Compositional Change in Fish Assemblage Structure in the Shatt Al-Arab River, Iraq

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ABSTRACT---- ***Shatt Al-Arab River suffered from deterioration in water quality due to seawater intrusion as a result of the decline in rate of discharge of freshwater during the recent years. Therefore, the fish assemblage structure in the river was assessed using taxonomic and functional metrics of assemblage structure during the period from November 2015 to October 2016. Fish were sampled monthly by different fishing gears including gill nets, cast net and electro-fishing from three sites on the river. The fish assemblage consisted of 111 fish species representing 50 families belong to Osteichthyes except three relate to Chondrichthyes. The fish fauna comprised 15 native, 13 exotic and 83 marine species. The most abundant species were Carassius auratus (13.24%), Oreochromis aureus (12.58%) and Planiliza klunzingeri (10.56%). The dominance value (D3) was 63.4%. The resident species formed 36.0%, occasional species 55.9% and seasonal species 8.1% of the total number of fish species. Fish diversity index ranged from 1.62 to 2.22, richness from 2.23 to 4.63 and evenness from 0.40 to 0.64. Canonical correspondence analysis indicated that water temperature and salinity correlated positively with the number of species. The results revealed that the fish assemblage in the river was clearly shifted in the number of species, the percents of exotic and marine species and the dominancy species compared with the previous status.***

Keywords-- Fish assemblage, ecological factors, biodiversity indices, Shatt Al-Arab River, Iraq

1. INTRODUCTION

Shatt Al-Arab River which originates from the confluence of Tigris and Euphrates rivers is the main surface water source in the region and serves around 3 million people, the majority living in Basra city. The river is widely used for human consumption, agricultural, trade and industrial activities, transportation, electric power plants and recreation. The main agricultural lands extend along the river banks with large date palm plantations. The discharge of the Shatt Al-Arab River to the Arabian Gulf varies seasonally corresponding to the fluctuations in the rivers Tigris, Euphrates and Karun and reaches the maximum during the spring flood period of each year. Previous estimates of the annual mean discharge of the Shatt-Al-Arab varied from 35km³ [1] to 45km³ [2]. The flow of Shatt Al-Arab during spring floods into the Gulf supports the surface water flow direction towards southwest including northwestern edges of Kuwait Bay and its influence extends southerly to Saudi Arabia coastline as stated by [3].

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. [4] stated that salt does not intrusion at low discharge more than 5.0km northwards Fao city, so the river becomes well mixed in all cases towards north and salt wedge will not arrive to confluence of Karun.

Under these circumstances, several studies have focused upon penetration of marine fish and fish assemblage structure in different parts of the Shatt Al-Arab River [5-8].

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 [9]. 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 [10].

Therefore, the Shatt Al-Arab River has been subjected to multiple impacts suffered from drastically reduced in water quantity and quality related to the decline in rates of the flow from the Tigris and the Euphrates Rivers and the diversion of the Karun and Karkha Rivers into Iranian terrene [11, 12]. The decreases of freshwater inflows into the estuary promoting the saline arm to extend from the Arabian Gulf up to 100km into Shatt Al-Arab during dry years and consequently resulting in high salinity levels in the river [13, 14]. The alteration of water discharge in the Shatt Al-Arab River and the saltwater intrusion further upstream have been discussed by several authors [15-18]. Also, many channels are branched from Shatt Al-Arab pass through cultivated farmlands and carry huge amount of agricultural runoff wastes and untreated wastewater towards Shatt Al-Arab River [19]. The deterioration of the Shatt Al-Arab water quality under these conditions has been considered by several authors [15, 20, 21, 17]. Other research efforts have been directed toward the fish assemblage structure during 2010-2012 [22, 23].

The goal of this study is to evaluate patterns of change in the fish assemblage in the above-mentioned stretch in the Shatt Al-Arab River by using taxonomic and functional metrics of assemblage structure.

1. MATERIALS AND METHOD

Shatt Al-Arab River forms from the confluence of the Tigris and Euphrates rivers at Qurna town northern Basra Governorate, and flows to southeastern direction towards the Arabian Gulf (Fig. 1). It is about 204 km, and varies in width from 250 m at Al-Qurna to more than 1,500 m at the estuary. Its depth fluctuates from 9m at Al-Dair, 10m in Abu Al-Khasib to 11m in Fao [24]. The tidal pattern in Shatt Al-Arab River likes that of upper part of the Gulf, and the dominant tide is of a semi-diurnal type with two high and two low waters occurring daily [25].

Sampling on the river was conducted once a month from the three sites (Fig. 1) during November 2015- October 2016. Site 1 (upstream) is located near Al-Dair Bridge (30° 47′ 51″ N, 47° 34′ 59″ E and 30° 45′ 51″ N, 47° 34′ 38″ E), site 2 (midstream) is sited in Abu Al-Khasib district (30° 27′ 01″ N, 47° 57′ 12″ E and 30° 27′ 40″ N, 48° 00′ 90″ E) and site 3 (downstream) is located north Fao town (30° 01′ 07″ N, 48° 26′ 47″ E and 29° 75′ 12″ N, 48° 28′ 57″ E).

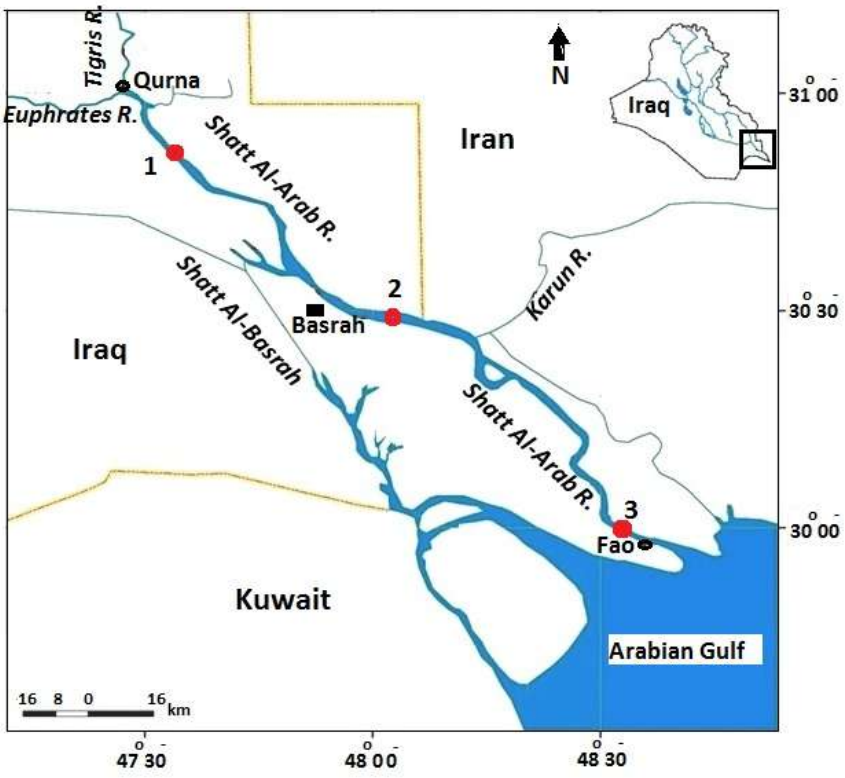

Figure 1: Map of Shatt Al-Arab River with locations of study sites.

Fish samples were regularly collected from each site by using gill nets (200-500 m length with 15- 35 mm mesh size), cast net (9 m diameter with 15x15 mm mesh size) and electro-fishing by generator engine (provides 300-400V and 10A). Fishes were counted and classified to species following [26-29].

Water temperatures and salinity were measured *in situ* using WTW portable instrument model 556 MPS. The monthly rate of discharge in the upstream of the Shatt Al-Arab River was obtained from Water Resources Directorate in Basrah.

The ecological indices of the fish assemblage in the Shatt Al-Arab, i.e. relative abundance, diversity, evenness and richness were calculated monthly according to [30-33]. Fish species divided into three categories according to their occurrence in the monthly samples following [34]. The three most abundant species was determined according to [35].

All statistical analyses were performed using the SPSS version 16 for Windows. The multiple linear correlation analysis was carried out on water parameters and fish to verify if there is any significant relationship by applying the multivariate analysis of ecological data using CANOCO program [36].

3. RESULTS

3.1 Ecological factors

Monthly changes in mean values in water temperatures, salinity and discharge rate in the Shatt Al-Arab River are presented in Figure 2. The average value of water temperature varied from13.3^{o}C in January to 34.7^{o}C, and salinity fluctuated from 1.1‰ in May to 9.7‰ in August. The discharge rate in the north of Shatt Al-Arab River varied from 40.88m^3/s in December to 59.75m^3/s in March, with overall value was 48.25m^3/s.

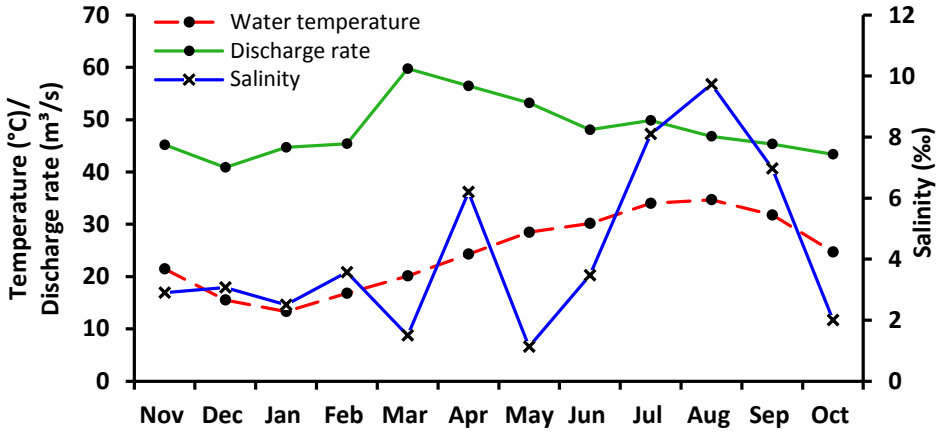

Figure 2: Monthly variations in some ecological factors of Shatt Al-Arab River (2015-2016)

3.2 Species composition

During the study, 95,347 fish belonging to 50 families, 89 genera and 111 species of bony and cartilaginous fish were captured from the Shatt Al-Arab River (Table 1). One hundred and eight bony species were composed, 15 of them were native, 83 marine and 13 exotic species. Taxonomically, the most abundant family in the river was Cyprinidae which was represented by 17 species followed by Carangidae (9 species), Sciaenidae (6 species), Mugilidae (5 species) and Sparidae (4 species). Engraulidae, Sillaginidae, Ariidae, Clupeidae, Belonidae, Cichlidae, Haemulidae and Gobiidae have three species each. Other families were contained two or one species each.

Monthly variations in the number and individuals of the species in the river are shown in Figure 3. The number of species ranged from 18 in February to 37 in December, July and October. Generally, the number of species started to increase from March to October. The total number of individuals showed a fluctuation and the lowest number was 5341 caught in January and the highest one (11818) in March.

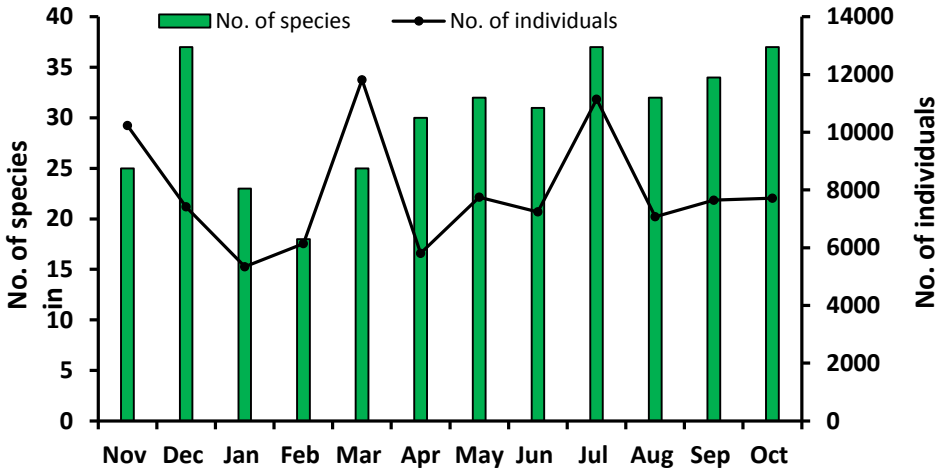

Figure 3: Monthly variations in the number of species and individuals in Shatt Al-Arab River (2015-2016)

Table 1: Fish species caught from the Shatt Al-Arab River during November 2015 - October 2016 (• Native, # Marine, ○ Exotic)

Family	Species	Family	Species	Family	Species
Chondereichthyes			*Planiliza subviridis* #	Soleidae	*Solea elongata* #
Rhinobatidae	*Glaucostegus granulatus* #		*Planiliza carinata* #		*Brachirus orientalis* #
Carcharhinidae	*Rhizoprionodon acutus* #		*Planiliza klunzingeri* #	Platycephalidae	*Platycephalus indicus* #
Hemiscylliidae	*Chiloscyllium arabicum* #		*Osteomugil speigleri* #		*Grammoplites suppositus* #
Osteichthyes		Sparidae	*Acanthopagrus arabicus* #	Gerreidae	*Gerres limbatus* #
Cyprinidae	*Carassius auratus* ○		*Sparidentex hasta* #		*Gerres macracanthus* #
	Hypophthalmichthys nobilis ○		*Crenidens crenidens* #	Polynemidae	*Polydactylus sextarius* #
	Hypophthalmichthys molitrix ○		*Argyrops spinifer* #		*Eleutheronema tetradactylum* #
	Chondrostoma regium •	Engraulidae	*Thryssa whiteheadi* #	Nemipteridae	*Scolopsis taeniata* #
	Arabibarbus grypus •		*Thryssa vitrirostris* #		*Nemipterus bipunctatus* #
	Luciobarbus xanthopterus •		*Thryssa dussumieri* #	Poeciliidae	*Poecilia latipinna* ○
	Leuciscus vorax •	Sillaginidae	*Sillago arabica* #		*Gambusia holbrooki* ○
	Carasobarbus luteus •		*Sillago sihama* #	Rachycentridae	*Rachycentron canadum* #
	Carasobarbus sublimus ○		*Sillago attenuata* #	Chirocentridae	*Chirocentrus nudus* #
	Hemiculter leucisculus ○	Ariidae	*Plicofollis dussumieri* #	Siganidae	*Siganus canaliculatus* #
	Alburnus mossulensis •		*Netuma thalassina* #	Batrachoididae	*Austrobatrachus dussumieri* #
	Acanthobrama marmid •		*Netuma bilineata* #	Synanceiidae	*Pseudosynanceia melanostigma* #
	Cyprinus carpio ○	Clupeidae	*Tenualosa ilisha* #	Synodontidae	*Saurida tumbil* #
	Cyprinion kais •		*Nematalosa persara* #	Stromateidae	*Pampus argenteus* #
	Ctenopharyngodon idella ○		*Nematalosa nasus* #	Triacanthidae	*Triacanthus biaculeatus* #
	Garra variabilis •	Belonidae	*Strongylura leiura* #	Cynoglossidae	*Cynoglossus arel* #
	Mesopotamichthys sharpeyi •		*Strongylura strongylura* #	Serranidae	*Epinephelus coioides* #
Carangidae	*Parastromateus niger* #		*Tylosurus crocodilus* #	Lutjanidae	*Lutjanus russellii* #
	Carangoides malabaricus #	Haemulidae	*Pomadasys kaakan* #	Leiognathidae	*Photopectoralis bindus* #
	Carangoides chrysophrys #		*Pomadasys stridens* #	Cepolidae	*Acanthocepola abbreviata* #

	Selar crumenophthalmus #		*Diagramma pictum* #	Scombridae	*Scomberomorus guttatus* #
	Alepes vari #	Cichlidae	*Oreochromis aureus* ○	Dussumieriidae	*Dussumieria acuta* #
	Alepes melanoptera #		*Oreochromis niloticus* ○	Apogonidae	*Apogonichthyoides taeniatus* #
	Alepes kleinii #		*Cptodon zillii* ○	Sphyraenidae	*Sphyraena obtusata* #
	Scomberoides commersonnianus #	Gobiidae	*Periophthalmus waltoni* #	Scatophagidae	*Scatophagus argus* #
	Rastrelliger kanagurta #		*Boleophthalmus dussumieri* #	Plotosidae	*Plotosus lineatus* #
Sciaenidae	*Protonibea diacanthus* #		*Bathygobius fuscus* #	Hemiramphidae	*Hyporhamphus limbatus* #
	Johnius belangerii #	Pristigasteridae	*Ilisha melastoma* #	Siluridae	*Silurus triostegus* ●
	Johnius sp. #		*Ilisha compressa* #	Heteropneustidae	*Heteropneustes fossilis* ○
	Johnius dussumieri #	Mullidae	*Upeneus sundaicus* #	Bagridae	*Mystus pelusius* ●
	Pennahia anea #		*Upeneus doriae* #	Mastacembelidae	*Mastacembelus mastacembelus* ●
	Otolithes ruber #	Terapontidae	*Terapon puta* #	Cyprinodontidae	*Aphanius dispar dispar* ●
Mugilidae	*Planiliza abu* ●		*Terapon theraps* #		

The monthly variations in the native, marine and exotic species are given in Figure 4. The number of native species varied from seven species in February to 17 species in December and constituted 13.9% of the total number of species. The marine species consisted 76.9% of the total number of species and fluctuated from nine species in February to 26 species in December. The exotic species formed 12.0% and changed from five species in November, February, March and September to seven species in July and December.

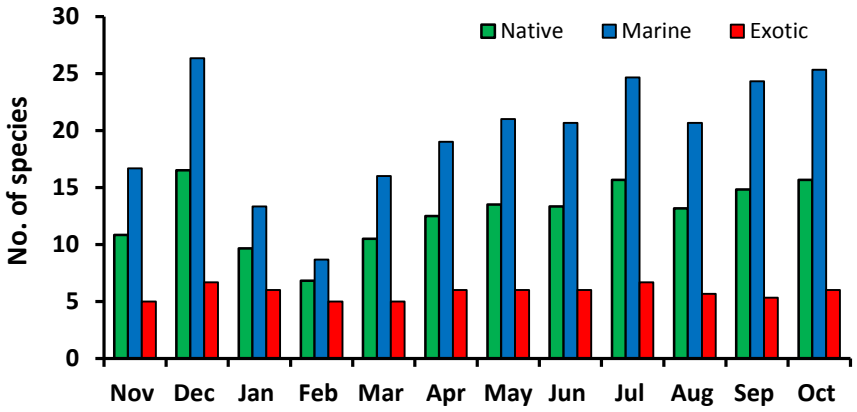

Figure 4: Monthly variations in the number of native, marine and exotic species in Shatt Al-Arab River (2015-2016)

3.3 Occurrence of species

The occurrence of collected species in the river was classified into three groups. The resident species were 40, 23 of them appeared in all 12 months (*P. subviridis, P. klunzingeri, P. abu, T. ilisha, N. nasus, T. whiteheadi, T. vitrirostris, J. belangerii, B. orientalis, A. arabicus, C. arel, P. indicus, O. aureus, O. niloticus, C. zillii, C. carpio , C. auratus, C. luteus, L. vorax, A. mossulensis, A. marmid, H. leucisculus* and *P. latipinna*), 13 in ten months (*J. dussumieri, J. sp, B. dussumieri, B. fuscus, S. arabica, S. sihama, S. hasta, I. melastoma, P. bindus, S. commersonnianus, S. triostegus, N. bilineata* and *C. sublimus*) and four species in nine months (*P. argenteus, H. limbatus, O. ruber* and *O. speigleri*). The resident species formed 36.0% of the total number of species. Of the nine seasonal species, one of them was captured in eight months (*M. pelusius*), six in seven months (*P. carinata, E. tetradactylum, S. argus, S. tumbil, I. compressa* and *C. nudus*) and two in six months (*A. vari* and *S. strongylura*). The seasonal species comprised 8.1% of the total number of species. Sixty two species were categorized as occasional; five of them were appeared in five months (*P. diacanthus, R. kanagurta, P. waltoni, P. melanostigma* and *L. xanthopterus*), six species in four months (*N. thalassina, N. persara, S. obtusata, D. acuta, G. macracanthus* and *G. holbrooki*), eight species in three months (*N. bipunctatus, S. taeniata, S. attenuate, C. crenidens, A. kleinii, E. coioides, C. idella* and *G. variabilis*), fourteen species in two months (*M. sharpeyi, C. kais, H. molitrix, H. nobilis, T. dussumieri, S. elongata, U. sundaicus, D. pictum, S. leiura, S. canaliculatus, P. lineatus, H. fossilis, M. mastacembelus* and *P. niger*) and the remaining in one month. The occasional species formed 55.9% of the total number of species.

3.4 Relative abundance

The relative abundances of all fish species caught from the Shatt Al-Arab River during the study period are presented in Table 2. It has been found that the fish assemblage was dominated by *C. auratus* composed of 13.24% of the total catch and varied from 5.84% in July to 26.79% in January. *O. aureus* comprising 12.58% of the total catch, it fluctuated from 7.61% in May to22.08% in December. *P. klunzingeri* was formed 10.56% and the relative abundance ranged from 0.34% in April to 22.69% in July. However, *T .ilisha* dominated the catches in the river during April and May constituted 27.45 and 26.38% of the total catch, respectively.

According to dominance index (D_3), three species formed 63.4% of the total catch of species in the River including *C. auratus, O. aureus* and *P. klunzingeri*.

3.5 Fish diversity indices

Monthly variations in diversity, richness and evenness indices of fish assemblage in the river are illustrated in Figure 5. The diversity index (*H*) fluctuated from 1.62 in January to 2.22 in October, with overall value 1.98. The richness index (*D*) changed from 2.23 in February to 4.63 in December, with overall value 3.73. The evenness index (*J*) ranged from 0.40 in January to 0.64 in March, with overall value 0.52.

Table 2. Monthly variations in relative abundance of all fish species caught from the Shatt Al-Arab River (2015-2016)

Species	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Total**
C .auratus	10.31	16.5	26.79	26.25	11.67	11.52	17.55	14.66	5.84	13.1	7.52	8.76	13.24
O .aureus	12.7	22.08	8.01	21.66	11.13	19.96	7.61	12.69	8.15	11.67	8.38	12.1	12.58
P .klunzingeri	16.85	2.88	7.15	6.87	3.91	0.34	9.92	11.98	22.69	9.23	15.71	10.68	10.56
P .abu	9.23	14.31	15.91	5.63	4.22	5.6	0.7	12.33	11.55	10.4	8.71	9.72	8.83
C .zillii	11.77	13.17	11.2	15.95	10.85	9.56	3.35	3.62	2.96	4.06	5.09	8.99	8.20
T .ilisha	0.84	0.85	0.15	0.03	9.84	27.45	26.38	7.91	3.67	2.02	1.56	0.56	6.55
P .subviridis	5.27	8.1	10.58	5.53	9.22	5.37	1.02	2.33	6.04	9.71	5.85	3.91	6.09
A .arabicus	7.11	7.76	3.82	0.21	0.02	0.14	0.14	0.17	6.29	4.3	10.21	8.38	4.18
J .dussumieri	7.37	3.71	3.93	-	3.4	6.15	0.09	1.56	2.67	4.47	5.01	6.27	3.78
C .carpio	0.47	1.31	0.09	0.15	0.06	0.14	0.13	5.55	10.35	9.58	5.61	3.07	3.24
T .whiteheadi	5.61	0.24	0.58	0.41	5.67	2.65	6.29	6.36	1.92	0.24	0.37	0.83	2.88
O .speigleri	-	5.39	7.86	-	4.03	1.02	-	1.34	3.41	0.13	2.16	2.55	2.31
J .Belangerii	0.05	0.09	0.09	3.34	1.92	1.14	4.6	3.11	2.25	3.73	3.57	2.92	2.21
N. nasus	0.31	0.09	0.02	0.37	1.63	0.14	8.63	2.58	0.05	0.08	5.41	7.17	2.20
C .luteus	2.42	0.16	0.41	1.19	0.23	1.64	1.83	3.09	1.33	5	3.53	1.41	1.81
T . vitrirostris	0.66	0.15	0.07	0.02	4.62	2.82	3.15	5.16	1.71	0.33	0.31	0.54	1.78
l . melastoma	6.95	0.04	0.02	0.1	5.71	-	0.08	0.07	0.04	0.07	0.03	0.08	1.50
S.. sihama	-	0.11	0.19	1.45	1.1	0.14	1.68	0.08	1.77	2.64	2.6	1.76	1.15
I. compressa	-	0.03	-	-	6.22	0.16	0.05	0.03	0.05	0.01	0.03	-	0.798
C . sublimus	-	0.08	0.26	1.5	0.12	1.24	0.05	1.02	0.77	2.64	0.22	1.39	0.706
S . arabica	0.16	0.05	0.15	1.45	0.01	0.07	0.01	-	0.08	0.16	2.75	4.04	0.697
S . hasta	0.18	0.18	0.06	0.07		0.1	0.03	0.03	3.3	0.23	0.16	0.21	0.482
H . leucisculus	0.07	0.05	0.11	0.07	2.42	0.16	0.94	0.23	0.25	0.27	0.03	0.05	0.481
O . niloticus	0.07	0.12	0.19	5.57	0.06	0.1	0.26	0.18	0.1	0.17	0.08	0.12	0.474
P . bindus	0.02	0.11	0.02	0.05	0.05	0.36	0.8	0.91	1	0.79	0.27	0.93	0.451
J. sp.	0.13	0.05	0.07	0.11	0.05	0.07		0.03	0.08	3.05	1.79	0.08	0.428
P . latipinna	0.06	0.3	0.17	0.23	1.16	0.29	0.99	0.47	0.09	0.3	0.26	0.23	0.404
L . vorax	0.3	0.3	0.17	0.31	0.05	0.09	0.05	0.18	0.12	0.08	1.39	0.08	0.252
A . mossulensis	0.25	0.03	0.06	0.76	0.17	0.1	0.57	0.22	0.04	0.1	0.01	0.03	0.187
A . marmid	0.11	0.04	1.09	0.24	0.04	0.1	0.04	0.07	0.1	0.16	0.03	0.03	0.138
B . fuscus	-	0.04	0.04	0.03	0.02	0.5	0.43	0.29	0.08	0.08	0.12	0.1	0.13
B . orientalis	0.1	0.34	0.15	0.07	0.02	0.1	0.18	0.07	0.09	0.08	0.04	0.12	0.107
N . bilineata	0.02	0.07	0.04	-	0.01	0.02	0.1	0.17	0.04	0.06	-	0.67	0.095
P . carinata	0.13	0.01	-	-	0.06	0.03	0.05	0.08	0.21	0.06	0.13	0.04	0.077
P . indicus	0.06	0.15	0.04	0.05	0.05	0.07	0.03	0.03	0.05	0.06	0.08	0.27	0.077
M . pelusius	-	0.01	0.04	-	0.03	0.03	0.32	0.1	0.08	0.07	0.07	0.08	0.069
Al . kleinii	-	-	-	-	-	-	0.39	0.35	0.04	-	-	-	0.063
B . dussumieri	0.08	0.05	0.02	0.03		0.12	0.09	0.06	0.07	0.08	0.08	0.06	0.061
C . arel	0.02	0.07	0.02	0.02	0.04	0.03	0.03	0.07	0.01	0.07	0.08	0.27	0.059

H . limbatus	-	0.01	0.02	-	-	0.09	0.21	0.22	0.05	0.06	0.04	0.04	0.058
G . holbrooki	-	-	-	-	-	-	0.41	0.12	0.06	-	0.07	-	0.056
O . ruber	-	0.01	0.04	0.08	-	-	0.06	0.01	0.04	0.2	0.04	0.08	0.044
S . triostegus	0.01	0.09	0.06	0.05	0.02	0.05	0.03	0.04	0.02	0.06	0.03	0.09	0.041
N . thalassina	-	-	-	-	0.01	-	-	0.01	-	-	0.03	0.41	0.038
N . persara	0.05	0.03	0.02	-	-	-	0.28	0.03	-	-	-	-	0.034
A . vari	-	-	-	-	-	-	0.03	0.21	0.06	0.01	0.01	0.01	0.028
S . commersonnianus	0.01	0.08	0.02	-	0.03	0.03	0.04	0.04	0.02	0.03	0.03	0.01	0.027
S . argus	-	0.05	0.07	0.05	-	0.03	0.03	0.04	0.04	-	-	0.03	0.025
P . argenteus	0.07	0.04	-	-	0.01	0.02	0.01	0.01	-	0.1	0.01	0.01	0.024
S . strongylura	-	0.01	-	-	0.03	0.03	0.06	0.01	0.04	0.01	0.03	0.03	0.022
C . crenidens	-	0.01	-	-	-	-	-	-	0.01	-	-	0.22	0.02
E . tetradactylum	-	0.03	0.02	-	0.01	-	-	-	0.03	0.04	0.09	0.03	0.02
T . dussumieri	0.13	0.03	-	-	-	-	-	-	-	-	-	-	0.016
C . nudus	-	0.01	-	-	-	-	0.03	0.01	0.02	0.03	0.01	0.05	0.014
M . sharpeyi	-	-	0.02	-	-	0.02	-	-	-	-	0.14	-	0.014
N . bipunctatus	-	0.07	-	-	-	-	-	-	-	0.08	0.01	-	0.013
S . tumbil	-	0.03	0.02	-	0.01	0.02	0.01	0.04	-	-		0.03	0.012
P . waltoni	-	-	-	-	0.01	-	-	-	0.02	0.03	0.04	0.03	0.01
P . diacanthus	-	0.01	0.06	-	-	0.02	-	-	0.01	-	-	0.04	0.009
A . dispar	-	-	-	-	-	-	-	-	0.08	-	-	-	0.009
L . xanthopterus	-	0.03	-	0.02	-	0.03	-	-	-	-	0.01	0.04	0.009
S . attenuate	-	0.01	-	-	-	-	0.05	0.01	0.02	-	-	-	0.008
D .acuta	-	0.04	0.06	-	-	0.02	0.01	-	-	-	-	-	0.008
H . molitrix	-	0.01	-	-	0.03	0.02	-	-	-	-	0.01	0.01	0.007
R . kanagurta	-	0.03	-	0.02	-	-	0.03	-	-	-	0.01	0.01	0.007
P . melanostigma	0.04	0.04	-	-	-	-	-	-	-	-	-	-	0.007
S . obtusata	-	0.03			0.02	-	-	-	0.01	-	0.01	-	0.006
G . variabilis	-	-	-	-	0.01	-	0.03	-	-	-	-	0.04	0.006
C .idella	-	-	0.04	0.03	-	0.02		0.01	-	-	-	-	0.006
M .mastacembelus	-	-	-	-	-	-	0.03	-	-	-	0.01	0.04	0.006
P .kaakan	-	-	-	-	-	-	-	-	-	-	-	0.06	0.005
S . taeniata	-	0.01	-	-	-	-	-	-	0.02	-	0.03	-	0.005
G . macracanthus	-	0.01	-	-	0.01	0.02	-	-	-	-	0.01	-	0.004
S . elongate	-	0.03	-	-	-	-	-	-	-	-	0.03	-	0.004
U . sundaicus	-	0.01	-	-	-	-	-	-	0.03	-	-	-	0.004
E . coioides	0.01	0.03	-	-	-	-	-	-	-	-	-	0.01	0.004
P . lineatus	-	0.01	-	-	-	-	-	-	-	-	-	0.04	0.004
C . regium	-	-	-	-	-	-	-	-	0.04	-	-	-	0.004
P . niger	-	-	-	-	-	-	-	-	-	0.03	0.01	-	0.003
D . pictum	-	0.01	-	-	-	-	-	-	0.02	-	-	-	0.003
S . canaliculatus	-	-	-	-	-	0.02	-	-	0.02	-	-	-	0.003

P . stridens	-	-	-	-	-	-	-	-	-	-	0.04	-	0.003
C . kais	-	-	-	-	-	-	0.03	-	-	0.01	-	-	0.003
H. fossilis	-	-	-	-	-	-	-	-	-	0.01	-	0.03	0.003
S . guttatus	-	-	-	-	-	-	-	-	-		0.03	-	0.002
G . limbatus	-	0.03	-	-	-	-	-	-	-	-	-	-	0.002
A . spinifer	-	0.03	-	-	-	-	-	-	-	-	-	-	0.002
U . doriae	-	0.03	-	-	-	-	-	-	-	-	-	-	0.002
S . leiura	-	-	-	0.02		-	-	-	-	-	-	0.01	0.002
G . granulatus	-	-	-	-	0.02	-	-	-	-	-	-	-	0.002
T . puta	-	-	-	-	-	-	0.03	-	-	-	-	-	0.002
T . theraps	-	-	-	-	-	-	0.03	-	-	-	-	-	0.002
H. nobilis	0.01	-	-	-	-	0.02	-	-	-	-	-	-	0.002
A . grypus	-	-	-	0.02	-	-	-	-	-	0.01	-	-	0.002
R . acutus	-	-	-	-	-	-	-	-	-	-	-	0.01	0.001
C. arabicum	-	-	-	-	-	-	-	-	-	-	-	0.01	0.001
A . dussumieri	-	-	-	-	-	-	-	-	-	-	-	0.01	0.001
A . abbreviate	-	0.01	-	-	-	-	-	-	-	-	-	-	0.001
A . taeniatus	-	0.01	-	-	-	-	-	-	-	-	-	-	0.001
P . sextarius	-	-	-	-	-	-	-	-	-	-	-	0.01	0.001
T. crocodilus	-	-	-	-	-	-	-	-	-	-	-	0.01	0.001
C. malabaricus	-	-	-	0.02	-		-	-	-	-	-	-	0.001
A. melanoptera	-	-	-	-	-	0.02	-	-	-	-	-	-	0.001
S. crumenophthalmus	-	-	-	-	-	-	-	-	-	-	-	0.01	0.001
C. chrysophrys	-	-	-	-	-	-	-	-	-	-	-	0.01	0.001
T. biaculeatus	-	-	-	-	-	-	0.01	-	-	-	-	-	0.001
R. canadum	-	-	-	-	-	-	0.01	-	-	-	-	-	0.001
G. suppositus	-	0.01	-	-	--	-	-	-	-	-	-	-	0.001
L. russellii	-	0.01	-	-	-	-	-	-	-	-	-	-	0.001
P. anea	-	-	-	-	0.01	-	-	-	-	-	-	-	0.001
P. dussumieri	0.01	-	-	-	-	-	-	-	-	-	-	-	0.001

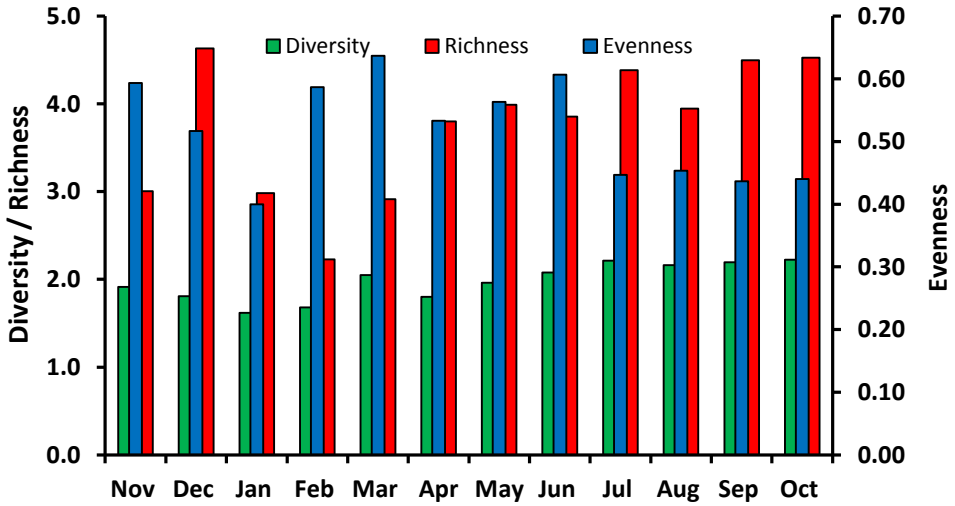

Figure 5: Monthly variations in the ecological indices values of the Shatt Al-Arab River (2015-2016)

3.6 Fish and ecological factors

Figure 6 illustrated the canonical correspondence analysis (CCA) ordination plot which summarized the relationships between fish species and some environmental variables in the Shatt Al-Arab River. The number of species was positively related to water temperature (0.356) and salinity (0.336), and weak negatively related to discharge rate (-0.165). The total number of individuals was positively related to discharge rate (0.360), weak positively related to average water temperature (0.188) and weak negatively related to average salinity (–0.031).

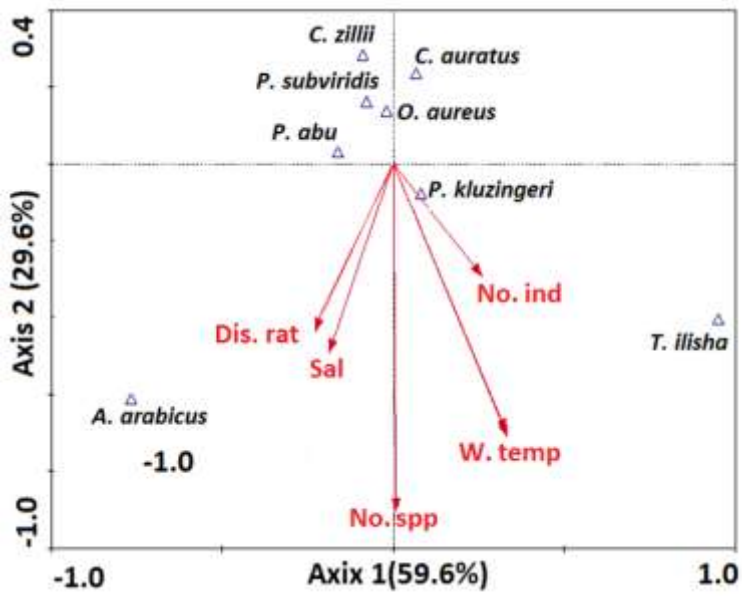

Figure 6: CCA ordination plots showing the relationship among fish species and some ecological factors in the Shatt Al-Arab River (W. temp= water temperature, Sal= salinity, Dis. rat= discharge rate, No.spp= number of species and No.ind= number of individuals)

4. DISCUSSION

Overall, the findings of the current study revealed that the fish assemblage in the Shatt Al-Arab River was clearly shifted in the number of species, the percents of exotic and marine species and the dominancy species compared with the previous status. The fish fauna of the river comprised of 111 species including 15 native, 83 marine and 13 exotic species. The three most abundant species were *C. auratus*, *O. aureus* and *P. klunzingeri* constituted 13.24%, 12.58% and 10.56% of the total individuals, respectively. These results were contrasted with the findings reported earlier about the fish assemblage in the river (Table 6). [37] mentioned that the fish assemblage in the Shatt Al-Arab River involved 40 fish species, 17 of them were native freshwater, 20 marine and 3 exotic species during 1989. Also, [22] collected 40 fish

species from the river, 9 of them were native, 25 marine and exotic alien species during 2010-2011. Moreover, [23] recorded 58 fish species including 16 native, 32 marine and 10 exotic species during 2011-2012. It is clear that the numbers of marine and exotic species increased in the river by 4-fold since 1989.

Table 3: Comparison of fish assemblage structure in Shatt Al-Arab River in different studies

Sampling year	No. of species	Species			References
		Native	Marine	Exotic	
1989	40	17	20	3	[37]
1982-1983	33	14	17	2	[6]
1992-1993	25	15	7	3	[38]
1993-1994	34	7	26	1	[8]
2010-2011	40	9	25	6	[22]
2011-2012	58	17	31	10	[23]
2015-2016	111	15	83	13	Present study

[6] stated that the most abundant species in the Shatt Al-Arab River were *P. abu, C. luteus* and *P. klunzingeri* during 1983-1982, whereas *N. nasus, P. abu* and *A. arabicus* during 1992-1993 [38]. [22] found that the dominated specie species in the river were *C. auratus, T. ilisha* and *P. subviridis* during 2010-2011, while [23] revealed that *C. auratus, T. ilisha* and *P. klunzingeri* were dominated the fish assemblage in the river during 2011-2012.

Also, the results of this study corroborate findings of declines among native fish throughout the region [39, 22, 40, 41]. Declining species include members of the cyprinid species (i.e. *L. xanthopetrus, A. grypus, M. sharpeyi* and *C. luteus*). [42] mentioned that native species represent the basic building blocks of a fish assemblage, and are a key component of diversity and the exotic species indicate biological pollution and a serious diversion from natural conditions, especially when they constitute a substantial percentage of the assemblage. The loss of any native species from an ecosystem can have detrimental impacts on ecosystem stability and function [43].

Distributions of many freshwater fish were confined to upstream sites, whereas marine species increased in abundance downstream, also certain exotic freshwater species, such as *C. carpio, C. zillii, O. aureus* and *P. latipinna* were found at downstream site. [37] 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.

These could be as a result of unfavorable environmental parameters, especially lower discharge rate, higher salinity and the changes in hydrological conditions. Several studies have been supportive of the deterioration of the Shatt Al-Arab water quality which attributed to reduced freshwater discharges from Tigris and Euphrates Rivers and the negative impact of salt intrusion from the Arabian Gulf [15, 20, 17, 14, 18], as a result of several hydrological projects constructed in the riparian countries [9], and the diversion of the Karun River into Iranian terrene [16]. The average rate of discharge in the upstream of the Shatt Al-Arab River was declined from $207m^3/s$ during 1977-1978 to $60m^3/s$ during 2014 [44]. Therefore, there is no effect of river discharge on the fish assemblage in the river due to the loss of seasonal changes and amount of the flow, and this allowed the saltwater from the Gulf to intrude upstream in the river, where salinity reached up to 25.9‰ in the lower reaches in the present study. [45] mentioned that the engineering controls on Tigris and Euphrates rivers have great reduced their seasonality. These conditions seem to support the considerable increasing in the number of marine and exotic species comparison with the past findings reported earlier on the river. The extremely tolerant species are the last to disappear in response do environmental degradation [46, 47], and they competes for food and nest space with the native ichthyofauna [48, 49]. Trends of tolerant species increases in relative abundance following impoundments and subsequent aquatic habitat alterations have been widely reported [50, 51, 43].

There were seasonal changes in fish diversity in the river and the richness indices had a general tendency to show high values during the period from March to October which could be attributed largely to the penetration of marine species especially anadromus species, such as *T. ilisha, P. klunzingeri, P. subviridis, A . arabicus, J. dussumieri, J. belangerii* and *T. whiteheadi* to feed, reproduce or nursing or migration route corresponding with increased in water temperature and salinity. This result is supported by the positive correlations between the number of species and water temperature and salinity, and the high percentage of the occasional species in the river. The abundance of marine species has led to an increase in the richness, evenness and diversity indices and created seasonal fluctuation in the relative

abundance [6, 38, 22, 23]. The effects of decreasing river flow and salinity intrusion on the fish assemblage structure have been observed in estuarine ecosystems around the world [52-57].

5. CONCLUSION

The results revealed that the fish assemblage in the river was clearly shifted in the number of species, the percents of exotic and marine species and the dominancy species compared with the previous status.

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