FISH ASSEMBLAGE STRUCTURE IN AL-DIWANIYA RIVER, MIDDLE OF IRAQ

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ABSTRACT

The fish species structure, occurrence, abundance and ecological indices of fish assemblage in the Al-Diwaniya River, middle of Iraq were studied. Fish were sampled monthly by different fishing gears from November 2016 to October 2017. Water temperature varied from 10.2°C in March to 32.8°C in August, dissolved oxygen values fluctuated from 5.0mg/l in August to 9.6mg/l cm in February, salinity ranged from 0.55‰ in April to 0.79 ‰ in July and pH values varied from 6.6 in August to 8.7 in March. A total 27 fish species belonging to eight families were collected, 19 of them were native and eight exotic species. The most abundant species were Carassius auratus, comprising 14.6% of the total catch, Planiliza abu (14.2%) and Oreochromis aureus (11.4%). The dominance value (D3) was 40.2%. Water temperature showed significantly positive correlation with the number of fish individuals and weak positive correlation with the number of species, while salinity showed weak positive correlations with the number of species and the individuals. The mean annual values of diversity, richness and evenness indices were 2.56, 3.37 and 0.81, respectively. The study shows that the fish assemblage structure in the Al-Diwaniya River was clearly differed from adjacent rivers in middle of Iraq by number of fish species, the dominancy species and the fish diversity.

Keywords: Fish assemblage, ecological factors, fish diversity, Al-Diwaniya River, Iraq

INTRODUCTION

Fish assemblage is an important element in aquatic ecosystem; it provides a good biological indication for the quality of freshwater ecosystems since it is sensitive to a broad range of stresses due to the human activities (Karr, 1981; Oberdorff et al., 2002). Identifying the spatial pattern of fish assemblages and the correlation between fish assemblages and environmental factors is basic for conserving and managing stream fish (Zhu et al., 2017).

Among the few studies on the fish assemblages in the rivers of the middle of Iraq are those of Al-Rudainy et al. (2006) on the ecology and biodiversity of fish community in Euphrates River at Al-Mussaib Power Station; Al-Amari (2011) on the biological and ecological aspects of fish community in Al-Hilla River; Khaddara (2014) on the ecological and biological study of fish community in Euphrates River at Al-Hindyah Barrier; and Abbas et el. (2017) on the evaluating the fish structure community of Euphrates River at Al-Hindyah Barrier, Babylon.

Nevertheless, the structure of the fish assemblage in the Al-Diwania River has not been studied, although several studies have been published on the water quality of the river (Alkam et al., 2012; Al-Sulaiman, 2016) or on the phytoplankton and epipelic algae (Yousif and Aldhamin, 2015; Alkam and Yassir, 2015) or on the distribution of zooplankton (Merhoon et al., 2017).

Therefore, the objective of this work was to describe the fish species structure, occurrence, abundance and ecological indices of fish assemblage in the Al-Diwaniya River, middle of Iraq.

MATERIALS AND METHODS

AL-Diwaniya River is an extension of the Al-Hilla River which is a branch of Euphrates River, in the middle of Iraq. It is 123 km long, 25-30m wide and 3-5m depth. The river is the major water resource for the AL-Diwaniya city, which flows through the city, then narrows in the districts of Sideer and Al-Hamzah and continues to flow until it fades in the district of Al-Rumaythah/Al-Muthanna Province. The samples were collected from two sites in the river between Daghghara barrier through Sinniyah district to the AL-Diwaniya city (Fig. 1), This section of the river is suitable for fishing operations and therefore most fishermen practice fishing here using different fishing methods. The predominant vegetations on the both banks of the river were *Phragmites australis* and *Typha domingensis,* whereas *Ceratophyllum demersum* was dominant in the deeper areas.

Figure 1. Map of Al-Qadisiyah Province showing the sampling sites in Al-Diwaniya River

The samples were collected monthly from November 2016 to October 2017. Water temperature, dissolved oxygen, salinity and pH were measured *in situ* from each site using Multi-meter portable instrument model Hanna. Fish sampling was carried out along the river between Daghghara barrier to the AL-Diwaniya city using seine net (3m long and 2.5m depth with a 20mm mesh size), gill nets (25m long with 20x20, 30x30 and 50x50mm mesh sizes), cast net (9m diameter with 15x15mm mesh size) and electro-fishing equipment (provides 150-300V). Fishes were counted and classified to species following Beckman (1962) and Coad (2017).

The relative abundance was calculated from the equation $n_i/N \times 100$ (Odum, 1970), where n_i is the number of individuals of 'i^{th}' species and $N= \Sigma n_i$. Shannon-Weaver index of diversity was obtained by the following equation $H' = -\Sigma p_i \ lnp_i$ (Shannon and Weaver, 1949), where $P_i = n_i/N$; n_i is the number of individuals of '*ith*' species and $N= \Sigma n_i$. The species richness was calculated using the equation $D= (S-1)/ln\ N$ (Margalef, 1968), where S is the number of

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species, N is the total number of individuals. The evenness is $J= H'/lnS$ (Pielou, 1977), where H' is the diversity and S is the number of species. Fish species divided into categories according to their occurrence in the monthly samples following Tyler (1971). The three most abundant species was determined by the following equation $D_3= [\sum_{i=1}^{3} pi.]$ 100 (Kwak and Peterson, 2007), where P_i is the proportion of the total sample represented by the i^{th} species.

All statistical analyses were performed using the SPSS version 16 for Windows.

RESULTS

Water temperature, dissolved oxygen, salinity and pH were not significantly differences between the two sampling sites (*T-test*= 0.005, 0.541, 0.549 and 0.347, $p \leq 0.05$), respectively. Therefore, the monthly variations in the mean values of these factors in the river are shown in Figures 2 and 3. Water temperature varied from the lowest value (10.2°C) during March to the highest value (32.8°C) during August. Dissolved oxygen values fluctuated from 5.0mg/l in August to 9.6mg/l cm in February (Fig. 2). Salinity values ranged from 0.55‰ in April to 0.79‰ in October. Narrow fluctuation of pH was observed during the study period, with the highest average value was 8.7 in March and a lowest of 6.6 in August (Fig. 3).

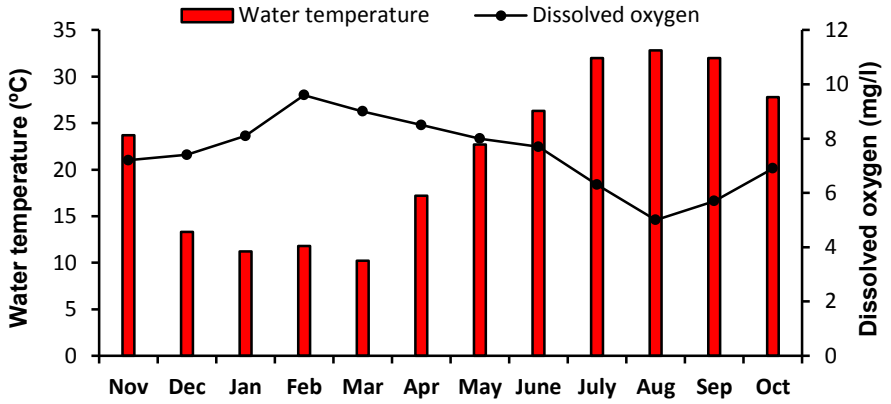

Figure 2. Monthly variations in water temperature and dissolved oxygen in Al-Diwaniya River

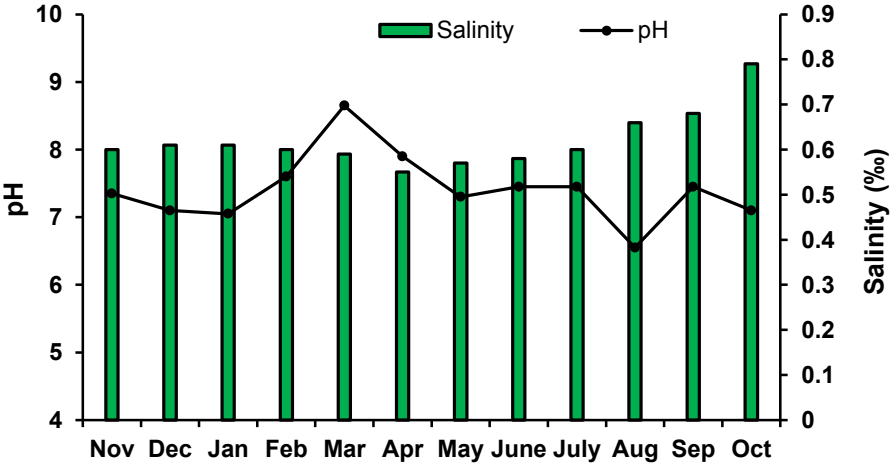

Figure 3. Monthly variations in water salinity and pH in Al-Diwaniya River

Twenty seven fish species belonging to eight families were collected from the Diwania River. Cyprinidae, the dominant family in terms of number of species was represented by eighteen

species (*Acanthobrama marmid, Alburnus caeruleu, A. mossulensis, Arabibarbus grypus, Carasobarbus luteus, C. sublimes, Carassius auratus, C. auratus auratus, Chondrostoma regium, Cyprinion kais, C. macrostomum Cyprinus carpio, Garra raiabilis, Hemiculter leucisculus, Luciobarbus barbulus, L. kersin, L. xanthopterus* and *Mesopotamichthys sharpeyi*). Other species belonged to the families Cichlidae (*Oreochromis aureus* and *Coptodon zilli*), Mugilidae (*Planiliza abu*), Poecillidae, (*Gambusia holbrooki*), Siluridae (*Silurus triostegus*), Mastacembelidae (*Mastacembelus mastacembelus*), Bagridae (*Mystus pelusius*) and Heteropneustidae (*Heteropneustus fossilis*).

The monthly fluctuations in the number and individuals of species in the river are shown in Figure 4. The number of species ranged from 16 in February to 27 in August to November. Generally, the number of species captured increased from March to November. A total of 13194 fish were caught from the river, they ranged from 315 in February to 2487 fish in August.

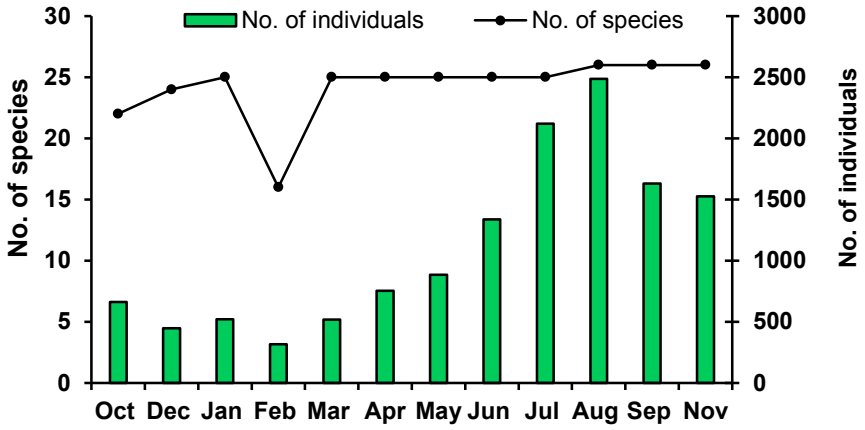

Figure 4. Monthly variations in the number of fish species and individuals in Al-Diwaniya River

The relationships between the number of fish species and their individuals with water temperature, salinity, dissolved oxygen and pH are displayed in Figure 5. Water temperature showed significantly positive correlation with the number of fish individuals (r= 0.906, p< 0.05) and weak positive correlation with the number of species (r= 0.448, p< 0.05). Salinity showed weak positive correlations with the number of species and the individuals. However, dissolved oxygen and pH exhibited negative correlations with both the number of species and individuals.

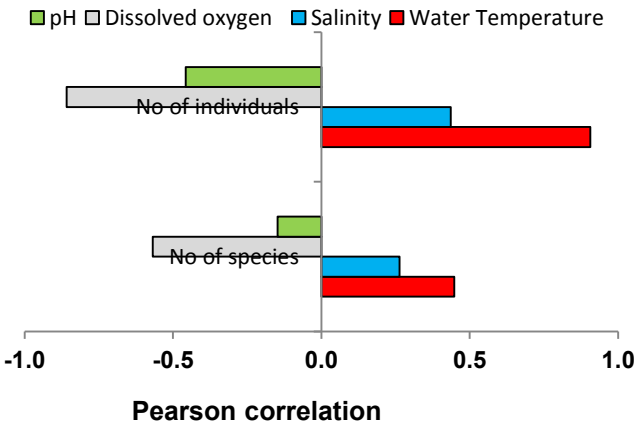

Figure 5. The correlations between the number of species and individuals and some ecological factors in Al-Diwaniya River

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The fish assemblage was comprised of nineteen native species (*A. marmid, A. caeruleu, A. mossulensis, A. grypus, C. luteus, C. sublimes, C. regius, C. kais, C. macrostomum, G. raiabilis, L. barbulus, L. kersin, L. vorax, L. xanthopterus, M. sharpeyi, P. abu, S. triostegus, M. mastacembelus* and *M. pelusius*) comprised 70.4% of the total number of species. Eight exotic species (*C. auratus, C. auratus auratus, C. carpio, H. leucisculus, O. aureus, C. zilli, G. holbrooki* and *H. fossilis,*) comprised 29.6% of the total number of species. The native species varied from 11 species in February to 18 species in March to October, whereas the exotic species changed from five species in February to eight species in August to November (Fig. 6).

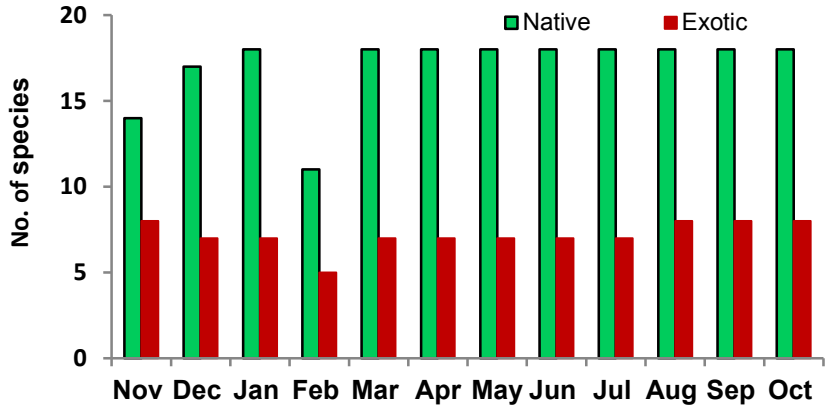

Figure 6. Monthly variations in the number of native and exotic fish species in Al-Diwaniya River

The incidence of collected fish species in Diwania River can be classified into two groups. The first group was the resident species represented by 25 species and formed 92.6% of the total catch, 16 of them appeared in 12 months (*C. auratus, P. abu*, *O. aureus C. luteus L. vorax, A. Grypus, L. Xanthopterus, M. Sharpeyi*, *A. Mossulensi*s, *A. Marmid, S. triostegus, M. pelusius, M. mastacembelus, C. carpio, H. fossilis* and *C. zillii*), five species in 11 months (*A. caeruleus, H. leucisculus, L. barbulus, G. holbrooki* and *G. raiabilis*), three in 10 months (*C. kais, L. kersin* and *C. regius*) and one (*C. macrostomum*) in 9 months. The second group was occasional species comprised of two species and constituted 7.4% of the total number of species, one of them was appeared in three months (*C. sublimes*) and the other (*C. auratus auratus*) in one month.

Table 1 shows the relative abundance of fish species in the Diwania River during the study period. It has been found that the fish assemblage was dominated by *C. auratus* (14.6%), it varied from 8.7% in May to 32.2% in December. *P. abu* comprising 14.2% of the assemblage, it fluctuated from 7.8% in February to 26.3% in October. *O. aureus* was formed 11.4% and relative abundance ranged from 5.0% in February to 25.4% in December. These three species formed 40.2% of the total number of species according to dominance index (D_3). *C. luteus* constituted 10.1% from the total assemblage; it varies from 1.5% in October to 13.7% in July. *L. vorax* was formed 6.4%, ranging from 2.0% in October to 10.2% in January.

The monthly variations in ecological indices relevant to fish species composition in the Diwania River during October 2016 - September 2017 are illustrated in Fig. 7. The diversity index (H) fluctuated from 2.09 in December to 2.82 in March, with an overall value of 2.56. The richness index (D) varied from 2.61 in January to 3.84 in February, with an overall value 3.37. The evenness index (J) ranged from 0.65 in December to 0.88 in March, with an overall value 0.81.

Table 1. Monthly variations in relative abundance of fish species collected from the Al-Diwaniya River during 2016-2017

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
Species	%	%	%	%	%	%	%	%	%	%	%	%	%
C. carassius	23.3	29.82	32.18	26.03	15.7	12.35	13.8	8.74	12.74	12.02	12.52	12.98	14.55
P. abu	26.32	16.14	13.68	11.11	7.75	9.43	12.44	14.95	11.84	15.2	14.23	15.54	14.18
O. aureus	16.79	18.61	25.43	10.48	5.04	8.9	10.75	11.06	12.5	9.69	9.94	9.44	11.42
C. luteus	1.51	5.83	4.43	11.11	9.3	9.3	10.29	9.19	9.62	13.71	11.23	11.54	10.08
L. vorax	1.97	3.14	3.28	10.16	8.72	6.77	6.11	4.86	8.35	7.32	6.26	5.9	6.38
A. grypus	0.45	0.67	1.16	6.98	8.14	8.76	8.03	6.5	9.29	8.36	3.93	3.8	6.27
L. xanthopterus	0.61	1.79	3.85	8.57	9.11	7.3	7.24	5.98	6.04	5.71	5.71	4.85	5.62
M. sharpeyi	0.61	2.47	0.77	6.67	8.53	6.91	6.22	7.47	5.09	5.07	5.09	4.2	5.09
A. mossulensis	11.35	7.4	3.66	2.86	5.62	5.58	4.19	2.17	2.08	2.57	2.39	1.84	3.4
A. caeruleus	0.61	0.67	0.19	-	0.58	1.99	2.49	3.89	4.2	2.73	5.09	3.54	2.99
A. marmid	0.61	2.02	2.5	0.95	5.43	4.65	3.85	3.21	1.51	2.05	3.01	2.1	2.52
S. triostegus	2.72	1.12	2.7	0.95	4.26	2.26	1.81	1.79	2.59	1.09	3.5	3.48	2.36
C. macrostomum	-	-	0.39	-	0.39	1.46	1.58	5.16	3.16	2.53	1.41	1.7	2.1
M. pelusius	0.91	0.9	0.39	0.63	1.94	2.79	3.39	2.02	1.98	1.25	2.7	3.48	2.06
M. mastacembelus	1.82	2.02	0.39	0.32	1.16	1.33	1.47	1.42	2.12	1.05	2.52	3.41	1.79
C. kais	-	0.45	0.19	-	0.78	0.93	0.68	2.69	2.5	2.41	1.72	2.3	1.76
C. carpio	1.97	0.9	0.58	0.32	2.13	2.92	0.68	2.47	1.37	1.73	1.84	1.7	1.68
H. leucisculus	0.3	0.22	0.39	-	0.39	0.66	0.57	0.97	0.8	1.53	1.6	1.31	0.99
L. kersin	-	0.45	0.58	-	1.36	0.66	0.9	2.54	0.38	0.76	1.29	1.31	0.96
H. fossilis	0.15	0.67	0.19	2.54	1.94	1.86	0.11	0.75	0.66	0.52	0.55	0.72	0.72
C. sublimus	-	-	-	-	-	-	-	-	-	0.72	1.41	2.75	0.63
C. zillii	6.51	1.57	0.77	0.32	0.19	0.4	0.79	0.3	0.09	0.08	0.25	0.13	0.61
L. barbulus	0.3	0.22	0.39	-	0.39	0.27	0.23	0.45	0.38	0.88	0.74	0.66	0.52
G. holbrooki	0.76	2.24	1.35	-	0.19	1.06	1.58	0.3	0.09	0.08	0.18	0.72	0.51
G. raiabilis	0.3	0.22	0.19	-	0.78	0.66	0.57	0.82	0.28	0.44	0.67	0.46	0.49
C. regius	-	0.45	0.39	-	0.19	0.8	0.23	0.3	0.33	0.48	0.25	0.13	0.32
C. auratus	0.15	-	-	-	-	-	-	-	-	-	-	-	0.01

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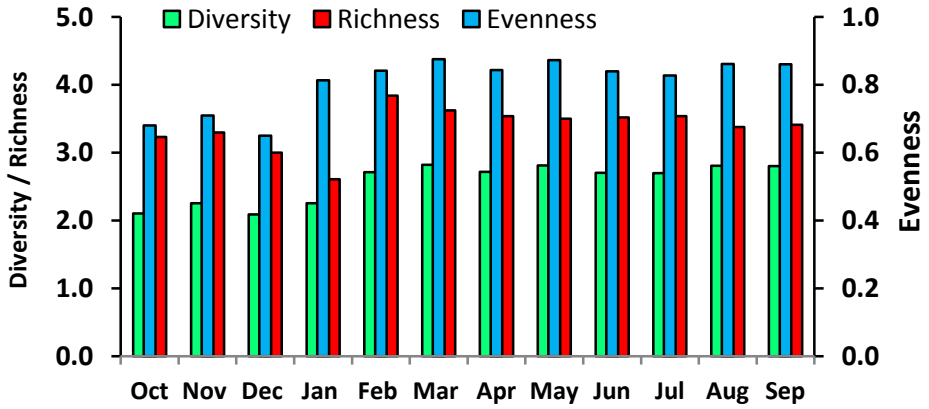

Figure 7. Monthly variations in the ecological indices values of the Al-Diwaniya River

DISCUSSION

Several works have being confirmed that fish species composition and abundance are strongly influenced by the water quality, the variation of water levels and discharges in the streams (Gergely et al., 2011; Sandu et al., 2013). The values of the water temperature, dissolved oxygen, salinity and pH parameters of the Al-Diwaniya water in the present study are compared with the values of these characters described in the previous studies on the river (Table 2). Generally, the results fall within the limits of those reported by other authors.

Table 2. Comparison of some ecological factors in the present study and other studies in the middle of Iraq

Sampling year	*Water temperature (°C)*	*Dissolved oxygen (mg/l)*	*Salinity (‰)*	*pH*	*References*
2012 – 2013	12-35	4.2 - 8.9	0.49-0.63	6.7-8.1	Alkam, *et al.* (2012)
2012 -2013 +	15-23	7.0-8.2	0.65-0.96	7.7-8.8	Alkam and Yassir (2015)
2014 *	28.9-31.2	6.3 to 8.0	0.46-0.52	7.5-8.1	Al-Sulaiman, (2016)
2015-2016	13-37	3.94-9.98	-	7.3-8.8	Merhoon, *et al*. (2017)
2016-2017	10.2-32.8	5.0-9.6	0.55-0.79	6.6-8.7	Present study

\+ November 2012 to April 2013 * March 2014 - October 2014

Water temperature is a factor of greater impact on the entire number of species and the total number of individuals compared to other factors, in present study water temperature has a stronger correlation with the total catch of fish individuals and positive correlation with the number of species. The temperature of water is one of the most important factors that determines, to a considerable extent, the trends and tendencies of variations in the river water quality. Rise in water temperature decreases the solubility of gases in particular dissolved oxygen. Also, temperature plays a vital part in chemical and biochemical reactions and is an important factor influencing self-purification in streams (Mohd et al., 2012). Water temperature regulate behavior attitude of aquatic organisms, for instance, fish migration and distribution (Durance and Ormerod, 2007).

The fish assemblage in the Al-Diwaniya River is dominated by cyprinid species. Cyprinids constitute the main component of the freshwater ichthyofauna and occur in almost every kind of freshwater habitat throughout Iraq (Al-Daham, 1982; Al-Rudainy et al., 2006; Coad, 2017; Al-Amari, 2011; Khaddara, 2014; Mohamed et al. 2017a, b).

Due to lack of information about fish assemblage composition in this river, we obliged to compare the results in this respect with the works that have been done on the adjacent rivers, i.e. the Euphrates River at Al-Mussaib power station and Al-Hindyah Barrier (Al-Rudainy et al., 2006; Khaddara, 2014; Abbas et al. 2017), and the Al-Hilla River (Al-Amari, 2011). It is apparent from the comparison that the fish assemblage structure in the Al-Diwaniya River was clearly differed from adjacent rivers by lower number of native species, higher number of exotic species, the dominancy species and the fish diversity. Fish assemblage in the Al-Diwaniya River comprised of 27 fish species including 19 native and 8 exotic species. The three most abundant species were *C. auratus, P. abu* and *O. aureus* constituted 14.6%, 14.2% and 11.4% of the total individuals, respectively. Al-Rudainy et al. (2006) collected 28 fish species from the Euphrates River/ Al-Mussaib power station during 2002-2003, 24 of them were native species and four exotic species, and the most abundant species during this period were *C. luteus*, *C. carpio* and *A. grypus* which formed 12.3, 11.4 and 11.1% of the total catches, respectively. Khaddara (2014) recorded 23 fish species from the Euphrates River/Al-Hindyah Barrier during 2012-2013, 18 of them were native and five exotic species, and the dominant species were *C. auratus, L. voraxv* and *C. Carpio* consisting 35.2, 15.3 and 11.8% of the total catches, respectively. Moreover, Abbas et al. (2017) mentioned that the fish assemblage in the Euphrates River/Al-Hindyah Barrier during 2014 -2015 consisted from 15 fish species, 12 native species and 3 exotic species, and the most abundance species were *P. liza* comprised 14.1% followed by *C. luteus* (12.6%) and *L. vorax* (11.6%). While, Al-Amari (2011) recorded 23 fish species from the Al-Hilla River during 2009-2010, 18 of them were native and five exotic species and the dominant species were *P. abu*, *C. auratus* and *A. mossulensis* constituting 61.7, 10.0 and 7.3%, respectively.

This tendency of declines among native fish and progresses among exotic fish have been observed in many Iraqi waters (Richardson et al., 2005; Mohamed et al., 2012, 2017; Mohamed and Abood, 2017). Hughes et al. (2006) 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, and including when they are deliberately introduced. Researchers have commonly observed habitat degradation facilitating the underlying mechanisms causing the loss of native fish diversity, the temporal replacement of specialized native fish by exotic fish (Scott and Helfman, 2001; Olden and Poff, 2003; Parks et al., 2014).

The diversity indices are now commonly applied to the study of fish composition and distribution, primarily to assess the health condition of rivers (Kwak and Peterson 2007). There are monthly changes in fish diversity in the river and the richness indices had a general trend to show high values during the period from February to September which could be related to joining of recruits of resident species after spring spawning and to the present of several species and increasing in their individuals, corresponding with increased in water temperature. This result is supported by the positive correlations with the abundance of fish individuals of all species and the number of species. The diversity, richness and evenness are relatively higher than those have been calculated in the region (Table 3), which reflects the large numbers of species and individuals that inhabit the river in the present study or differential in fish sampling protocols. The human activities such as urbanization, agriculture, channel modification, impoundment and exotic species introductions have directly and

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indirectly influenced fish assemblage structure by disrupting natural spatially-structured environmental gradients and alter fish assemblage composition (Parks et al., 2014; Kautza and Sullivan, 2015).

Table 3. Comparison of fish ecological indices in different waters in middle of Iraq

Ecosystem	*No. of species*	*Diversity*	*Richness*	*Evenness*	*References*
Al-Hilla River	23	0.65-2.19 (1.56)	1.38-3.36 (2.73)	0.23-0.74 (0.49)	Al-Amari (2011)
Euphrates River	23	1.26-2.39 (1.97)	0.79-3.23 (2.25)	0.65-0.86 (0.78)	Khaddara (2014)
Al-Diwaniya River	27	2.09-2.82 (2.56)	2.61-3.84 (3.37)	0.65-0.88 (0.81)	Present study

CONCLUSIONS

The study shows that the fish assemblage structure in the Al-Diwaniya River was clearly differed from adjacent rivers in middle of Iraq by number of fish species, the dominancy species and the fish diversity.

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