Longitudinal patterns of fish community structure in the Shatt Al-Arab River, Iraq

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Abstract

The fish assemblage and some ecological variables for three sites in the Shatt Al-Arab River, Iraq during 2010 and 2011 was used to assess the effect of environmental conditions on longitudinal seasonal variations in fish species abundance and distribution patterns. A total 1460 fishes belonging to 40 species and 19 families, all belonging to Osteichthyes, were captured using seine net. The fish fauna consisted of nine native, 25 marine and six alien species. Cyprinidae, the dominant family, was represented by ten species. *Carassius auratus* was the most abundant species numerically comprising 20.3%, followed by *Tenualosa ilisha* (13.3%) and *Liza subviridis* (8.7%). Salinity gradient showed significant differences among the sites and ranged from 0.8‰ to 7.6‰. Results suggested the present of three ecological fish guilds in Shatt Al-Arab River, each representing unique species associations, habitat characteristics, and spatial fish distributions.

Introduction

Longitudinal zonation concepts describe the downstream changes in chemical, physical and biological properties of rivers, including information on ecological fish guilds can enhance the usefulness of fish zonation concepts, in a way that they can be used as tools for assessment and management of the ecological integrity of large rivers **(**Aarts and Nienhuis, 2003**).** One of the prominent concepts in stream ecology is that longitudinal gradients in habitat characteristics structure the composition of fish assemblages (Hughes and Gammon, 1987).

Several studies have focused on the ecological fish guilds in the natural ecosystems (Sheldon, 1968; Raat 2001; Grift *et al.* 2001; Aarts and Nienhuis, 2003;

Barletta, *et al.*, 2005; Pouilly, *et al*., 2006; Ibanez, *et al.* 2007; Yongfeng, 2010).

The major river source in the Arabian Gulf is the Shatt-Al-Arab being located at the head of the Gulf and being fed by the Euphrates, Tigris and Karun rivers. Bibik *et at.* (1970) considered this estuary to be one of the most productive areas in that region. The water level of Shatt Al-Arab River is affected by the tide of the Gulf as well as discharging rates of Tigris and Euphrates rivers. Previous estimates of the annual mean discharge of the Shatt-Al-Arab varied from 35km³/yr (Saad, 1978), being equivalent to 0.15 m/yr when being evenly distributed over the surface of the Gulf, to 45km³/yr (0.19 m/yr) (Reynolds, 1993).

Under these circumstances, several taxonomic studies were published about freshwater and marine fishes of Iraq (Khalaf, 1961; Mahdi, 1962; Banister, 1980; Al-Daham 1982; Coad 1991), but all of them don't make any indication to a collection being made from Shatt Al-Arab River. Other studies have focused upon fish taxonomy, penetration of marine fish and fish assemblage structure in the upper reaches of the Shatt Al-Arab River (Al-Nasiri and Shamsul-Hoda, 1975; Al-Hassan and Hussain, 1985; Al-Hassan and Naama, 1986; Al-Hassan, *et al.* 1989; Hussain, *et al.* 1989; Hussain, *et al.* 1995; Hussain, *et al.* 1997). Other research efforts have been directed toward the fish assemblage structure in Shatt Al-Arab River estuary and Iraqi marine waters (Ali, 1993; Hussain, *et al.*, 1999). However, there is no specific work is dealing with the fish fauna in the entire Shatt Al-Arab River.

During the last years, the Mesopotamian rivers were suffering from various problems amongst them new hydrological projects, several large dams in Turkey, Syria, Iran, and Iraq have diverted water from the Tigris and Euphrates and their tributaries for irrigation, flood control, and hydroelectric power. Prior to the end of the twentieth century the discharge rate of the Tigris ranged from 3000 m^3/s to less than 500 m^3/s, while that of the Euphrates ranged from 2000 m^3/s to less than 250 m^3/s (Plaziat and Younis, 2005). Moreover, the diversion of Karun River towards the Iranian side was put in practice during 2009 (Hameed and Aljorany, 2011). These led to the salt water of the gulf to penetrate further upstream, it extended beyond Basra city. It is expected to altered water characteristics and substantial changes in the native aquatic life in the Shatt Al-Arab River.

Our main objectives in this study, therefore, are to examine the longitudinal pattern of faunal composition exhibited by fishes in Shatt Al-Arab River and to determine the main environmental factors responsible for the variation in local assemblage richness. This work is one of the first attempts to analyze changes in the fish assemblages along a longitudinal reaches of

the Shatt Al-Arab River, one of the most used Iraqi aquatic systems.

Materials and Methods

The Shatt Al-Arab River is formed by the confluence of Tigris and Euphrates rivers at Qurna, flows southeastern direction to open in the Arabian Gulf south of Al-Fao city. The total length of Shatt Al-Arab River is about 204 km, the width varies from 400 to 1500m, and hundreds outlets in the form of small rivers and canals are found on both sides of Shatt Al-Arab River (Al-Lami, 2009). Its maximum depth is ranged from 9m in Dayer site to 10m in Sihan (near Hamdan) site to 11m in Al-Fao (Al-Mayahi, 2011). Three tributaries flow into the river, Al-Suwab River which is connected at 15 km south of Qurna, Garmat Ali River that drains Al-Hammar marsh, and Karun River which flow through the Iranian territory and discharge its water in Shatt Al-Arab River, 35 km downstream of Basrah. The tide in the river is a mixture of the diurnal and semi-diurnal types, mainly semi-diurnal (Al-Ramadhan and Pastour, 1987).

Sampling on the river was conducted once a season from June 2010 to March 2011. Three sampling sites hereafter designated as Al-Dayer (upper river), Hamdan (middle river) and Al-Fao (lower river) were selected (Fig. 1). Al-Dayer site is located between south of Basrah Paper Plants Factory and north of Al-Hartha Power Station. Hamdan site is situated at the confluence of Hamdan River with Shatt Al-Arab River and Al-Fao site is located further south and was approximately 2 km north of Al-Fao port.

Fish were sampled seasonally, summer (June), autumn (October), winter (January) and spring (March) at each site using seine net (50x3m , 10mm mesh size). All fish collected were identified to species and counted. Species identification was based on Beckman (1962), Carpenter *et al.* (1997) and Coad (2010). Besides the fish sampling, a total of five variables were used to describe environmental conditions at each of the three sites. These variables were water temperature, salinity, dissolved oxygen and pH measured by YSI 556 MPS instrument, and transparency by Secchi disc.

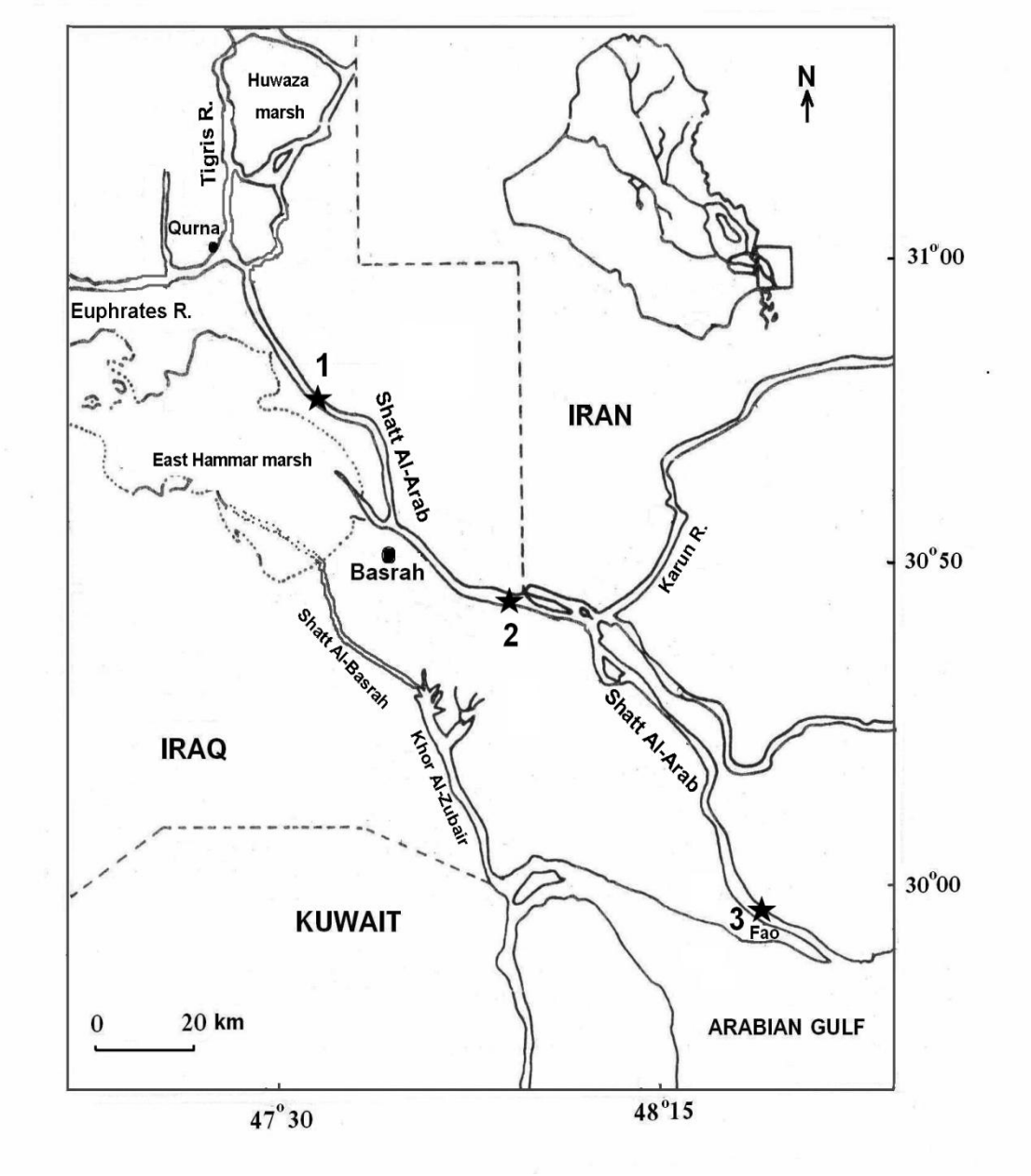

Fig. 1. Map of Shatt Al-Arab showing the study sites

The analysis of the nature of the fish assemblage in the three sites was carried out by the following methods and indices: relative abundance (Odum, 1970), diversity index (Shannon and Weaver, 1949), evenness index (Pielou, 1977), richness index (Margalef, 1968) and similarity index (Boesch, 1977).

The two matrices (fish species and ecological factors) were mostly analyzed with ordination techniques. Associations between environmental variables with the distribution

of fish species were quantified by using Canonical Correspondence Analysis, CCA, CANOCO 4.5 (ter Braak and Smilauer, 2002). CCA is a nonlinear ordination technique especially designed for direct analysis of the relationships between multivariate ecological data sets. Monte Carlo permutation techniques (499 permutations) were used to test the significance of the different environmental factors on fish species composition.

Analysis of variance (ANOVA) was used to assess ecological differences ($p \leq 0.05$) among river sites. All statistical computations were made using SPSS software (version 11, 2001) statistical package.

Results

Ecological factors

Seasonal changes in some ecological factors in the three study sites of Shatt Al-Arab River are given in Table 1. Water temperature, dissolved oxygen and pH exhibited no significant differences between the three sites (F= 0.00, 1.512 and 1.22, $p \leq 0.05$), respectively. Water temperature ranged from 14.6 ^{o}C during winter in Al-Fao site to 28.5^{o}C during summer in Al-Dayer site. Dissolved oxygen ranged from 7.2 mg/l during summer in Al-Fao site to 12.5 mg/l during winter in both Al-Dayer and Hamdan sites, while pH changed from 7.1 during winter in Hamdan site to 8.3 during summer in Al-fao site.

Salinity and transparency showed significant differences between the three sites (F= 24.1 and 17.82, $p \leq 0.05$), respectively. Salinity changed from 0.8‰ during winter and spring to 1.8 ‰ during summer in Al-Dayer site, from 1.4‰ during winter to 3.8‰ during summer in Hamdan site, and from 4.3‰ during winter to 7.6% during summer in Al-Fao site. The lowest values of transparency recorded in Al-Fao site and the highest values in Al-Dayer site, throughout the year (Table 1).

Species distribution

A total of 40 fish species belonging to 19 families were caught from the three sites in Shatt Al-Arab River, including 15 freshwater and 25 marine species (Table 2). The most diverse family was Cyprinidae with ten species (25% of species). Sciaenidae was represented by four (10%) and three families (Mugilidae, Clupeidae and Gobiidae) had three species each. The remaining families were represented by either two or one species.

The total numbers of fish species collected from Al-Dayer, Hamdan and Al-Fao sites were 18, 23 and 26 species, respectively (Table 2). There were more marine species represented in Al-Fao samples (23 species) than in the samples from Hamdan (12 species) and Al-Dayer (7 species). The number of freshwater fish were 11, 10 and 3 species captured in Al-Dayer, Hamdan and Al-Fao sites, respectively. No native species were collected from Al-Fao site, while, six and seven species were captured in Al-Dayer and Hamdan sites, respectively. Most alien

species (5 species) were found in Al-Dayer site. However, the fish fauna of Shatt Al-Arab River was comprised of nine native (22.5%), six alien (15%) and 25 marine species (62.5%).

There were seasonal variations in the number of species in all sites. The highest numbers were 11, 19 and 17 species captured during summer from Al-Dayer, Hamdan and Al-Fao sites, respectively, while the lowest numbers were 4 and 5 species collected during winter from Al-Dayer and Hamdan sites, respectively, and 12 species from Al-Fao site during summer and spring.

Table 1. Seasonal variations in the ecological factors at the three studied sites in Shatt Al-Arab during 2010-2011.

Al-Dayer	**Water Temperature (°C)**	**Salinity ‰**	**Dissolved Oxygen (mg/l)**	**pH**	**Transparency (cm)**
Summer	28.5	1.8	8.5	7.9	47
Autumn	23	1.2	9.5	7.7	56
Winter	15.2	0.8	12.5	7.5	55
Spring	21	0.8	10	7.8	43
Mean	21.9	1.2	10.1	7.7	50.3
Hamdan					
Summer	27	3.8	7.5	8	47
Autumn	22	2.3	8.6	7.9	42.5
Winter	15.5	1.4	12.5	7.1	48
Spring	23	1.9	8.5	7.7	36
Mean	21.9	2.4	9.3	7.7	43.4
Al-Fao					
Summer	27	7.6	7.2	8.3	12
Autumn	25	6.2	7.5	8	8
Winter	14.6	4.3	9.3	7.7	20
Spring	14.6	5.8	8.2	7.9	33
Mean	20.3	6.0	8.1	8.0	18.3

Species abundance

A total of 1460 fish were collected from the Shatt Al-Arab River, included 302 fish from Al-Dayer, 590 fish from Hamdan and 568 fish from Al-Fao site. The highest number of fish individuals was captured during summer (645 fish) and the lowest during winter (225 fish).

Table 3 explained the seasonal variations in the relative abundance of different species at each site from June 2010 to March 2011. *Carasius auartus* was the most abundant species of the fish assemblage of Shatt Al-Arab River comprising 20.3% of the total numbers followed by *Tenualosa ilisha* (13.6%), *Liza subviridis* (8.9%), *L. abu* (8.3%), *Johnius belangerii* (6.2%) and *Thrysa hamiltoni* (6.2%).

Dominant fish species changed locally along the river (Table 3), in Al-Dayer site, *C. auratus* was dominant in summer; *Acanthobrama marmid* in autumn; *L. abu* in winter; and *T. ilisha* in spring. The most dominant species constituted 85.8% of the total number of individuals captured in this site included *L. abu* (25.9%), *T. ilisha* (24.3%), *C. auratus* (23.1%) and *A. marmid* (12.5%).

Table 2. Nomenclature of the fish sampled from the three sites of Shatt Al-Arab

Family	Species	Al-Dayer	Hamdan	Al-Fao
Cyprinidae	*Alburnus mossulensis* * º	+	+	
=	*Acanthobrama marmid* * º	+		
=	*Barbus luteus* * º	+	+	
=	*Carassius auratus* + º	+	+	+
=	*Cyprinus carpio* + º	+		+
=	*Barbus grypus* * º		+	
=	*Aspius vorax* * º		+	
=	*Ctenopharyngodon idella* + º		+	
=	*Hemiculter leucisculus* + º	+		
=	*Barbus* ssp. * º		+	
Sciaenidae	*Otolithes rubber* #			+
=	*Johnius sina* #			+
=	*Johnius vogeri* #			+
=	*Johnius belangerii* #			+
Mugilidae	*Liza abu* * º	+	+	
=	*Liza subviridis* #	+	+	+
=	*Liza klunzingeri* #		+	+
Clupeidae	*Tenualosa ilisha* #	+	+	+
=	*Anodontostoma chacunda* #		+	
=	*Amblygaster sirm* #		+	
Gobiidae	*Bathygobius fuscus* #		+	+
=	*Boleophthalmus dussumieri* #			+
=	*Periophthalmus waltoni* #			+
Engraulidae	*Thryssa hamiltoni* #	+	+	+
=	*Thryssa whitheadi* #	+	+	+
Sparidae	*Acanthopagrus latus* #	+	+	+
=	*Sparidentex hasta* #	+	+	+
Pristigasteridae	*Ilisha compressa* #			+
=	*Ilisha melastoma* #			+
Bagridae	*Mystex pelusius* * º	+	+	
Poecillidae	*Pocilia latipinna* + º	+	+	+
Solidae	*Brachirus orientalis* #	+		+
Cichlidae	*Tilapia Zillii* + º	+	+	
Cynoglossidae	*Cynoglossus arel* #			+
Sillaginidae	*Silago sihama* #		+	+
Polynemidae	*Eleutheronema tetradactylum* #			+
Platycephalidae	*Platycephalus indicus* #			+
Gerreidae	*Gerres oyena* #		+	+
Carangidae	*Scomberoides commersonnianus* #			+
Poecillidae	*Mastacembelus mastacembelus* * º	+		
Total		18	23	26

* Native fish, + Alien fish, # Marine fish, º Freshwater fish

Table 3. Seasonal variations in the relative abundance of different species at each site in Shatt Al-Arab during 2010-2011

	Al-Dayre				Hamdan				Al-Fao				
Species	**Summer**	**Autumn**	**Winter**	**Spring**	**Summer**	**Autumn**	**Winter**	**Spring**	**Summer**	**Autumn**	**Winter**	**Spring**	**Total**
C. auratus	56.2	26.8	0.0	9.4	14.5	73.0	34.8	26.8	0.0	0.0	1.2	0.0	20.8
T. ilisha	13.3	2.8	0.0	81.2	0.0	0.0	47.8	29.6	0.0	7.0	31.1	24.2	13.6
L. subviridis	0.0	0.0	2.4	0.0	26.4	3.0	0.0	1.4	6.1	16.3	3.1	10.8	8.9
L. abu	1.0	9.9	92.7	0.0	12.5	18.0	8.7	0.0	0.0	0.0	0.0	0.0	8.3
J. belangerii	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	30.3	0.0	0.6	12.5	6.2
T. hamiltoni	0.0	0.0	0.0	1.2	0.0	1.0	0.0	12.7	20.5	7.0	11.8	5.0	6.2
A. latus	0.0	2.8	0.0	0.0	3.4	2.5	0.0	15.5	11.1	14.0	0.6	5.0	4.7
T. whitheadi	0.0	0.0	0.0	1.2	0.3	1.0	0.0	14.1	7.8	0.0	16.1	6.7	4.6
P. latipinna	14.3	0.0	0.0	0.0	12.5	0.0	4.3	0.0	1.6	0.0	0.0	0.0	3.9
J. sina	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	11.6	23.6	9.2	3.8
L. klunzingeri	0.0	0.0	0.0	0.0	11.5	0.0	0.0	0.0	6.6	2.3	0.0	0.8	3.6
A. marmid	4.8	45.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.5
A. chacunda	0.0	0.0	0.0	0.0	10.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.1
I. compressa	13.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2	4.7	1.2	17.5	1.9
S. hasta	1.0	1.4	0.0	0.0	0.3	0.0	0.0	0.0	7.8	0.0	0.0	1.7	1.6
J. vogeri	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.0	5.8	1.0
A. mossulensis	1.0	4.2	2.4	0.0	1.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6
S. commersonnianus	15.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.3	0.0	0.0	0.5
A. vorax	0.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4
C. arel	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.7	0.0	0.4
G. oyena	26.8	0.0	0.0	0.0	1.7	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.4
B. fuscus	0.0	0.0	0.0	0.0	0.3	0.0	4.3	0.0	1.2	2.3	0.0	0.0	0.4
B. dussumieri	5.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.6	0.0	0.0	0.3
M. mastacembelus	0.0	0.0	0.0	5.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3
E. tetradactylum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.6	0.0	0.0	0.0	0.3
S. sihama	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.4	4.7	0.6	0.0	0.3
B. luteus	1.9	0.0	0.0	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3
C. carpio	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2	0.0	0.0	0.0	0.3
B. orientalis	0.0	4.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.3
T. Zillii	0.0	0.0	0.0	1.2	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
I. melastoma	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.0	0.0	0.8	0.2
M. pelusius	1.9	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
H. leucisculus	0.0	2.8	2.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
B. grypus	0.0	0.0	0.0	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
C. idella	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
A. sirm	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.1
P. indicus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.1
B. waltoni	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.3	0.0	0.0	0.1
O. ruber	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.1

In Hamdan site, *L. subviridis* was dominant in summer, *C. auratus* in autumn, and *T. ilisha* in winter and spring. The most dominant species caught in this site formed 74.2%, included *C. auratus* (37.3%), *T. ilisha* (19.4%), *L. abu* (9.8%), and *L. subviridis* (7.7%).

In Al-Fao site, *J. belangerii* was dominant in summer, *L. subviridis* in autumn and *T. ilisha* in winter and spring (Table 3). The most dominant species consisted 48.8% of the total number of individuals captured in this site, included *T. ilisha* (15.5%), *J. sina* (11.3%), *T. hamiltoni* (11.1%) and *J. belangerii* (10.9%).

Figure 2 shows the relative abundance of the ten most abundant species in each site. *L. abu* was the dominant species (25.9%) in Al-Dayer site, followed by *T. ilisha* (24.3%), *C. auartus* (23.1%) and *A. marmid* (12.5%). In Hamdan site, *C. auartus* was the dominant species (37.3%), followed by *T. ilisha* (19.4%), *L. abu* (9.8) and *L. subviridis* (7.7%). *L. abu* (9.8). *T. ilisha* was the dominant species (15.5%) in Al-Fao site, followed by *J. sina* (11.3%), *T. hamiltoni* (11.1%) and *J. belangerii* (10.9%).

Diversity indices

Seasonal variations in diversity, richness and evenness indices in the three sites were illustrated in Figure 3. Higher diversity values noticed in autumn at Al-Dayer and Al-Fao and in summer at Hamdan. The lowest values were in winter at Al-Dayer and Al-Fao and in autumn at Hamdan. The overall values of diversity index at Al-Dayer, Hamdan and Al-Fao sites were 1.91, 2.13 and 2.56, respectively. The highest values of richness were recorded in summer at the three sites, and the lowest values were in winter at Al-Dayer and in spring at Hamdan and Al-Fao (Fig. 3). The overall values of richness index at Al-Dayer, Hamdan and Al-Fao sites were 2.98, 3.45 and 3.94, respectively. The peaks of evenness were noticed in autumn at Al-Dayer and Al-Fao and in spring at Hamdan. The lowest values were found in winter at Al-Dayer and Al-Fao and in autumn at Hamdan (Fig. 3). The overall values of evenness index at Al-Dayer, Hamdan and Al-Fao sites were 0.66, 0.68 and 0.79, respectively.

In general, the values of Jaccared similarity index of fish species between the study sites were low. The lowest value of similarity index (29.4%) was found between Al-Dayer and Al-Fao sites and the highest value (46.4%) between Al-Dayer and Hamdan sites. However, the similarity value between Al-Fao and Hamdan sites was 32.4%.

Effect of ecological factors

The environmental habitat vectors on the CCA ordination diagrams represent the relationships between fish species distribution and environmental variables in Shatt Al-Arab River are given in figure 4. Water temperature in Al-Dayer site was highly positive correlated with salinity (r= 0.900) and pH (r= 0.913), while was negative correlated with both transparency (r= -0.390) and dissolved oxygen (r= -0.971). Also, salinity showed significant positive correlation with pH (r= 0.681), and negative correlated with transparency (r= -0.107) and dissolved oxygen (r= -0.777). Dissolved oxygen exhibited positive correlation with transparency (r= 0.432) and highly negative correlated with pH (r= -0.932). Fish species was highly positive correlated with water temperature (r= 0.967) and salinity (r= 0.930). Therefore, most species in this site captured during summer, autumn and spring. Transparency showed negative low correlation with number of fish species (r= -0.145). The marine fish species were affected more by water temperature and salinity than by other factors.

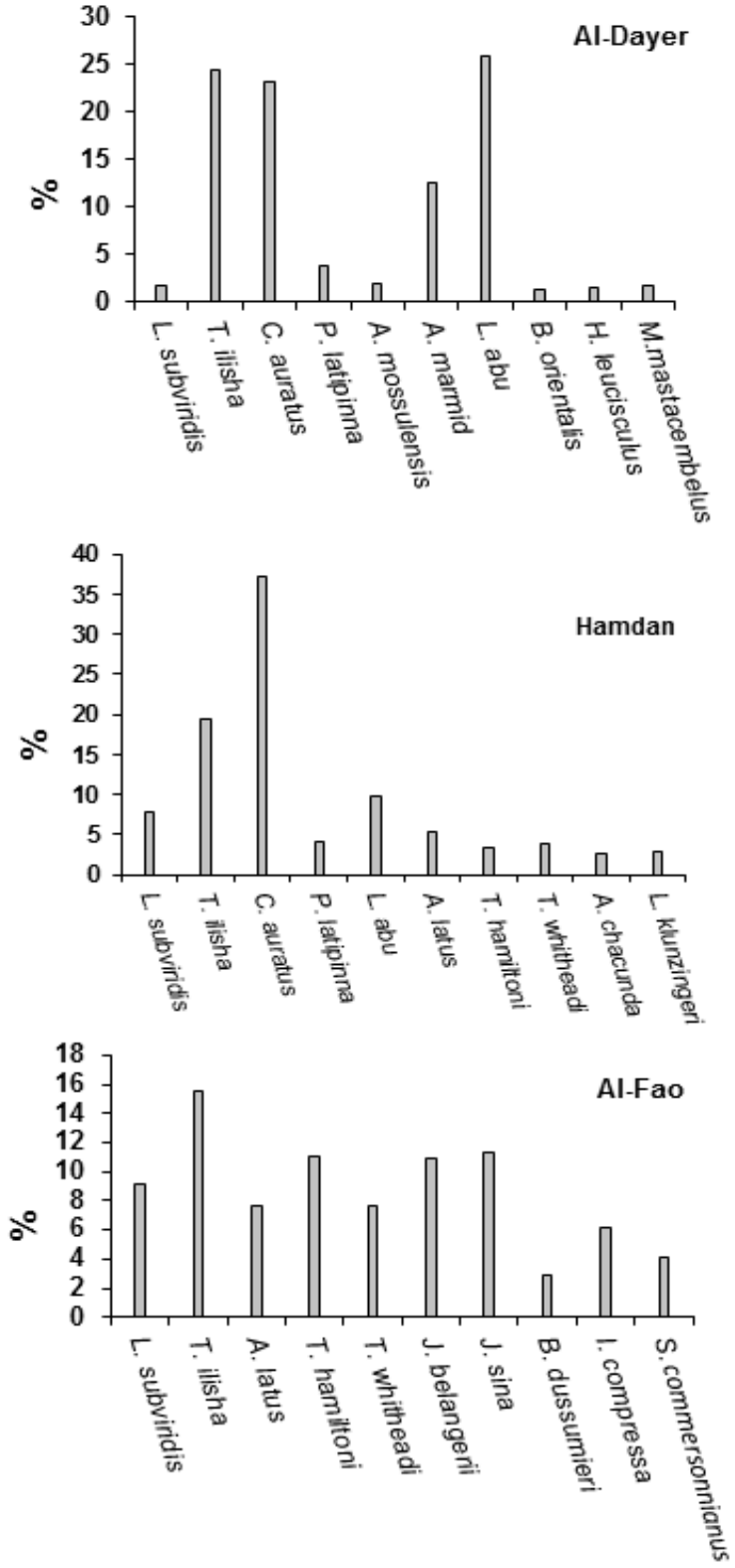

Fig. 2. Relative abundance of the first ten abundant species in the study sites during 2010-2011.

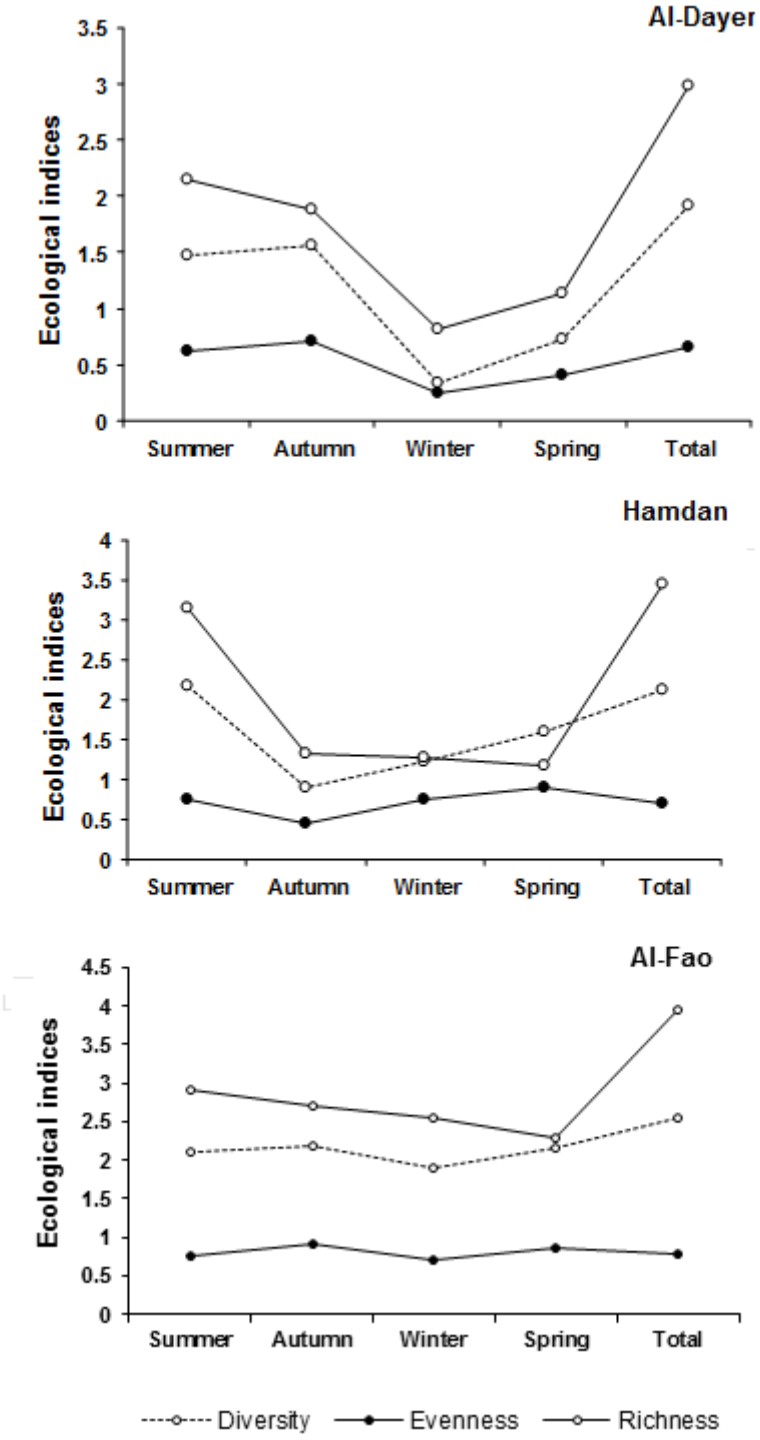

Fig. 3. Seasonal variations in ecological indices of fish assemblage in the three sites of Shatt Al-Arab during 2010-2011.

Also, it can be noticed from figure 4 that the number of fish species in Hamdan site was highly positive correlated with salinity (r= 0.990) and also affected by gradually increased in water temperature (r= 0.802). Therefore, most species captured in this site was recorded during summer and the lowest was during winter and spring (Fig. 4).

From figure 4, it can be seen that the highest correlation in Al-Fao site was between salinity and

pH (r= 0.990) and both of them positively correlated with water temperature and negative with both dissolved oxygen and transparency. The occurrence of fish species was not significant correlated with salinity (r= 0.496) and water temperature (r= 0.470), and most species captured throughout the year, especially during winter and summer (Fig. 4).

Discussion

Community ecology has been defined as the study of the organization of ecological communities, including the number, identity, abundance, and ecological attributes of member species, the relationships among these species, and how the organization of species varies over space and through time (Gee and Giller 1987).

Historically, the discharge of the Shatt Al-Arab River reached a maximum during spring flood during April-June, the first wave of the flood water entered the Gulf during February-March, from the Karun River which was characterized by lower temperature and salinity; this was followed by the second wave which from the Tigris and Euphrates rivers (Sudgen, 1963). The charge rate of Karun River into Shatt Al-Arab River in the past years was about 800m³/s and this was reflected as higher river discharge into the Arabian Gulf, so that the salt water does not intrusion at low discharge more than 5 km northwards Al-Fao port, so the river becomes well mixed in all cases towards north and salt wedge would not arrive to confluence of Karun River (Al-Mahdi, 1996). Sea tides seem to affect the water level in Shatt Al-Arab River and hence it ranged from 3 m near the mouth to 0.5 m at Basrah city; the influence of the tide was felt about 140 km inland with a penetration of marine organisms upstream (Rzoska, 1980).

Also, the historical connection of Shatt Al-Arab River with the Arabian Gulf and its environmental factors enables several marine species to penetrate northward in addition to a number of fish species that ascend this water way during the spring time (Al-Hassan and Hussain, 1985).

During the last years, the Shatt Al-Arab River was suffering from great problem in water quality due to declined in the discharge rates of the Tigris and Euphrates Rivers due to construction of more than thirty large dams, particularly those recently built in the headwater region of Turkey, the Southeast Anatolia Project basin (Partow, 2001). The net average of water discharge in the upstream of Shatt-Al-Arab declined to 186 m^3/s during 2007-2008 (Al-Lami, 2009), and the diversion of Karun River away from Shatt Al-Arab River during 2009 (Hameed and Aljorany, 2011). These influenced directly by increased the level of salinity in the middle and lower sites of the Shatt Al-Arab River, due to penetrated of sea water further upstream. It is clear from the present study that salinity ranged from 1.4 to 3.8‰, with mean value 2.4‰ in middle site and 4.3 to 7.6‰, with mean 6.0‰ in Al-Fao site, whereas, Mahdi *et al.* (2002) stated that the salinity of Shatt Al-Arab River at Abu Al-Khaseeb (Hamdan site) ranged from 0.7 to 1.4‰, with mean value 1.1‰ during 1997-1998. Also, Hussain *et al.* (1999) found that the salinity of Shatt Al-Arab River in Al-Fao port was ranged from 0.7‰ to 9.7‰, with mean value 4.9‰ during 1993.

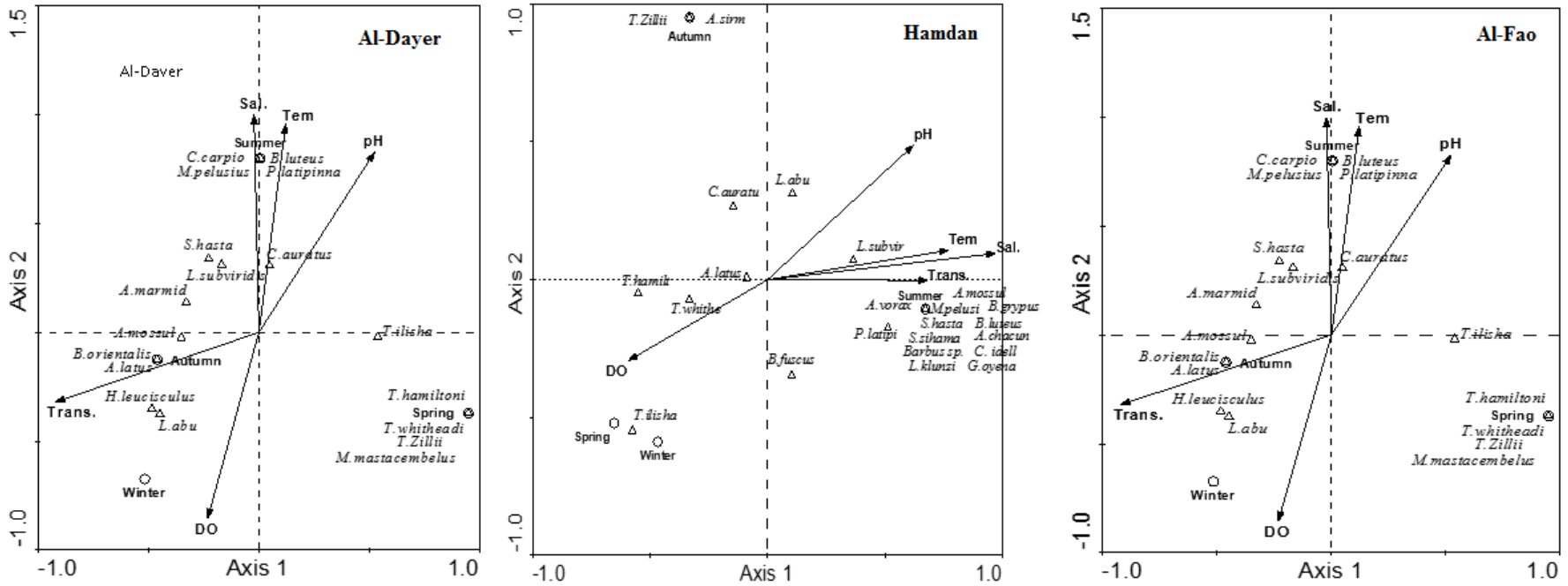

Fig. 4. Canonical correspondence analysis ordination plots showing of fish species and ecological factors at the three sites in the Shatt Al-Arab during 2010-2011 (fish species (Δ), season (o), ecological factor (→)).

Under this circumstance, and from the results of canonical correspondence analysis (CCA) for the associations between environmental factors and the distribution of fish species in the three sites of the Shatt Al-Arab River, in addition to low values of Jaccard similarity between sites, suggested that the fish assemblage of Shatt Al-Arab River can be divided into three ecological fish guilds, each representing unique species associations, habitat characteristics, and spatial distributions.

The first ecological fish guild represented the upper Shatt Al-Arab River characterized by low values of salinity, turbidity, number of species and diversity indices. The freshwater and marine species constituted 61.1% and 38.9% of this assemblage, respectively. The most dominant species were *L. abu*, *T. ilisha*, *C. auratus* and *A. marmid*, and all consisted 85.8% of the total number of individuals in this site. Comparing the species composition in this guild with the results of Hussain *et al.* (1995) for the fish assemblage of Shatt Al-Arab River at Sindbad Island Station (directly south Al-Dayer site) during 1992-1993, we can conclude that the guild of the upper reaches of Shatt Al-Arab River was clearly dissimilar in abundance of marine species, types of dominated species and values of diversity indices. They found 21 fish species, 6 of them were marine species (*L. carinata, T. ilisha, Bathygobius fuscus; T. Hamiltoni, Silago sihama* and *L. subviridis*) constituted 28.6% from the fish assemblage in this station. Also, *A. marmid* was the dominated species (59.2%), followed by *L. abu* (11.2%), *Alburnus mossulensis* (8.6%), *Barbus luteus* (7.5%) and *Garra rufa* (7.1%). *T. ilisha* formed only 0.18% from the fish assemblage in this station. The overall values of diversity, richness and evenness indices were 1.19, 2.50 and 0.37, respectively (Hussain, *et al.*, 1995).

The marine species move further toward the lower reaches of Mesopotamian rivers and marshes, Mohamed, *et al.*, (2008a) found 23 fish species, 8 of them were marine fish in the artisanal fisheries of the lower reaches of Euphrates and Tigris rivers, at Qurna, north of Basrah during 2005. Thirty one fish species were capture from the East Hammar marsh during 2006-2007 consisting of 20 freshwater and 11 marine species, and the overall values of diversity, richness and evenness indices were 1.53, 1.76 and 0.60, respectively (Mohamed, *et al.*, 2009).

The second ecological fish guild was at middle Shatt Al-Arab River characterized by increasing in the values of salinity, number of species and diversity indices compared with the previous site, contained 23, 13 of them were marine species (56.5%). The most dominant species were *C. auratus*, *T. ilisha*, *L. abu* and *L. subviridis*, and all constituted 74.2% of the total number of individuals in this site. However, most previous surveys have been conducted the region between Garmat Ali and Abu Al-Khasib of the Shatt

Al-Arab River concerning the fish fauna (Al-Nasiri and Shamsul-Hoda, 1975; Al-Hassan and Hussain, 1985; Al-Hassan, *et al.*, 1989; Hussain, *et al.*, 1989, 1995, 1997). All these surveys indicated the occurrence of several marine species. Al-Nasiri and Shamsul-Hoda (1975) listed 32 species including 12 marine species. Al-Hassan and Hussain (1985) recorded the penetration of 16 marine species to the upper reaches. Hussain, *et al.* (1989) found 33 species, 14 of them marine species. Hussain, *et al.* (1997) mentioned 25 species, 7 of them marine species. Compared with these studies, the present study reported higher percentage of marine species in this region.

The third ecological fish guild was in the lower reaches of Shatt Al-Arab River which characterized by highest values of salinity, turbidity, number of species and diversity indices. The marine species dominated the guild and formed 88.5% (23 species) and freshwater species consisted only 11.5% (3 species). The most dominant species were *T. ilisha*, *J. sina*, *T. hamiltoni* and *J. belangerii*, and all marine species and consisted 48.8% of the total number of individuals in this site. Comparing the species composition in this guild with the results of Hussain *et al.* (1999) for the fish assemblage of Shatt Al-Arab River at Al-Fao port, during 1993-1994, again we can conclude that the fish guild of the lower reaches of Shatt Al-Arab River was also clearly dissimilar in abundance of freshwater and marine species, and the types of dominated species. They captured 26 species, 8 freshwater species (*Cyprinus carpio, Parasilurus triostegus, B. xanthopterus, B. sharpeyi, B. kersin, L. abu, A. marmid and G. variabilis*) constituted 16.2% from the fish assemblage in this station. *L. subvirdis* was the dominated species (24.2%), followed by *Acanthopagrus latus* (17.7%), *Arius tenuispinis* (12.5%) and *C. carpio* (11.6%).

The results supported that the physical properties, especially salinity may provide some possible causes for the differences in the distribution, abundance and species composition along Shatt Al-Arab River River. Al-Hassan, *et al.* (1989) stated that marine species are limited to the middle and the lower regions of Shatt Al-Arab River and their number decreased toward the upper reaches of the river, and freshwater fauna exhibited a reverse trend of distribution in the river. As environmental conditions change, some fish species migrate in response to changing salinity, moving up and down the estuary (Blaber and Blaber, 1980, 1989; Barletta *et al.*, 2003). Moreover, the fish species move seasonally due to ontogenetic development (Laegdsgaard and Johnson, 2001).

The importance of the more abundant species varied considerably in each of the three sites of the Shatt Al-Arab River. *L. abu* was captured in highest numbers principally in the upper site. The species was the most dominant species in many Iraqi inland waters; in Habbaniyah, Tharthar and Razzazah lakes

(Epler *et al*., 2001); in Habbaniyah Lake and Al-Qadisiya Reservoir (Al-Rudainy *et al*., 1999, 2001); in Al-Huwaza marsh (Mohamed *et al*., 2008c); in Al-Hammar marsh (Hussain *et al.,* 2009); in Al-Hilla river (Al-Amari, 2011).

C. auratus, an alien species occurred in all three sites, captured in highest numbers principally in the middle site, after that in the upper site and few numbers in the lower site. Despite *C. auratus* appeared in Shatt Al-Arab River in early nineties (Al-Shammaa *et al*. 2002), the species was the most dominant species in Shatt Al-Arab River in the present study.

Hilsa shad, *T. iIisha* is known to be anadromous, making a spawning migration to the upper reaches of the Shatt Al-Arab River during spring and early summer (Hussain *et al.,* 1994; Al-Noor, 1998; Mohamed *et al*., 2008b; Al- Okailee, 2010), considered the prevailing species in the lower site. Nevertheless, the species spreads along the river and its abundance increased toward the upper reaches of the river. Mohamed *et al.* (2009) stated that *T. ilisha* constituted 10.1% of the total numbers of fishes in Hammar marsh during 2006-2007.

Longitudinal and seasonal changes in salinity appeared to be the main factor that structured the fish assemblage in the entire Shatt Al-Arab River system.

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أنماط التركيب الطولي لمجتمع أسماك نهر شط العرب، العراق

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الخلاصة

وصف تجمع اسماك وبعض المتغيرات البيئية لثلاث مناطق في نهر شط العرب خلال فترة 2010–2011 وذلك لتقييم تأثير الظروف البيئية على التغيرات الطولية الموسمية بأنماط وفرة وتوزيع الأسماك. صيد ت الأسماك بواسطة شبكة الكرفة وكان عددها 1460 سمكة تنتمي إلى 40 نوعا ولتسعة عشر عائلة وجميعها من صنف الأسماك العظمية. تكون تجمع الأسماك من تسعة أنواع مقيمة native species و25 أنواع بحرية marine species وستة أنواع غريبة alien species. كانت السيادة لعائلة اسماك الشبوطيات Cyprinidae والتي تمثلت بعشرة أنواع. سادت اسماك الكارب البروسي *Carassius auratus* عدديا على مجتمع الأسماك بنسبة 20.3 %، ثم الصبور *Tenualosa ilisha* بنسبة 13.3% والبياح الأخضر *Liza subviridis* بنسبة 8.7%. لوحظ تدرج مهم في قيم الملوحة بين المناطق الثلاث وتراوحت القيم بين 0.8 ‰ في منطقة الدير و7.6 ‰ في منطقة الفاو. أظهرت النتائج وجود ثلاث تجمعات موقعيه للأسماك على امتداد شط العرب، تختلف فيما بينها بتوكيبة أنواع الأسماك والصفات البيئية.