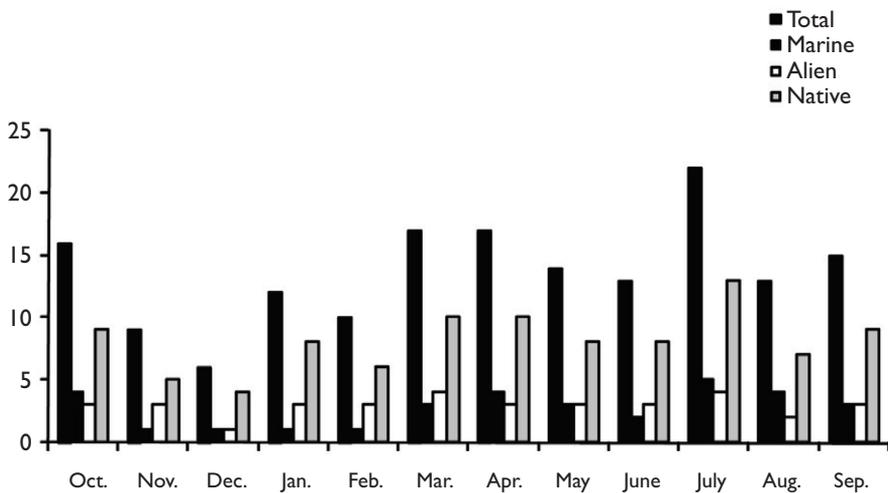


Figure 4. Monthly occurrence of total, native, alien and marine species in Al-Hammar Marsh

pagrus latus) and twelve in one month (*Barbus grypus*, *Mastacembelus mastacembelus*, *Boleophthalmus dussumieri*, *Scatophagus argus*, *Gambusia holbrooki*, *Ctenopharyngodon idella*, *Acanthopagrus berda*, *Rhynchorhamphus georgii*, *Poecilia latipinna*, *Brachirus orientalis*, *Liza klunzingeri* and *Alburnus* sp.).

The monthly variation of similarity of fish species composition in the marsh during the study period is shown in Fig. 5. The highest similarity level was found during May (77%) and the lowest during December (29%). Generally, the similarity level was high during the spring and summer months.

Relative abundance and ecological indices

A total of 16,199 fishes belonging to 31 species were collected from Al-Hammar Marsh, the highest number (2920) being in September and the lowest (800) in December. *Liza abu* was the most abundant species comprising 35.9% of the total number followed by *Carassius auratus* (23.6%), *Acanthobrama marmid* (10.8%) and *Tenualosa ilisha* (10.1%). The previous four species accounted for over 80% of the total catches. *Liza abu* was the dominant species throughout the year except October, with a peak in April. *Carassius auratus* was second in dominance (Table 1).

Monthly variations in ecological indices of species are illustrated in Fig. 6. The diversity index fluctuated from 1.07 in November to 2.01 in July, with an overall value of 1.53. The richness index ranged from 0.74 in December to 2.83 in July, with an overall value of 1.76. The evenness index ranged from 0.48 in November to 0.84 in December, with an overall value of 0.60.

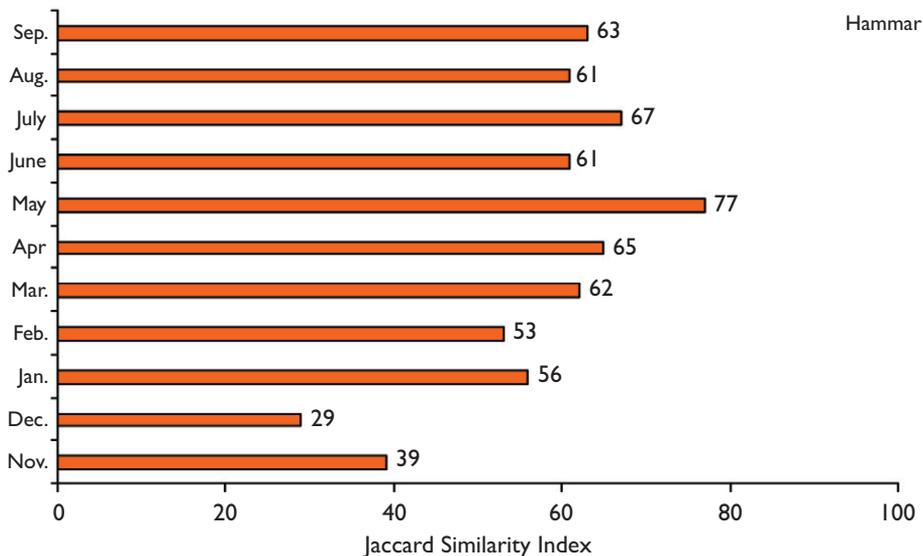


Figure 5. Monthly variations of similarity of species in Al-Hammar Marsh

Table 1. Monthly relative abundance (%) of fish species caught in the Al-Hammar Marsh.

Fish species	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Total
<i>Liza abu</i>	23.9	47.9	30.6	47.1	38.5	20.8	43.4	37.8	41.7	32.1	60.8	25.2	35.85
<i>Carassius auratus</i> +	42.8	41	20.5	28.7	23.5	18.9	28.6	21	34.5	23.8	15.4	6.4	23.6
<i>Acanthobrama marmid</i>	1.4	7.6	29	16	31.4	30.6	16.7	8.9	1.8	3.5	5.5	1.78	10.79
<i>Tenualosa ilisha</i> *	18.7					0.08	0.06	0.1		15.7	1.4	38.6	10.05
<i>Thryssa whiteheadi</i> *	3.2					0.3	0.12	0.7	0.4	1.9	8.7	14.9	3.79
<i>Alburnus mossulensis</i>	4.62	2	13.4	3.7	2	14.2	1.59	3.4	1.1	0.78		3.79	3.9
<i>Cyprinus carpio</i> +	0.17			0.2	0.1	0.3	0.29	17.2	11.1	3.2	0.9	0.7	2.86
<i>Aspius vorax</i>	0.3	0.09		0.2		0.38	0.77	3.9	6.1	1.34	2.3	2.8	1.78
<i>Barbus lateus</i>	0.3		0.3	0.2	1.5	0.84	1.4	2.5	1.1	3.8	3.6	2.2	1.65
<i>Liza subviridis</i> *	3.7	0.2	6.3	2.2	1.6	2.4	1.4	0.2	0.9	0.6	0.49	1.6	1.63
<i>Silurus triostegus</i>	0.3	1.1				0.76	1.95	3.2	0.3	0.42	0.6	0.27	0.76
<i>Heteropneustes fossilis</i> +	0.08	0.09		0.2	0.6	3.04	2.48	0.5	0.7	0.12		0.03	0.68
<i>Pocilia latipinna</i> +										6			0.62
<i>Cyprinion macrostomum</i>										4.3	0.2	0.03	0.46
<i>Aphanius dispar</i>	0.08			0.3	0.5	4		0.2		0.06			0.4
<i>Boleophthalmus dussumieri</i> *	0.08												0.006
<i>Aphanius mento</i>						3.12	0.24		0.4				0.31
<i>Alburnus sp.</i>												1.5	0.27
<i>Bathygobius fuscus</i> *	0.08			0.2			0.94	0.4	0.1	0.06			0.17
<i>Barbus sharpeyi</i>	0.08				0.3	0.08	0.06			0.7	0.1	0.2	0.15
<i>Acanthopagrus latus</i> *							0.06			1.1			0.12
<i>Barbus grypus</i>										0.2			0.05
<i>Mastacembelus mastacembelus</i>				0.8									0.05
<i>Barbus xanthopterus</i>						0.15				0.06			0.02
<i>Liza klunzingeri</i> *										0.18			0.02
<i>Scatophagus argus</i> *													0.006
<i>Gambusia balrooki</i> +													0.006
<i>Ctenopharyngodon idella</i> +		0.09				0.08							0.006
<i>Acanthopagrus berda</i> *													0.006
<i>Rhynchorhamphus georgii</i> *							0.06				0.1		0.006
<i>Brachirus orientalis</i> *													0.006
Total No. fish										0.06			16199

* Marine species + Alien species

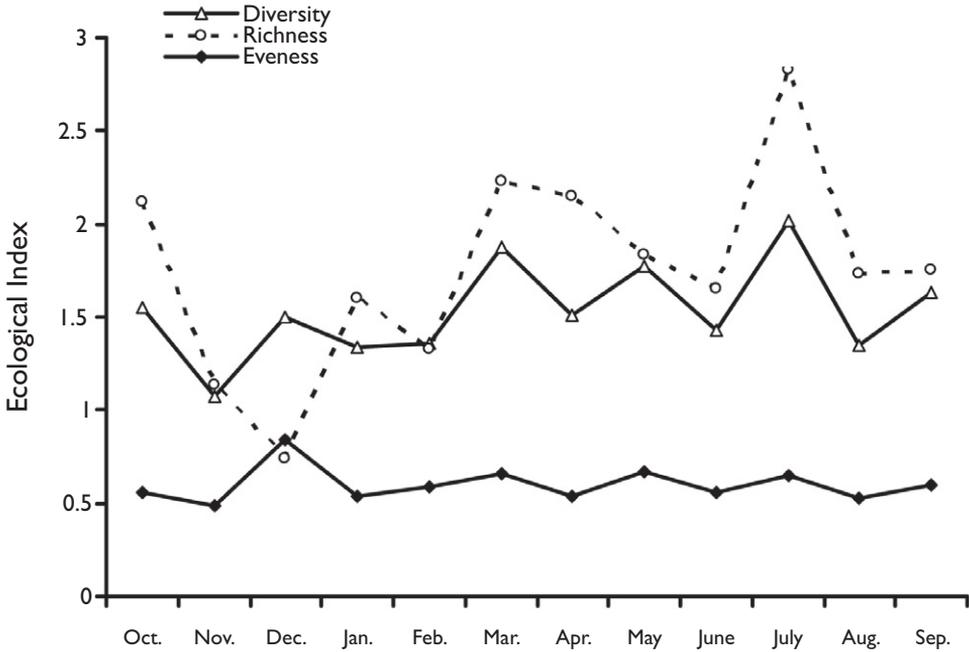


Figure 6. Monthly variations in ecological indices of fish species composition in Al-Hammar Marsh.

Discussion

Coad (1991) gave the total number of fishes in fresh waters of Iraq as 58 consisting of 43 freshwater, eight marine and seven exotic species. The number of species collected from the restored Al-Hammar Marsh was 31, nearly similar to a previous estimate by Al-Daham (1982) at 33 for all southern marshes. However, the species constitution was different from historical observations, several freshwater species having disappeared due to the long desiccation and degradation of the Al-Hammar environment, and the numbers being added to by more alien and marine species (Khalaf 1961, Mahdi 1962).

The deterioration of water quality of the Al-Hammar Marsh led to several cyprinid species disappearing even before the desiccation, e.g., *Barbus subquincunciatus* and *B. scheich*, which disappeared due to an increase in salinity from 0.4g/l in the 1970s (Al-Saadi et al. 1981) to 6.3g/l in the early 1990s (Al-Rikabi 1992). After inundation in 2003, a few native species substantially decreased in number, e.g., *Barbus xanthopterus* and *B. grypus* with very low relative abundance 0.02% and 0.05% respectively, due to scarcity of benthic food resources (insects and mollusks), competition with the alien species *Cyprinus carpio* (Al-Kanaani 1989), and increased salinity. Other native species became rare due to the loss of their habitat to the introduced species, e.g., *Barbus sharpeyi* to *Ctenopharyngodon idella* and *Barbus luteus*

to *Carassius auratus* as indicated by their low abundance (Richardson 2008, Barak and Mohamed 1983, Jasim 1988). In general, the freshwater species composition of Al-Hammar Marsh was similar to other southern Iraqi marshes indicating that desiccation altered the fish composition in all southern marshes (Hussain et al. 2008, Richardson 2008).

The most abundant species in Al-Hammar, *Liza abu*, *Carassius auratus* and *Acanthobrama marmid*, were identical to other southern marshes because the ichthyofauna was originally derived from the Tigris, Euphrates and Shatt al-Arab rivers. The major difference was the seasonal occurrence of marine species in the Al-Hammar Marsh, but not in other southern marshes (CIMI 2006). The abundance of marine species led to an increase in richness, evenness and diversity indices and created seasonal fluctuation in relative abundance and total number of individuals in comparison with other freshwater marshes of southern Iraq (Hussain et al. 2006, Richardson 2008).

Because of the lack of data on the marshes before desiccation, comparisons were made with studies on other Iraqi lakes and reservoirs. During the 1980s, Epler et al. (2001) found in Habbaniyah, Tharthar and Razzazah lakes (central Iraq) that *Liza abu* was the most abundant species followed by *Alburnus mossulensis*. In the late 1990s, Al-Rudainy et al. (1999, 2001) showed that the fish assemblages in Habbaniyah Lake and Al-Qadisiya Reservoir (western Iraq) were also dominated by *Liza abu* and *Carassius auratus*, similar to the situation in Al-Hammar Marsh and other southern marshes (Hussain et al. 2006, 2008; Mohamed et al. 2009).

Higher diversity and richness in the eastern Al-Hammar Marsh during summer (July) could be due to recruitment of resident species after spring spawning (Ahmed et al. 1984, Dawood 1986, Jasim 1988, Naama et al. 1986), more individuals brought with the spring flood from the Euphrates River, and to the penetration of marine species especially anadromous ones such as *Tenuulosa ilisha* and *Liza subviridis*. Emigration of marine species back to the Shatt al-Arab Estuary and the Arabian Gulf in winter (December) (Mohamed et al. 2009), led to higher evenness values and return of the fish assemblage to its stable state consisting of resident freshwater species during winter and early spring. Monthly similarity was the highest in May (77%), coinciding with the gathering of many freshwater species for spawning. The September peak in total number of individuals was due to an increase in number of *T. ilisha* juveniles (Mohamed et al. 2009).

Temperature has a stronger correlation with number of species and the total number of individuals (catch) than salinity. Increase of temperature in spring and summer accelerated the productivity cycle of plankton and also decomposition rates of organic materials, i.e. more food resources become available for fish (Hammadi et al. 2007, Al-Sodani et al. 2007). The same conclusion was reached for the Khor Al-Zubair lagoon by Ali and Hussain (1990), reflecting that temperature was more related to species abundance than salinity in this tidal marsh. Temperature also clearly relates to seasonal patterns within southern Iraq.

The seasonal existence of marine species indicates that the restored Al-Hammar Marsh plays a vital part in the recovery of fisheries (*Tenuulosa ilisha*, *Liza subviridis*,

L. klunzingeri and the shrimp *Metapenaeus affinis*) of the north-western Arabian Gulf after becoming noticeably degraded during the period of desiccation of the Al-Hammar Marsh in the 1990s. Al-Yamani et al. (2007) indicated a close interrelationship between the southern Iraqi marshes and the environment of the north-western Arabian Gulf.

It seems that the restored Al-Hammar Marsh plays a role as a feeding and nursery ground for juveniles of marine species like *Tenualosa ilisha*, *Liza subviridis* and *Thryssa whiteheadi*, thick submergent plants like *Ceratophyllum demersum* offering a suitable cover from predatory fishes like *Aspius vorax* and *Silurus triostegus*, and from waterfowl. Globally, tidal marshes have a higher biological productivity than other freshwater marshes and offer protection from large marine predators.

The extreme desiccation of the marshes of southern Iraq in August 2009, as evidenced by satellite imagery, has destroyed the role of this marsh in the ecology of the fish fauna. It may still recover again if climate improves and a sufficient supply of water is released from upriver countries.

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