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Ecological and biological aspects of fish assemblage in the Chybayish marsh, Southern Iraq

Abdul-Razak M. Mohamed[1*], Najah A. Hussain[2], Sajed S. Al-Noor[1], Falah M. Mutlak[3], Ibrahim M. Al-Sudani[1], Ahmed M. Mojer[1]

[1] Department of Fisheries and Marine Resources, College of Agriculture, University of Basrah, Iraq,
e-mail: abdul19532001@yahoo.com
[2] Department of Biology, College of Science, University of Basrah, Iraq
[3] Marine Science Centre, University of Basrah, Iraq

Abstract

The characteristic of fish assemblage in the restored Chybayish marsh was described in the time of 3 years after restoration. As much as 14 species were caught from October 2005 to September 2006. Detritovorus species, *Liza abu* was the most abundant species, followed by *Carassius auratus* and *Barbus luteus*. Fish species diversity indices were lower than in other restored southern marshes which may reflect the still degraded environment of the marsh and decreased productivity of vegetation. Diets varied among fishes. Most of them depended on two or three major foods, and five principal pathways of energy flow in the food web. Currently, restoration by reflooding of drained marshes is proceeding and the ecological effects of this massive water diversion needs elaborated research. Some solutions to retain water in the marsh even in the unfavorable climatic conditions have been suggested.

Key words: Species compositions, alien species, diversity indices, food habits, Mesopotamia wetlands.

1. Introduction

The marshes of southern Iraq were the largest wetlands in southwest Asia and Europe, covering over 15 000 km² and historically densely covered with tall reed beds, interspersed with several large open-water bodies. These marshes were a natural refuge for many aquatic organisms, especially fish and birds. Because of their environmental, hydrological and meteorological conditions, they formed a unique ecosystem, which allows aquatic biota to flourish. In 1990, the Food and Agriculture Organization of the United Nations (FAO) estimated that the total inland catch of fish in Iraq was 23 600 tons, with over 60% of this coming from the Mesopotamian marshes (Partow 2001). They were the permanent habitat for millions of birds and a flyway for millions more migrating between Siberia and Africa (Maltby 1994; Evans 2002). Spring floods used to occur from February to May caused by snowmelt in the headwater region in Turkey and the Zagros Mountains in Iran and northern Iraq. These short-lived but intense seasonal floods, which formerly have been on the order of 1.5 to 3 meters (with a record of 9 meters on the Tigris in 1954), were causing large-scale inundations (Scott 1995). Due to flat topography, the flood pulses were able to maintain an extensive complex of interconnected shallow lakes, back swamps and marshlands in the lower Mesopotamian plain. The extent of the marshlands being very variable might dry up completely in shallower areas due to high summer temperatures, leaving salt flats and reverting back to desert conditions. This highly dynamic ecosystem was therefore dependent on spring floods for its replenishment and very existence (Patrow 2001). The marshes were considered to be a highly important breeding, staging and wintering area for large populations of a broad variety of waterfowl species. Difficulty of access, however, has limited comprehensive ornithological investigations of the site. Endemic sub-species of the Smooth-coated Otter were reported in the region (Scott 1995).

Since the 1980s the Mesopotamian marshlands were suffering from various problems. One of them was construction of more than 30 large dams in Turkey, Syria, Iran, and Iraq that diverted water from the Tigris, Euphrates and their tributaries for irrigation, flood control, and hydroelectric power. Additionally, the constructions of drainage systems diverting the major rivers surrounding the marshes, and drainage processes in the 1990s led to a substantial loss of native aquatic flora and fauna well-known for a long period as marsh biota of southern Iraq. In 2002, 85% of permanent marshes defined in 1973 had been environmentally destroyed, and only 3% of the Central marshes, 14.5% of the Hammar marshes and 35% of the Hawizeh marshes near the Iranian border remained (Partow 2001; Richardson, Hussain 2006).

In 2003, after the invasion of Iraq, several embankments preventing water from the Euphrates River from flowing into the marshes were breached with help of the local farmers. This allowed to reflood large areas of the Central marshes, i.e. Al-Awdeh marsh in the northwest, Abu Zirig marsh in the southwest, and Chybayish marsh in the south. However, as of summer 2004, the middle core of the Central marshes remains dry and the northeastern and eastern fringes have been converted to agricultural crops of mostly extensive rice and wheat production (Partow 2001).

Despite of the importance of the Chybayish marsh for freshwater fishes, no proper studies have focused on the fish species composition, fish biology and ecology, and fisheries before desiccation, as compared with other southern marshes (before, see: Barak, Mohamed 1982, 1983; Mohamed, Barak 1988; Hussain *et al.* 1992; Mohamed, Ali 1994; and after see: Hussain *et al.* 2008; 2009a; 2009b; Mohamed *et al.* 2008a; 2008b; 2009; Coad 2010). Some studies have focused on phytoplankton and plants communities in Chybayish marsh before desiccation (Pankow *et al.* 1979) and after desiccation (Al-Obaidi 2006; Al-Abbawy, Al-Mayah 2010; Abd 2010).

The objectives of this study were therefore to describe the fish community and associated metrics in Chybayish marsh after restoration and to compare its fish assemblage structure with other similar ecosystems in the region (Hammar and Hawizeh marshes).

2. Materials and methods

The Central marshes are located immediately above the confluence of the two large Middle East rivers, the Tigris and Euphrates, at the heart of the Mesopotamian wetland ecosystem (Fig. 1). The Tigris binds them from the east and the Euphrates from the south. The area is roughly delimited by a triangle between Nasiriyah, Amarah and Qurna cities. They cover an area of about 3000 km², which may extend to well over 4000 km² during flood periods. The marshes historically received water mainly from Tigris distributaries branching southward from Amarah city. The construction of the Glory and Prosperity rivers in 1993, stopped water inflow from the Tigris River and diverted it from the marshland into the Euphrates River leading to a complete dry out of the Central marshes. As a consequence the aquatic habitats were destroyed (Richardson, Hussain 2006). After reflooding in 2003, the marshes were partially restored, among them the southern part, the Chybayish marsh. Maximum water depth of Chybayish marsh ranges from 1.0-2.5 m. In 2006-2007 there were 27 species of aquatic plants registered which gave a restoration percentage of aquatic macrophyte species at the level of 61.36%. Almost entire marsh was covered by tall reed-beds of *Phragmites australis* and *Typha domingensis*, in addition to *Ceratophyllum demersum*, *Nagas* sp., *Potamageton pectinatus*, *P. perfiolatus*, *Meriophylum sipctum*, *Salvinia natans* and *Vallisiniria spirlais* (Al-Abbawy, Al-Mayah 2010; Abd 2010).

Fieldwork included monthly sampling of the fish fauna from two selected sites, Abu-Sobat (N 30° 57′ 92″, E 47° 02′ 23″) and Baghdadia (N 31° 07′ 58″, E 47° 03′ 07″) in Chybayish marsh (Fig. 1) from October 2005 to September 2006. During daylight, fishing was carried out by seine net (20 m long with a 2.5 cm mesh) in the littoral zone and by boat electrofishing in the open water. The electrofishing boat was equipped with a generator engine (providing 220 V and 10 A). During the evening hours, fixed gill nets (50 to 100 m long with 2.5 cm to 10 cm mesh size) were placed in the open water and left overnight. The net was removed the following morning after approximately 10 h by

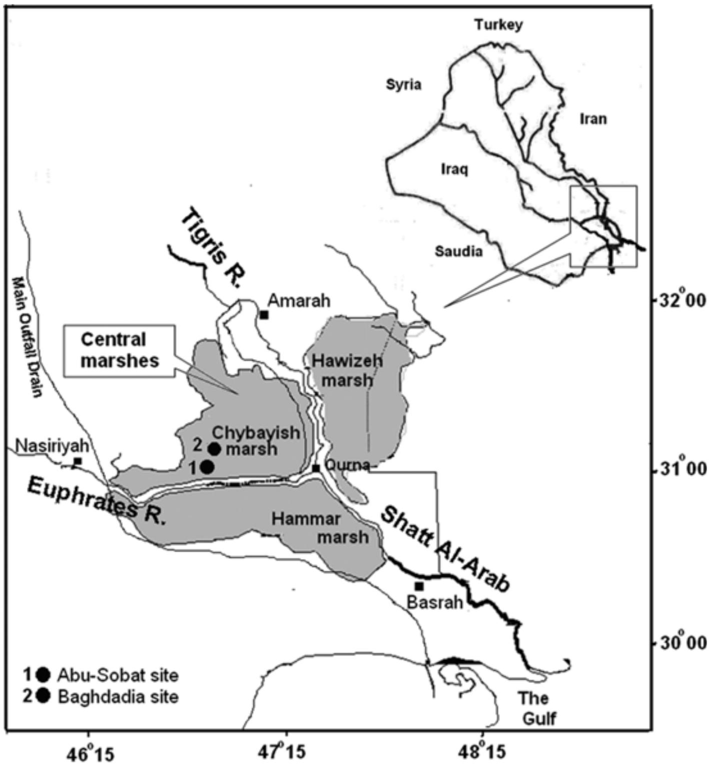

Fig. 1. Map of the southern marshes of Iraq, showing the location of Chybayish marsh

local fishermen. Fish individuals were identified and counted. Fishes were immediately preserved in crushed ice. Water temperature and salinity were measured by YSI 556 MPS instrument, 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) and Beckman (1962).

In the laboratory, fishes were dissected ventrally and each stomach removed and the food contents were identified under dissecting microscope (Edmondson 1959). Three analytical methods were adopted, i.e., volumetric, numerical and frequency of occurrence (Windell 1971) to analyze stomach contents. To assess the importance of various food items, an index of relative importance (IRI) designated by Pinkas *et al*. (1971) was used as follows:

$$IRI = (N + V) \times F$$

where, N, V and F represent numerical, volumetric and occurrence values respectively.

The similarity among fish species based on their diet was calculated according to Jaccard similarity coefficient, using SPSS software (ver. 11, 2001) statistical package.

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

3. Results

3.1. Fish community

Fourteen fish species were collected belonging to seven families (Table I). Cyprinidae, the dominant family in terms of number of species was represented by eight species (*Carassius auratus*, *Barbus luteus*, *Barbus sharpeyi*, *Aspius vorax*, *Cyprinus carpio*, *Acanthobrama marmid*, *Alburnus mossulensis* and *Cyprinion microstmum*). Other species belonged to the families Mugilidae (*Liza abu*), Cyprinodontidae (*Aphinus dispar*), Poecillidae, (*Gambusia holbrooki*), Siluridae (*Silurus triostegus*), Mastacembelidae (*Mastacembelus mastacembelus*) and Heteropneustidae (*Heteropneustus fossilis*).

The fish fauna was comprised of ten native species (*B. luteus*, *B. sharpeyi*, *A. vorax*, *A. marmid*, *A. mossulensis*, *C. microstmum*, *L. abu*, *A. dispar*, *S. triostegus* and *M. mastacembelus*) constituted 71% of the total number of species. Four aliened species (*C. carpio*, *H. fossilis*, *G. holbrooki* and *C. auratus*) comprised 24% of the total number of species. The highest numbers of total and native species were in June and the lowest in December (Table I). There is a slight variation in the number of alien species throughout the year.

The occurrence of collected species in the Chybayish marsh was classified into three groups. The resident species were eight ones, four of them appeared in all 12 months (*L. abu*, *C. auratus*, *A. vorax* and *S. triostegus*) and four in 10 months (*B. luteus*, *C. carpio*, *A. mossulensis* and *A. marmid*). The resident species formed 57% of the total number of species. Only one seasonal species (*H. fossilis*) was recorded in the Chybayish marsh and comprised 7% of the total number of species. The occasional species comprised 36% of the total number of species. Five species were categorized as occasional; one of them was appeared in four months (*M. matacembelus*), one in two months (*C. microstmum*) and three in one month (*B. sharpeyi*, *A. dispar* and *G. holbrooki*).

Table I. Monthly variations in relative abundance (%) of fish species caught in Chybayish marshes, Iraq during 2005-2006.

Fish family	Fish species	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.
Cyprinidae	*Carassius auratus* * +	24	41	13	10	27	10	17	29	13	27	21	34
	Barbus luteus +	1	2	2	-	2	4	5	14	4	2	11	-
	Alburnus mossulensis +	16	2	-	2	8	4	2	3	3	3	2	-
	Aspius vorax +	1	6	5	8	1	2	2	2	0	0	4	6
	Cyprinus carpio * +	-	-	2	1	2	0	6	3	0	3	1	5
	Acanthobrama marmid +	0.4	0.9	-	1.1	5.4	7	3.3		0.7	0.9	0.5	0.6
	Cyprinion microstmum #	-	-	-	-	-	0.6	-	-	-	0.2	-	-
	Barbus sharpeyi #	-	-	-	-	-	-	-		0.1	-	-	-
Mugilidae	*Liza abu* +	51	47	76	77	48	64	53	41	77	52	44	44
Siluridae	*Silurus triostegus* +	4	2	2	1	5	3	1	9	1	4	15	8
Heteropneustidae	*Heteropneustus fossilis* * º	2	-	-	-	2	6	10	-	0	8	1	-
Poecillidae	*Gambusia holbrooki* * #	-	-	-	-	-	-	2.1	-	-	-	-	-
Mastacembelidae	*Matacembelus matacembelus* #	0.8	-	-	-	-	-	-	-	0.1	-	0.2	1.2
Cyprinodontidae	*Aphinus dispar* #	-	-	-	-	0.9	-	-	-	-	-	-	-
Total catch		252	468	636	356	223	341	332	177	1263	462	411	174
Total no. of species		9	7	6	7	10	10	10	7	11	10	10	7
No. of native species		7	6	4	5	7	7	6	5	8	7	7	5
No. of alien species		2	1	2	2	3	3	4	2	3	3	3	2
Diversity index		1.4	1.2	0.9	0.9	1.5	1.4	1.6	1.5	0.9	1.4	1.6	1.3
Richness index		1.5	1	0.8	1.2	1.7	1.5	1.6	1.2	1.4	1.5	1.5	1.2
Eveness index		0.6	0.6	0.5	0.4	0.7	0.6	0.7	0.8	0.5	0.6	0.7	0.7

+ Resident species, # Occasional species, º Seasonal species, * Alien species

The highest number of fish (1263) was in June and the lowest number (174) was in September (Table I). *L. abu* was the most abundant species comprising 62% of the total numbers followed by *C. auratus* (20%) and *B. luteus* (4%). However, *L. abu* was the dominant species throughout the year.

The highest similarity level of fish species composition in the marsh was found during August (90%) and the lowest was in December (50%). Generally, the similarity level was high during summer months.

3.2. Ecological indices

Monthly variations in ecological indices of species in the marsh are shown in Table I. The diversity index fluctuated from 0.9 in December and January to 1.6 in August, with overall value 1.3. The richness indices changed from 0.8 in December to 1.7 in February, with overall value 1.2. The evenness index ranged from 0.4 in January to 0.8 in May, with overall value 0.7.

3.3. Environmental variables

Water temperature changed from 13°C in January to 31.5°C in June, and salinity from 0.9 g dm^{-3} in March and 2.3 g dm^{-3} in July. Water temperature showed weak positive correlations with the number of species and the total catch of fish species ($r = 0.248$ and 0.343 respectively, $P < 0.05$), while salinity showed very weak positive correlations with the number of species and the total catch of fish species ($r = 0.126$ and 0.072 respectively, $P < 0.05$).

3.4. Food composition

Foods which represented more than 10% relative importance were considered to be major (Fig. 2).

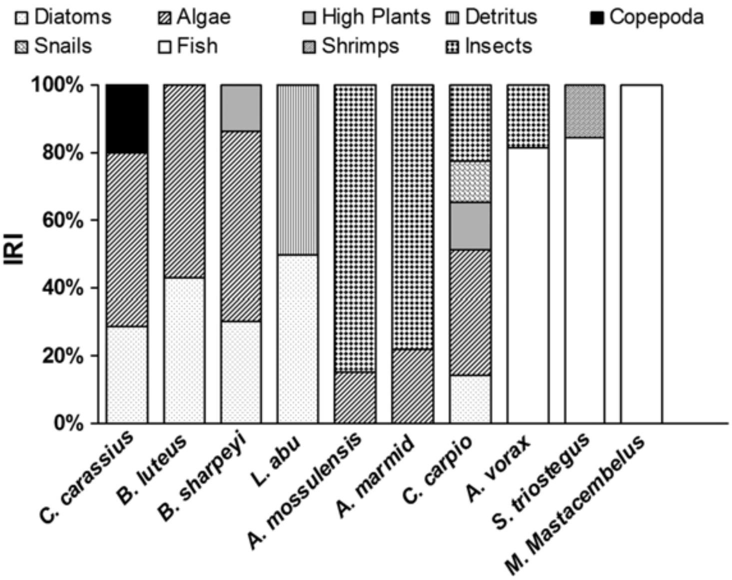

Fig. 2. Relative importance index (IRI) of items in the diet of fish species in Chybayish marsh, Iraq during 2005-2006.

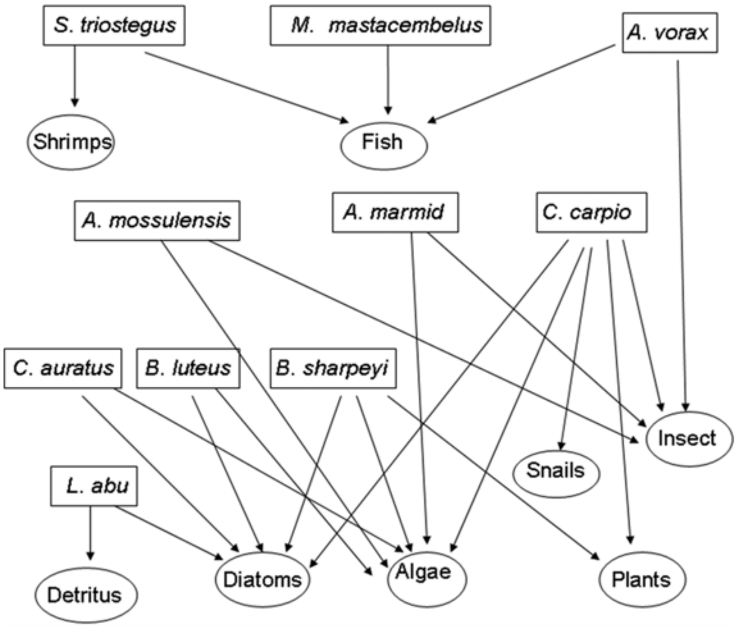

Fig. 3. Food web relations of the five trophic guilds of fish distinguished in the Chybayish marsh, Iraq during 2005-2006.

Most species depended on two or three major food items, except *C. carpio*. *C. auratus* fed on algae (46%) and diatoms (25%). *B. luteus* fed primarily on algae (44%) and diatoms (33%). Algae dominated the diet of *B. sharpeyi* constituting 50% of the total, followed by diatoms (27%) and plant tissues (12%). Detritus and diatoms formed 47% of the food items each of *L. abu*. *A. mossulensis* fed mostly on insects (74%) and algae (13%). Insects comprised 63% of the total food items of *A. marmid*, followed by algae 18%. *C. carpio* fed on algae (33%), insects (20%), snails (11%), diatoms (13%) and plants (13%). Fish formed 73% and insects 17% of the food items of *A. vorax*. *S. triostegus* preyed on fish (81%) and shrimps (15%). *M. Mastacembelus* fed on fish entirely.

Five principal pathways of energy flow in the food web of fish in the Chybayish marsh are simply described in Figure 3 according to Jaccard similarity coefficient. (1) The species, which are represented by *B. sharpeyi*, *B. luteus* and *C. carassius*, feed mainly on algae and diatoms; (2) The species, which is represented by *L. abu*, feed chiefly on organic detritus and diatoms; (3) The species, which are represented by *A. mossulensis* and *A. marmid*, feed mostly on insects and algae; (4) The species, which is represented by *C. carpio*, feed chiefly on algae, insects, snails, diatoms and plants; (5) The species, which are represented by *A. vorax*, *S. triostegus* and *M. mastacembelus*, prey mostly on fish.

4. Discussion

As much as 14 fish species recorded in the restored Chybayish marsh, three of which were exotic species, whereas, Mohamed *et al.* (2008b; 2009) and Hussian *et al.* (2009b) listed 15 fish species in the restored Hawizeh marsh, three of them were exotic species, and 31 fish species in the restored Hammar marsh consisting of 20 freshwater and 11 diadromous species. Hammar marsh receives waters from both the Euphrates and Shatt Al-Arab rivers and is aeffected by semi diurnal tide from the Arabian Gulf. Therefore, the fish assemblage of this marsh differed from the other two restored marshes by the occurrence of marine diadromous fish species in addition to freshwater species, both native and alien (Table II).

The fish-species composition of the restored Chybayish marsh were identical to those present in Hawizeh marsh (Mohamed *et al.* 2008b), they were

Table II. Presence–absence of fish species in the three restored southern marshes, Iraq during 2005-2006.

Family	Species	Hammar marsh [1]	Hawizeh marsh [2]	Chybayish marsh
Cyprinidae	*Carassius auratus +*	+	+	+
	Barbus luteus	+	+	+
	Barbus sharpeyi	+	+	+
	Aspius vorax	+	+	+
	Barbus xanthopterus	+	+	-
	Barbus grypus	+	+	-
	Cyprinus carpio +	+	+	+
	Ctenopharyngodon Idella +	+	-	-
	Acanthobrama marmid	+	+	+
	Acanthobrama lissneri	+	-	-
	Alburnus mossulensis	+	+	+
	Cyprinion microstmum	+	+	+
	Hemiculter leucisculus	-	+	-
	Liza abu	+	+	+
	*Liza subviridis **	+	-	-
	*Liza klunzingri **	+	-	-
	*Acanthopagrus latus **	+	-	-
	*Sparidentex hasta **	+	-	-
Cyprinodontidae	*Aphinus dispar*	+	-	+
	Aphinus mento	+	-	-
Poecillidae	*Gambbusia holbrooki +*	+	-	+
	Poecillius sphenops +	+	-	-
Clupeidae	*Tenualosa ilisha **	+	-	-
Siluridae	*Silurus triostegus*	+	+	+
Mastacembelidae	*Mastacembelus mastacembelus*	+	+	+
Heteropneustidae	*Heteropneustus fossilis +*	+	+	+
Engraulidae	*Thryssa mystax **	+	-	-
Scatophagidae	*Scatophagus arqus **	+	-	-
Gobiidae	*Bathygobies fuscus**	+	-	-
	*Boleophthalmus boddarti **	+	-	-
Hemiramphidae	*Hemiramphus georgii **	+	-	-
Solidae	*Synaptura orientalis**	+	-	-
Total number		32	15	14

* Marine species; + alien species; [1] Hussain *et al.* 2009b; [2] Mohamed *et al.* 2008b.

composed of fresh water species only (Table II). They also were similar to the fresh water species component of Hammar fish structure after excluding the seasonal migratory marine species (Hussain *et al.* 2009b). The fish habitat of Chybayish marsh could be described as limnophilic species derived mainly from the lower reaches of Tigris and Euphrates rivers with few eurytopic strays. Several studies have focused on the ecological fish guilds in the natural ecosystems (Raat 2001; Grift *et al.* 2001; Aarts, Nienhuis 2003; Moyle *et al.* 2007; Yongfeng 2010). For instance, Aarts and Nienhuis (2003) stated there were five flow preference guilds of adult fishes in the Netherlands, such as rheophilic, limnophilic, eurytopic, anadromous and catadromous species. However, various forms of ecological rehabilitation in the Dutch Rhine were identified, floodplain development, optimization of migration routes, and restoration of spawning and nursery areas during the last three decades, and the results revealed that the fish fauna were dominated by eurytopic cyprinids, rheophilous species declined in numbers and anadromous fish became scarce or extinct (Raat 2001).

The seasonal abundance of diadromous marine species increases the values of fish diversity and richness indices in Hammar marsh compared to Chybayish and Hawizeh marshes, assuming that the same fishing effort was applied at the three marshes (Hussian *et al.* 2009b; Mohamed *et al.* 2008b). The low diversity and richness in Chybayish marsh reflect the degraded environment of the marsh and decreased productivity of vegetation as demonstrated by Hamdan *et al.* (2010).

Detritovorus species, *L. abu* was the most abundant species in Chybayish marsh (comprised 62%), but its abundance in Hawizeh (37%) and Hammar (36%) did not reach the level of dominancy on fish assemblages. Other species in Chybayish appeared in low abundance, such as *B. sharpeyi*, *A. vorax* and *B. luteus*. This could be caused by unfavorable environmental parameters, especially higher salinity and changed hydrological conditions. Before desiccation water influx was coming from Tigris at the north of marsh, following natural gradient of terrain. After inundation in 2003 water was coming from Euphrates from the south, against the slope, which led to stagnation, lower water quality and low water level. Apart from that, Tigris River water contains less dissolved minerals than the Euphrates River (Hamdan *et al.* 2010) which exacerbated the problem of salinity. Richardson *et al*. (2005) mentioned that *B. sharpeyi* was the most important historic endemic fish species with the highest commercial value in all the marshes, but greatly reduced numbers and size.

Deterioration of water quality of the marshes led to several cyprinid species disappearance even before desiccation. This includes species like *B. subquicucitus* and *B. scheich.* The others, especially *B. xanthopetrus*, *B. grypus*, *B. sharpeyi* and *B. luteus* were substantially decreased in abundance. Several factors are thought to be behind the shift in species composition, and cyprinids disappearance from the restored marshes. One of the most important impacts was the construction of more than 30 large dams, particularly those recently built in the headwater region of Turkey, the Southeast Anatolia Project (GAP). It has substantially reduced the water supply and effectively eliminated the flood pulses that sustained wetland ecosystems in the lower Tigris-Euphrates basin (Partow 2001). Prior to the end of the twentieth century the discharge rate of the Tigris ranged from 3000 $m^3 s^{-1}$ to less than 500 $m^3 s^{-1}$, while that of the Euphrates ranged from 2000 $m^3 s^{-1}$ to less than 250 $m^3 s^{-1}$ (Plaziat, Younis 2005). In addition, there has been a marked degradation of water quality in the mainstreams of the Tigris and Euphrates, due to saline return drainage from irrigation schemes and dam retention of sediment and nutrients (Partow 2001). Salinity of the Chybayish marshes increased from 0.4-0.6 g dm^{-3} in seventies of the past century (Pankow *et al*.1979; Al-Saadi *et al.* 1981) to 6.3 g dm^{-3} during 2008/2009 (Abd 2010), which hindered the growth of vegetation in Chybayish marsh (Hamdan *et al.* 2010). Furthermore, the construction of drainage systems and diversions of major rivers surrounding the marsh areas, and the drainage processes of southern marshlands in the 1990s (Richardson, Hussain 2006) added up to species composition shift. Lastly, the scarcity of benthic food resources and competition with alien/introduce species, *C. carpio* (Al-Kanaani 1989) and recently with *C. auratus* (Hussain *et al.* 2006) played an important role in this process.

The ichthyofauna of Chybayish marsh is dominated by cyprinid species. This was also found in other Iraqi waters (Al-Daham 1982; Coad 1991; Hussain *et al.* 1997; 2009b; Mohamed *et al.* 2008b). During the 1980s, Epler *et al.* (2001) found in Habbaniyah, Tharthar and Razzazah lakes (central Iraq) that *L. abu* was the most abundant species followed by *A. 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 *L. abu* and *C. auratus*, similar to the situation in Chybayish marsh and other southern marshes after inundation (Mohamed *et al.* 2008b; Hussain *et al.* 2009b). In general the southern marshes and in particular Chybayish marsh could be classified after the dominating key species, *L. abu* and *C. auratus* which are associated with other specific fish species of southern marshes, as epipotamal (*Barbus* spp.) and metapotamal (Cyprinid family).

In general the diets of examined species were similar to that previously reviewed by Hussain, Ali (2006) before desiccation with certain differences. These differences could be related to the developing environment after more than decade of desiccation. Species like *B. luteus* changed its diet to be herbivorous previously considered as omnivorous (Barak, Mohamed 1982). The same was with *C. carpio* that changed its diet to be carnivorous, previously considered as omnivorous (Dawood 1986; Al-Kanaani 1989). *S. triostegus* and *A. vorax* shifted their diet to be fully predators on small fish previously carnivorous (Al-Mukhtar 1982; Al-Sayab 1988; Hussein, Al-Kanaani 1991).

It seemed that fish assemblage of Chybayish marsh was disturbed with high dominance of two species, the first native (*L. abu*) and second alien (C. *auratus*). These two species formed more than 80% of total fish abundance. Such high percentage has never been encounter in other southern marshes like Hawizeh, Suq Al-Shuyak, Hammar, even though *L. abu* and *C. auratus* were most abundant species occupying first and second ranks respectively in these marshes.

Restoration of Iraqi marshes to their historical (1970s) state clearly depends on the amount of water available in the Tigris-Euphrates river system. Approximately 70% of the water entering Iraq comes from rivers flow controlled by other countries (Partow 2001), and the annual rainfall amounts only to around 10 cm in southern Iraq. The drought of the southern marshes during 2009 (dry year), as witnessed by these marshes, played its role in the ecology of fishes.

Several of the engineering structures built in Iraq in the 1950s were originally intended for flood protection purposes and did effectively eliminate the seasonal flooding cycle driving the ecological dynamics of the marshlands (Partow 2001). There is a logical need to review their role now, whether they have been rendered redundant by the recent dams built in Turkey and northern Iraq. In particular, the utility of the massive off-river water storage reservoirs of the Tharthar, Habbaniyah and Razaza needs to be re-evaluated and due consideration given to the modification of their future roles.

Currently, restoration by reflooding of drained marshes is proceeding and some of the used agricultural water has been shifted to the marshes by connecting water bodies in the marshes to the Main Outfall Drain permanently as another source of replenishment. However, this practice has not been studied in terms of expected elevated salinity and long-term nutrient and pesticide effects. The ecological effects of this massive water diversion need elaborated research. Another source of replenishment is the sweet and oligosaline surface water available in southern marshes region (Al-Dabbas, Manii 2009), as supplementary source for rehabilitee of Chybayish marsh.

Conclusions

The present research shows that the fish structure of the restored Chybayish marsh was identical to those present in Hawizeh and Hammar marshes if excluding the seasonal migratory marine species from the last one. However, fish assemblage of Chybayish marsh was disturbed with high dominance of two species, *L. abu* (native and detritovorus species) and C. *auratus* (exotic species). Diets varied among fishes, most of them depended on two or three major foods. Low values of diversity indices in Chybayish marsh may reflect the degraded environment of the marsh and decrease productivity of vegetation compared with the other two restored marshes. Some solutions to retain water in the marsh even in the unfavorable climatic conditions have been suggested, such as return to the original water scheme i.e. from Tigris river as before desiccation period during the nineties of last century, replenishment from sweet and oligosaline surface water and ground water available in southern marshes region and planned rationing of available water resources to restored the most important ecological part of Chybayish like Al-Baghdadia openness marsh.

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