



ISSN: 0067-2904

## Fish Assemblage Structure in Al-Huwaizah marsh southern of Iraq after inscribed on the World Heritage List

Basim M. Hubain Al-Thahaibawi<sup>1</sup>, Kadhim H. Younis<sup>2</sup>, Ithar K.A. Al-Mayaly<sup>1</sup>

<sup>1</sup>Department of Biology, College of Science, University of Baghdad, Baghdad, Iraq

<sup>2</sup>Department of Marine Vertebrates, Marine Science Centre, University of Basra, Basra, Iraq

### Abstract

The fish assemblage structure in Al-Huwaizah marsh, southern of Iraq was assessed. Fish samples collected monthly by different fishing means from period December 2017 to November 2018. A total of 28959 individual of fish belonging to 9 families and 19 species were collected, 11 of them of native species and 8 of alien species. The numerical dominance index value (D3) of the highest three abundant species comprised 74.26% of the total fish caught, included *Planiliza abu* (Al-Keshny) 38.2% ; *Coptodon zilli* (Tilapia red abdomen) 29.41% and *Carassius auratus* (Prussian carp) 6.65%. The total weight of fish caught 2,190,680 tan, highest weight 312,242kg achieved in July, while lowest weight 41,590 kg found in September. The weight dominance index value (D3) of the highest three species in weight recorded 1,409,973 tan of the total weight of fish caught included *C. zilli* (Tilapia red abdomen) 659,994 kg , *S. triostegus* (Jerry fresh water) 495,784 kg and *O. aureus* (Blue tilapia) 245,195kg. The annual rate value for diversity, richness and evenness indices amounted 1.88, 1.75 and 0.64, respectively. Some of physical and chemical properties were studied such as water temperature which ranged from 11.5°C in January to 31.02°C in August month, dissolved oxygen ranged from 2.24 mg/l in September to 9.9mg/l in February, salinity varied from 1.37‰ in November to 3.76‰ in September and pH which ranged from 7.4 in June to 8.15 in December. Jaccard Similarity Index (Ss%) was used to know the similarity degree between the monthly catch samples. Also associations between distribution of fish species and the environmental variables were quantified by using canonical correspondence analysis (CCA).

**Keywords:** Fish assemblage, ecological factors, biodiversity indices, Al-Huwaizah marsh, Iraq

### تركيبة تجمع الاسماك في هور الحويزة جنوب العراق بعد ادراجه على لائحة التراث العالمي

باسم محمد حنين الذهباوي<sup>1\*</sup>، كاظم حسن يونس<sup>2</sup>، إيثار كامل عباس الميالي<sup>1</sup>

<sup>1</sup>قسم علوم الحياة، كلية العلوم، جامعة بغداد، العراق

<sup>2</sup>قسم الفقريات البحرية، مركز علوم البحار، جامعة البصرة، العراق

### الخلاصة

تم تقييم تركيبة تجمع الأسماك في هور الحويزة جنوب العراق. جمعت عينات الأسماك شهرياً بوسائل صيد مختلفة للفترة من كانون الأول 2017 الى تشرين الثاني 2018. تم جمع 28959 فرد من الاسماك تنتمي الى 9 عوائل و 19 نوعاً من الأسماك، 11 منها من الانواع المتوطنة و 8 من الانواع الغريبة. شكلت قيمة دليل السيادة العددية (D3) من اعلى ثلاثة انواع وفرة 74.26% من المصيد الكلي للأسماك، تضمنت *Planiliza abu* (الخشنى) 38.2%، *Coptodon zilli* (البطي احمر البطن) 29.41%

\* Emil: Basim\_moh74@yahoo.com

و *Carassius auratus* (الكارب البروسي) 6.65% . بلغ الوزن الكلي للأسماك المصطادة في هور الحويزة 2,190,680 طن , اعلى وزن 312,242 كغم تحقق في تموز، بينما اقل وزن 41.590 كغم وجد في ايلول . سجلت قيمة دليل السيادة الوزنية (D3) من اعلى ثلاثة انواع بالوزن 1,409,973 طن من إجمالي وزن الأسماك المصطادة شملت *C.zilli* (البطي احمر البطن) 659,994 كغم , *S. triostegus* (جري المياه العذبة) 495,784 كغم و *O.aureus* (البطي الازرق) 254,195 كغم . بلغت قيمة المعدل السنوي لادلة التنوع والغنى والتكافؤ 1.88 و 1.75 و 0.64 على التوالي. تم دراسة بعض الخصائص الفيزيائية والكيميائية مثل حرارة الماء التي تراوحت من 11.5 درجة مئوية في كانون الثاني الى 31.02 درجة مئوية في شهر اب, وتراوحت نسبة الأوكسجين المذاب من 2.24 ملغم / لتر في أيلول إلى 9.9 ملغم /لتر في شهر شباط ، وتباينت الملوحة من 1.37‰ في تشرين الثاني إلى 3.76‰ في أيلول والرقم الهيدروجيني الذي تراوح من 7.4 في حزيران إلى 8.15 في كانون الاول. تم استخدام دليل التشابه جكارد لمعرفة درجة التشابه في التركيب النوعي بين عينات الصيد الشهرية كذلك تم تحديد الارتباط بين توزيع أنواع الأسماك والمتغيرات البيئية باستخدام التحليل الكنسي المتعدد (CCA) .

## Introduction

Mesopotamian marshes in southern of Iraq are the biggest complex of wetlands in Iraq and one of the most important aquatic systems in the Middle East [1] and in southwest Asia with an area twice the size of the Everglades in Florida [2], covering an area of more than 15,000 km<sup>2</sup> representing about 44% of inland freshwater and oligo-saline water bodies of Iraq [3]. These marshes were characterized by thickets of aquatic vegetation, generally consisting of common reed, *Phragmites australis* and rushes, *Typha domingensis* [4] and therefore constitute a natural shelters for many of the special birds, fish, buffalo and other aquatic life [5] and major source of inland fisheries (60%) in Iraq [6]. They were the permanent habitat for millions of waterfowls and a flyway for migrating between Siberia and Africa [7]. Nevertheless, the marshes are important for economic, social and biodiversity values characterized by frequency of water flows, production of commercially important vegetation and fish, support endangered species and sustain freshwater and marine fish [8]. These marshes were encountered various issues during the last three decades amongst them construction of new hydrological projects in upper parts of the Euphrates and Tigris Rivers and drainage activities in the 1990s desiccating the southern marshlands [3]. Since mid-2003, great efforts were made to restore the marshlands.

The Mesopotamian Marshlands (Al-Huwaizah marsh) were listed as a World Heritage Site (UNESCO), making them most unique wetlands in the world during the 40th session in the World Heritage Committee under cultural criteria (iii) and (v) and natural criteria (ix) and (x) in Istanbul in 2016. The UNESCO considered it as one of the natural components of Iraq with an estimated area about 90,663 hectares (906.63 km<sup>2</sup>) [9].

After inundation the marsh in April 2003, published research papers dealt mostly with the fish species composition, but unfortunately few studies were detected dealing with the fish stock assessment in this marsh as studies [10-12]. There is no published information on the species composition, fish ecology, and fisheries of the Al-Huwaizah marsh until last study by Youns *et al.* [12] on Um Al-Nia'aj position. The specific objective of the present work is to describe the status of fish assemblage structure of Al-Huwaizah marsh and abundance to compare this with the state of the fish assemblage in this marsh before a decade.

## Materials and Methods

### Description of study area

This is considered as a first study for nature of fish assemblage in Al-Huwaizah marsh after inscribed on the World Heritage List. Al-Huwaizah marsh lies to the east of the Tigris River, straddling the Iran-Iraq border and lies approximately 70 km of Al-Ammara city. It extends between (31°00'-31°45'N, 47°25'-47° 50'E). The area is distributed by 79% for the Iraqi part and by 21% for the Iranian part [13]. Its length is about 80 km, from the Iraqi-Iranian borders to the east of the Tigris river from its western part, with wide of 30km [14]. Thus the average of the size of the marsh is about 2400 km<sup>2</sup> which extends to 3500 km<sup>2</sup> during the flood season and shrinks to 650 km<sup>2</sup> during the season of dryness, which is only applicable to deep water areas. The reservoir of this marsh attains about 7000 billions m<sup>3</sup> obtained from the water excess of the nearest Tigris and 2-4 meters above sea level [15]. The marsh is largely fed by two main distributaries departing from the Tigris River near

AL-Ammarah city, known as Al-Musharah and Al-Kahla rivers. Added to this is water from rainfall, and water from the rivers arriving from Iran, such as the Al-Karkha, Tayib and Duwayaraj Rivers, which empty into Al-Sanna'f marsh and which in turn supplies Al-Huwaizah marsh.

Fish were collected a monthly from four selected stations included Umm Al-Ward ( N 31°33' 45.50" : E 47° 32' 9.15": ), Um Al-Nia'aj ( N 31°35' 45.15" : E 47° 38' 22.50"), Al-Souda north ( N 31°40' 22.26" : E 47° 39' 50.38") and Al-Adaim (N 31° 41' 22.36" : E 47° 45' 35.40") in Al-Huwaizah marsh from December 2017 to November 2018(Figure -1). Water temperature, dissolved oxygen, salinity and pH were measured *in situ* using digital portable WTW Multi-meter model (Multi 350i meter). Water depth was measured by ionic-ruler, which is divided from 0-400 cm. Fish sampling was carried out from each station using seine net (20 m long with a 2.5 cm mesh size), fixed and drifted gill nets (120 m long with 2.5 cm to 10 cm mesh size) and electro-fishing by generator engines(provides 300-400V and 10A), it was used in the places where the vegetation very density and can not be caught. Specimens were immediately transported to the laboratory by box with crushed ice. The weight of fish was calculated monthly for each caught species in gram and Kilogram using a balance type Sartorius (BL3100). Fish were counted and classified in to species based on [16-19].

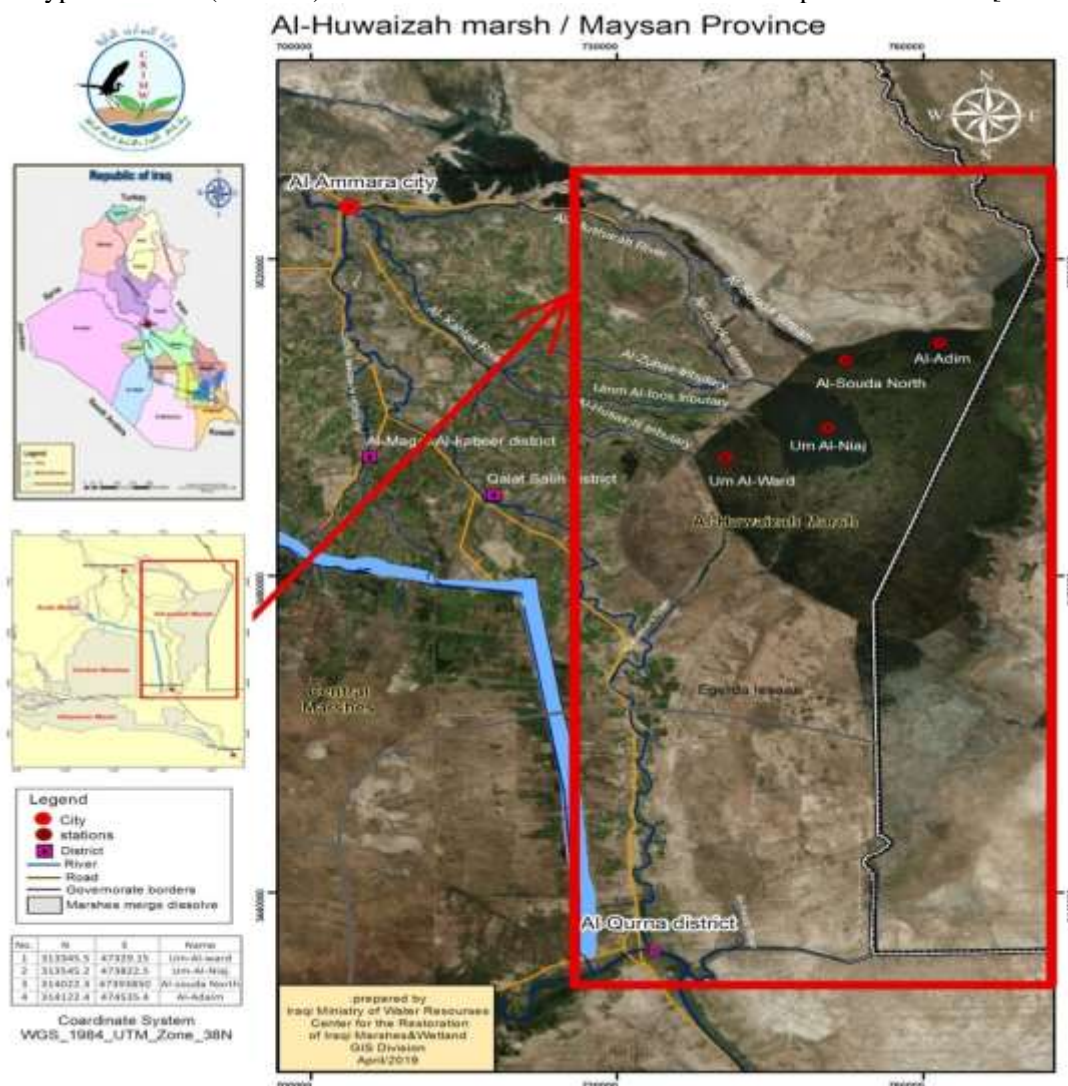


Figure 1- Al-Huwaizah marsh location in Maysan province southern of Iraq [20].

The relative abundance (Ra%) was calculated from the equation  $ni / N \times 100$  [21]. Shannon-Weaver index of diversity obtained by the following equation  $H = -\sum pi \ln pi$  [22]. The species richness was calculated using the equation  $D = (S-1) / \ln N$  [23]. The evenness is  $J = H / \ln S$  [24]. The three most abundant species determined by the following equation  $D3 = (\sum_{i=1}^3 pi) \times 100$  [25]. Jaccard Similarity

Index (Ss%) was used to determine the degree of similarity among study months by the following equation  $IS_j = [a/(a+b+c)] \times 100$  [26].

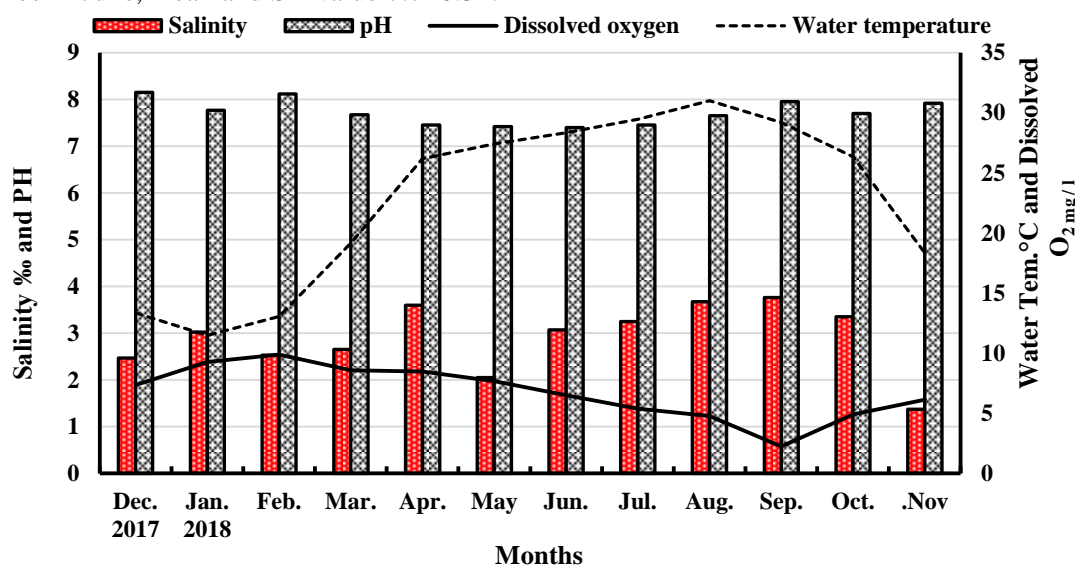
### Statistical analysis

The data of this study treated by using two statistical programs, statistical package for social sciences (SPSS) version 22 for F-test, the mean  $\pm$  SD (standard deviation) for water parameters among stations and months by using analysis of variance (ANOVA), correlation between water parameters and number of fish species and individuals. Whereas the multiple linear correlation analysis carried out on water parameters and fish to verify if there is any significant relationship by applying the canonical correspondence analysis (CCA) of ecological data using CANOCO program [27]. All these tests were conducted at the probability of 0.05.

## Results and Discussion

### Ecological factors

It was found there are no significant differences ( $F = 0.67, 0.85, 0.59$  and  $0.38, p > 0.05$ ) among the four sampling stations with the values of water temperature, dissolved oxygen, salinity and pH, when they were measured. The monthly variations in the mean values of these factors were shown in (Figure-2). Water temperature values were varied, where the lowest value  $11.5^\circ\text{C}$  recorded in January, while the highest value  $31.02^\circ\text{C}$  revealed in August, where mean and SD value was  $22.8 \pm 7.23$ . Dissolved oxygen values ranged from  $2.24$  mg/l in September to  $9.9$  mg/l in February, mean and SD value  $6.72 \pm 2.34$ . Also the salinity values ranged from  $1.37\text{‰}$  in November to  $3.76\text{‰}$  in September, mean and SD value  $2.9 \pm 0.95$ . Whereas narrow fluctuation of pH was observed during the study period, where the highest mean value of  $8.15$  was tested in December, while lowest average value  $7.4$  was examined in June, mean and SD value  $7.7 \pm 0.31$ .



**Figure 2-** Monthly variations in the means of some ecological factors of Al-Huwaizah marsh

On the other hand, the average water depth in Al-Huwaizah marsh ranged from 33 cm in September to 98 cm in February, where maximum depth 118 cm was found in April at station 2, while minimum depth 27 cm was reported in September at station 4. Significant differences ( $P \leq 0.05$ ) were detected in water depth among study stations.

Fish assemblage structure and composition were distinctly varied in the marsh which corresponds to hydrological and geomorphic differences. However, fish distributions associated with closely correspond to habitat features. Water temperature is one necessary of environmental variables affecting the distribution and abundance of different fish, the feeding activity and food consumption are affected by temperature because of the lower temperature than ideal limits [28]. Also, salinity may also participate in differences of distribution and abundance of fish species and their composition inside the marsh. Moreover, fish presence, distribution, and movement along aquatic environments are influenced by overlapping of living and non-living factors either directly or indirectly [29] thus declare that it is difficult to base species existing on a specific environmental factor [30].

**Species composition**

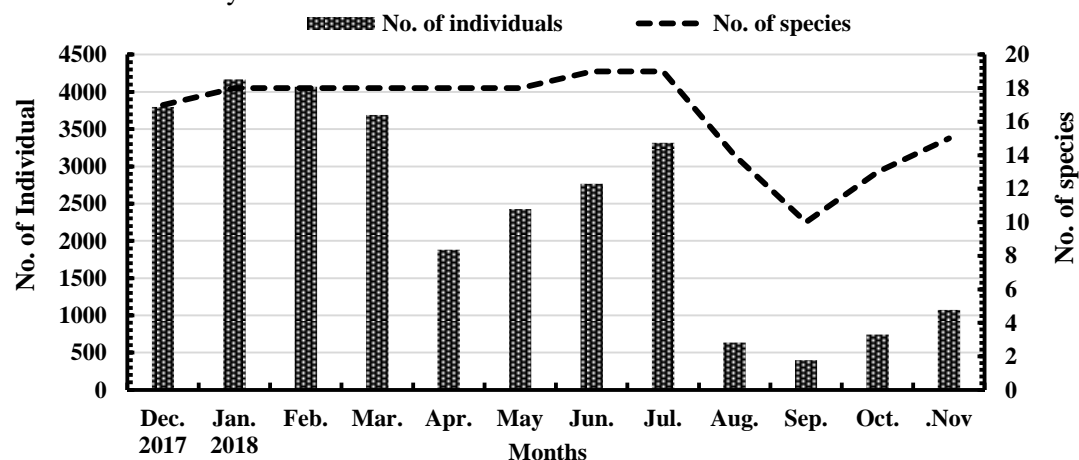
Altogether, nineteen fish species belonging to nine families and seventeen genera were collected from four studied stations in Al-Huwaizah marsh (Table -1). Cyprinidae was the most dominated family in terms of number of species represented by nine species followed by Cichlidae family (3 species), whereas Mugilidae, Siluridae, Heteropneustidae, Bagridae, Mastacembelidae, Cyprinodontidae and Poeciliidae families were contained one species each.

**Table 1-** Monthly variations in relative abundance for fish species which collected of Al-Huwaizah marsh during study period

Family	Species	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Total
		2017	2018											
Mugilidae	<i>Planiliza abu</i> +	37.57	40.64	39.62	35.79	38.15	41.23	43.71	40.87	39.27	33.25	29.34	35.91	38.2
Cichlidae	<i>Coptodon zillii</i> *	38.01	34.61	32.32	33.84	28.8	26.4	20.83	16.82	21.29	15.11	18.17	15.4	29.41
Cyprinidae	<i>Carassius auratus</i> *	4.16	2.69	6.57	7.8	9.62	8.4	8.24	6.1	9.78	11.59	10.9	9.05	6.65
Siluridae	<i>Silurus triostegus</i> +	4.27	4.63	4.89	4.88	6.11	6.14	5.93	7.26	8.36	8.31	6.73	5.5	5.52
Cichlidae	<i>Oreochromis aureus</i> *	3.37	2.45	2.78	3.09	3.72	3.46	3.43	4.37	7.41	8.82	7.81	8.02	3.72
Cyprinidae	<i>Carasobarbus luteus</i> +	2.58	3.24	2.85	2.76	1.81	2.64	3.9	5.37	0.95			4.38	3.07
Heteropneustidae	<i>Heteropneustes fossilis</i> *	1.13	1.58	1.35	1.87	2.71	1.8	1.66	2.83	4.26	12.34	9.02	6.44	2.35
Cyprinidae	<i>Alburnus mossulensis</i> +	1.79	2.09	2.24	2.14	2.66	2.76	2.75	2.71	1.89	2.52	2.69	1.87	2.31
Cyprinidae	<i>Leuciscus vorax</i> +	2.05	2.28	2.02	1.98	2.39	2.72	2.24	2.44				2.43	2.1
Cichlidae	<i>Oreochromis niloticus</i> *	1.08	0.98	1.03	2.03	0.48	0.45	1.01	2.38	1.74		0.94	1.12	1.23
Cyprinidae	<i>Carasobarbus sublimus</i> +	0.92	1.11	0.96	0.92	0.63	0.53	1.37	2.62				1.58	1.11
Cyprinidae	<i>Hemiculter leucisculus</i> *	0.63	0.74	1.06	1	1.17	1.27	0.94	0.75	1.1	1.01	1.35	1.21	0.94
Bagridae	<i>Mystus Pelusius</i> +							1.41	1.99	1.89	6.8	9.83	5.13	0.94
Cyprinidae	<i>Cyprinus carpio</i> *	0.69	0.67	0.52	0.43	0.21	0.25	0.25	0.36	0.95		2.28	1.68	0.56
Cyprinodontidae	<i>Aphanius dispar</i> +		0.7	0.61	0.49	0.58	0.58	0.7	0.66	0.95				0.49
Cyprinidae	<i>Acanthobrama marmid</i> +	0.45	0.55	0.27	0.38	0.53	0.62	0.8	0.51		0.25	0.54		0.46
Mastacembelidae	<i>Mastacembelus mastacembelus</i> +	0.5	0.38	0.39	0.08	0.11	0.25	0.47	1.57					0.44
Poeciliidae	<i>Gambusia holbrooki</i> *	0.53	0.48	0.42	0.38	0.27	0.29	0.18	0.15	0.16		0.4	0.28	0.34
Cyprinidae	<i>Mesopotamichthys sharpeyi</i> +	0.26	0.17	0.1	0.14	0.05	0.21	0.18	0.24					0.16

**+ Native species ; \* Alien species**

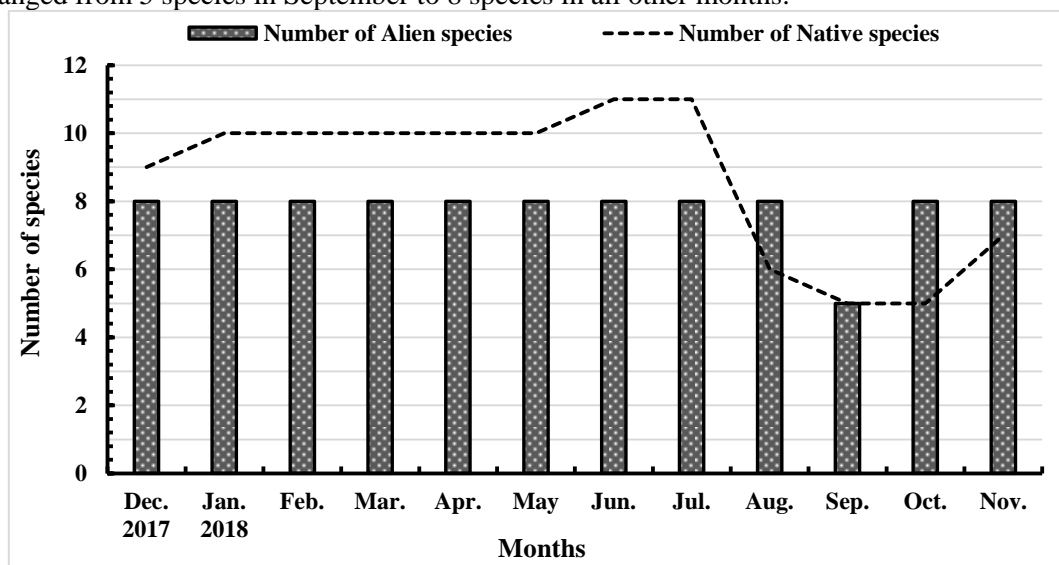
The monthly fluctuations in number species and individuals were shown in (Figure-3). The number of species ranged from 10 species in September to 19 species in June and July. Generally, the number of fish captured species increased from December till July. A total of 28959 individual of fish were caught from Al-Huwaizah marsh during the study period, they ranged from 397 fish in September to 4166 fish in January.



**Figure 3-**Monthly variations in the total number of caught fish species and individuals at Al-Huwaizah marsh during study period



The fish species of Al-Huwaizah marsh broadly classified into 11 native and 8 of alien freshwater fish species. The monthly variations in these categories are given in (Figure-4). The native fish species constituted 57.89% of the total number of fish species and varied from 5 species in both September and October months to 11 species in June and July months, whereas the alien species formed 42.11% and ranged from 5 species in September to 8 species in all other months.



**Figure 4-** Monthly variations in number of the native and alien fish species of Al-Huwaizah marsh

The results of the present study revealed that the fish assemblage was clearly shifted in the present of alien and the dominancy species and the fish diversity compared with the previous status. The number of native species is naturally declining, accompanied by an increase in number of alien species, that represented as a form of disturbances coming from human influences, and entering these species represents the increasing biological disturbance with deteriorating water quality and the environment Mohamed *et al.*[31], thus the increase in proportion of alien species coincides with the high percent of individuals of the tolerant species this supported study Costa and Schulz [32] where showed that the tolerant species are the last to leave the water surface at the deterioration time. Overall, this study recorded highest number of native and alien of fish species in Al-Huwaizah marsh.

The native fish recorded 15870 individual forming 54.8 %, the highest number 2243 individual done in December 2017 comprised 14.13%, while the lowest number 203 individual presented in September by 1.28% of the total number of the native fish individuals. Whereas the alien fish achieved 13089 individual giving a percentage 45.2% of the total number of fish captured. The highest number 2169 fish collected in February formed 16.57%, while lowest number 194 fish finding during September comprised 1.48% of the total number of alien fish individuals . In addition the highest proportion of native fish species that recorded in the Al-Huwaizah marsh included *P. abu* 38.2 % ; *S. triostegus* 5.52% ; *C. luteus* 3.07% ; *A. mossulensis* 2.1% and *L. vorax* 2.1% , whereas the highest proportion of alien fish species included *C. zilli* 29.41% ; *C. auratus* 6.65% ; *O. aureus* 3.72% ; *H. fossilis* 2.35% and *O. niloticus* 1.23% (Table -1).

*Planiliza abu* and *Coptodon zillii* have an overall numerical dominance comprised 67.61% of a total number of fish caught in the present study. One of the reasons that led to the increase these two species their highly tolerant to environmental conditions and ability to adapt themselves to new environments with rapid reproduction and easy distribution [33].The inland waters in Iraq have clearly faced several drastic variations which included habitat alterations, entry alien species and declines in native fish communities [18,34]. As well as, Hussein 2010[35] revealed the ability of alien species in influencing on composition the fish community through competition, predation and interference with resident local fish. However, these changes in the structure of fish assemblage in Al-Huwaizah marsh due to the decline in discharge rates of Tigris River Al-Mahmood *et al.* [36]. Moreover, Welcomme [37] stated that fish assemblage in rivers, lakes and reservoirs vary widely in the abundance from year to year, and these variations are in response to fluctuations in precipitation and flood strength.

The number of alien fish species was increased considerably comparison with the past findings reported earlier on the marsh. Moreover, two new species were recorded for the first time in Al-Huwaizah marsh southern Iraq, at Maysan Province namely *C. sublimes* of native species which first recorded by Mohamed *et al.*[38] from the upper reaches of the Shatt al-Arab River, and other *O. niloticus* of alien species, this species was first recorded by Al-Faisal and Mutlak [39] in Shatt Al-Arab River, at Basrah Province, Iraq. In addition this species was not recorded in the previous studies conducted on Al-Huwaizah marsh.

#### Relative abundance

The highest proportions of captured fish families included Mugilidae family in the first rank where comprised 38.2% ; Cichlidae family get the second rank with 34.36% ; Cyprinidae family was rank at third level by 17.36% ; Siluridae family ranked fourth gave percent 5.52% and Heteropneustidae family came in the fifth rank formed 2.35%, whereas the lowest proportions included Bagridae, Cyprinodontidae , Mastacembelidae and Poeciliidae families and comprised 0.94% ; 0.49% ; 0.44% and 0.34%, respectively.

According to dominance index (D3) there are three species formed 74.26% of the total number of fish caught were in the order following : *Planiliza abu* which composed 38.2% of the total catch, it varied from 29.34% in October to 43.71% in June. *Coptodon zillii* comprising 29.41% , it fluctuated from 15.11% in September to 38.01% in December and *Carassius auratus* was formed 6.65%, its relative abundance ranged from 2.69% in January to 11.59% in September (Table -1).

Degradation of water quality in the southern marshes led to several Cyprinid species disappearance or substantially decreased in abundance, such as *Arabibarbus grypus*, *Luciobarbus xanthopetrus*, *Luciobarbus kersin*, *Mesopotamichthys sharpeyi* [40, 41]. Furthermore, Hughes and Whittier [42] stated that the native species represent the basic building blocks of a fish assemblage, and are a key component of diversity and the alien 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. The extremely tolerant species are the last to disappear in response do environmental degradation Costa and Schulz[32]. 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 alien fish [43, 44].

#### Quantities of fishing

The results of the present study showed there are monthly and total variations in caught fish families (Table -2). The total weight of fish captured in Al-Huwaizah marsh reached to 2,190,680 tan. The highest weight 312,242 kg collected in July, while lowest weight 41,590 kg done in September. Nine of fish families captured in the study area included Cichlidae family which occupied the first rank with total weight amounted 996,723 kg comprised 45.5% where varied from 13,890 kg in September to 148,428 kg in February ; Siluridae family came in the second rank with total weight amounted 495,784 kg forming 22.63%, it ranged from 15,646 kg in September to 76,954 kg in July; the third rank was occupied by Cyprinidae family achieved 384,855kg where varied from 3,372kg in September to 61,888 kg in July; Mugilidae family came in the fourth rank get 231,320 kg with 10.56%, the highest weight 44,550 kg in July, and lowest weight 3,480 kg in September and Heteropneustidae family occupied the fifth rank of 48,184 kg comprised 2.2% , where laid between 1,929 kg in August and 7,080 kg in July, whereas Bagridae , Mastacembelidae , Cyprinodontidae and Poeciliidae families formed 0.83%, 0.68%., 0.03 and 0.0 % respectively, from the total weight of fish caught within Al-Huwaizah marsh .

According to dominance index (D3) there are three species recorded 1,409,973 tan of the total weight of fish caught were in the order following : *C.zilli* achieved as a highest weight where reached to 659,994 kg and varied from 3,957 kg in September to 123,462 kg in February ; *S. triostegus* achieved 495,784 kg and ranged from 15,646 kg in September to 76,954 kg in July; *O.aureus* recorded 254,195 kg laid between 9,933 kg in September and 48,974 kg in July.

**Table 2-** Monthly variations in weight (Kg) of fish caught at Al-Huwaizah marsh during study period

The Species	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Total
	2017	2018											
<i>C. zillii</i>	105,576	110,436	123462	107,445	49,823	56,338	39,758	34,820	8,691	3,957	9,053	10,635	659,994
<i>S. triostegus</i>	42,576	59,651	58,752	50,376	33,964	41,934	45,823	76,954	25,472	15,646	22,917	21,719	495,784
<i>O. aureus</i>	15,397	11,148	16,648	18,006	1,2894	23,130	33,306	48,974	14,284	9,933	18,699	31,776	254,195
<i>P. abu</i>	18,148	19,475	19,186	18,926	1,1381	28,268	37,280	44,550	8,671	3,480	7,954	14,001	231,320
<i>C. auratus</i>	11,077	7,760	18,721	18,782	1,2845	13,425	15,471	14,322	4,291	2,848	5,975	7,708	133,225
<i>O. niloticus</i>	3,066	3,138	8,318	16,320	1,727	3,223	11,218	26,479	3,223		2,127	3,695	82,534
<i>L. vorax</i>	8,311	9,563	9,511	8,234	4,360	6,558	8,155	13,118				4,402	72,212
<i>C. carpio</i>	7,105	8,379	6,685	6,071	1,684	2,613	3,662	5,919	2,552		6,442	6,268	57,380
<i>C. luteus</i>	5,824	6,828	5,758	5,637	2,309	3,786	7,038	13,918	4,610			3,375	54,934
<i>H. fossilis</i>	3,919	3,973	3,286	4,373	3,029	3,671	4,015	7,080	1,929	3,481	4,624	4,804	48,184
<i>C. sublimus</i>	2,081	2,327	1,937	1,880	0,815	0,797	2,526	6,794				1,172	20,329
<i>M. Pelusius</i>							2,769	4,201	0,720	1,721	5,052	3,647	18,110
<i>M. sharpeyi</i>	2,817	2,542	1,460	1,803	0,348	2,365	2,162	3,292					16,789
<i>M. mastacembelus</i>	1,213	1,107	1,246	0,271	0,227	1,360	2,403	7,184					15,011
<i>H. leucisculus</i>	0,357	0,448	1,152	2,261	1,825	2,464	2,212	1,725	0,544	0,278	0,690	0,898	14,854
<i>A. mossulensis</i>	0,849	1,197	1,397	1,193	0,794	1,057	1,426	2,450	0,305	0,229	0,566	0,572	12,035
<i>A. marmid</i>	0,229	0,339	0,198	0,254	0,190	0,228	1,177	0,350		0,17	0,115		3,097
<i>A. dispar</i>		0,89	900	0,71	0,51	0,90	0,168	0,113	0,21				0,693
<i>G. holbrooki</i>	0,04	0,028	0,028	0,028	0,011	0,011	0,008	0,008	0	0	0	0	0,162
<b>Total Weight</b>	<b>228,545</b>	<b>248,400</b>	<b>277,807</b>	<b>261,903</b>	<b>138,266</b>	<b>191,307</b>	<b>220,569</b>	<b>312,243</b>	<b>71,164</b>	<b>41,590</b>	<b>84,214</b>	<b>,672114</b>	<b>2,190,680</b>

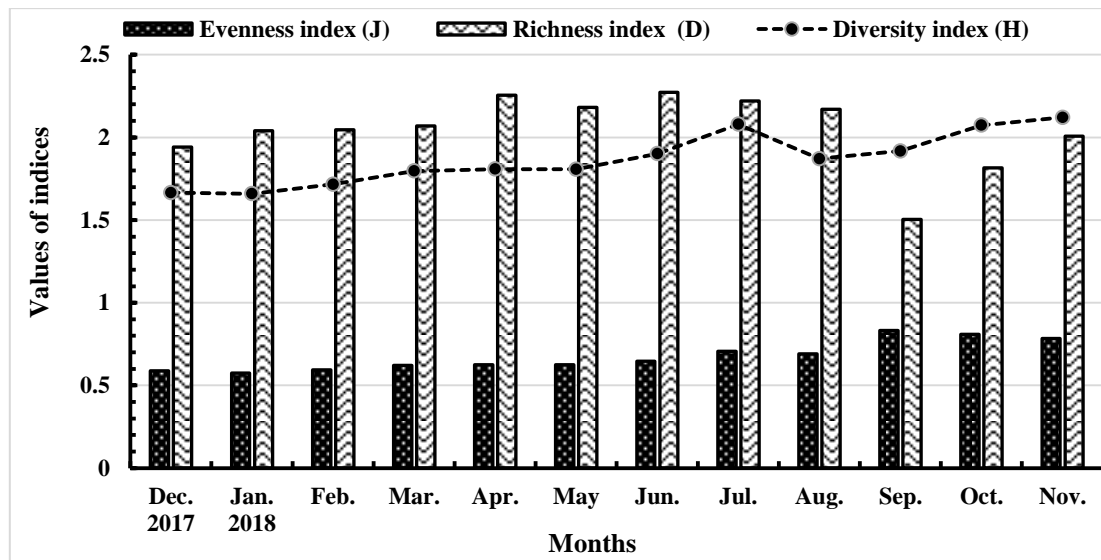
Al-Huwaizah marsh witnessed significant monthly fluctuations in fishing quantities for families and individual species. The highest weight recorded in July that due to the large numbers of fish caught than the other months, also the changes in temperature and salinity concentration have an effect on mass of fish, while the lowest quantities caught were in September, August and October months respectively, because of the lower level of water in these month, decrease in the number of fish caught individuals in the study area, in addition the disappearance of some sensitive species as *M. mastacembelus*, *M. sharpeyi* and *L. vorax* with the increase in the number of alien species, thus caused a large variation between the quantities of fishing during the study months, and this could be caused by unfavorable environmental parameters, especially higher salinity and changed hydrological conditions Mohamed *et al.*[45]. Also, the fishery has also been associated with the period of fish movement, feeding activity and the reproduction of local species [46].

There are negative insignificant correlation ( $P > 0.05$ ) between water temperature and the total number of species ( $r = -0.561$ ); negative significant correlation ( $P \leq 0.05$ ) between water temperature and total number of individuals ( $r = -0.654$ ); positive significant correlation ( $P \leq 0.05$ ) for dissolved oxygen with the total number of species and total number of individuals ( $r = 0.788$  and  $r = 0.731$ ) respectively, water depth showed positive significant correlation ( $P \leq 0.05$ ) with the total number of species and total number of individuals ( $r = 0.815$  and  $r = 0.698$ ) respectively, salinity showed negative insignificant correlation ( $P > 0.05$ ) with the total number of species and total number of individuals ( $r = -0.347$  and  $r = -0.315$ ) respectively, also pH showed negative insignificant correlation ( $P > 0.05$ ) with the total number of species and total number of individuals ( $r = -0.383$  and  $r = -0.196$ ) respectively.

### Fish ecological indices

Monthly variations in diversity, richness and evenness indices of fish assemblage in Al-Huwaizah marsh are illustrated in (Figure - 5). The diversity index (H) fluctuated from 1.66 in January to 2.12 in November, with overall value 1.88. The richness index (D) changed from 1.5 in September to 2.27 in June, with overall value 1.75. In addition the evenness index (J) ranged from 0.57 in January to 0.83 in September, with overall value 0.64. The correlation coefficient (r) finding there are significant positive correlation ( $P \leq 0.05$ ) between water temperature with both evenness index (J) ( $r = 0.595$ ) and diversity index (H) where r value ( $r = 0.361$ ), it showed negative correlated with richness index (D) ( $r = -0.397$ ), whereas dissolved oxygen showed significant positive correlation ( $P \leq 0.05$ ) with richness index (D) where r value ( $r = 0.684$ ) and negative correlated with evenness index (J) and r value ( $r = -0.754$ ).



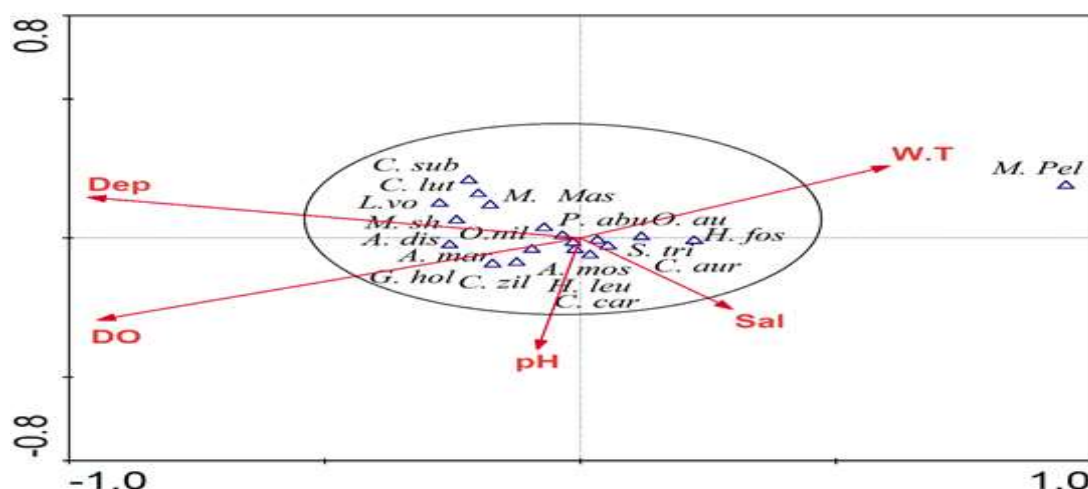


**Figure 5-** Monthly variations in the ecological indices values of Al-Huwaizah marsh during the study period

There are seasonal changes in fish diversity in the marsh and the richness indices had a general tendency to show high values during the period from April to September which could be attributed largely to the increase in alien fish individuals. This result is supported by the positive significant correlations ( $P \leq 0.05$ ) between the number of species and dissolved oxygen ( $r = 0.788$ ), and negative insignificant correlations ( $P > 0.05$ ) with salinity ( $r = -0.429$ ). The abundance of alien species has led to an increase in the richness, evenness and diversity indices and created seasonal fluctuation in the relative abundance Hussain *et al.*[47]. Whereas, the rising discharge of water Tigris River shares in the presence variation in composition of fish community in Al-Huwaizah marsh, whereas this result reflected the Richness index (D) value which express on the extent healthy the water body in terms of numerical abundance and fish diversity Rathertm *et al.*[48].

**Canonical correspondence analysis (CCA)**

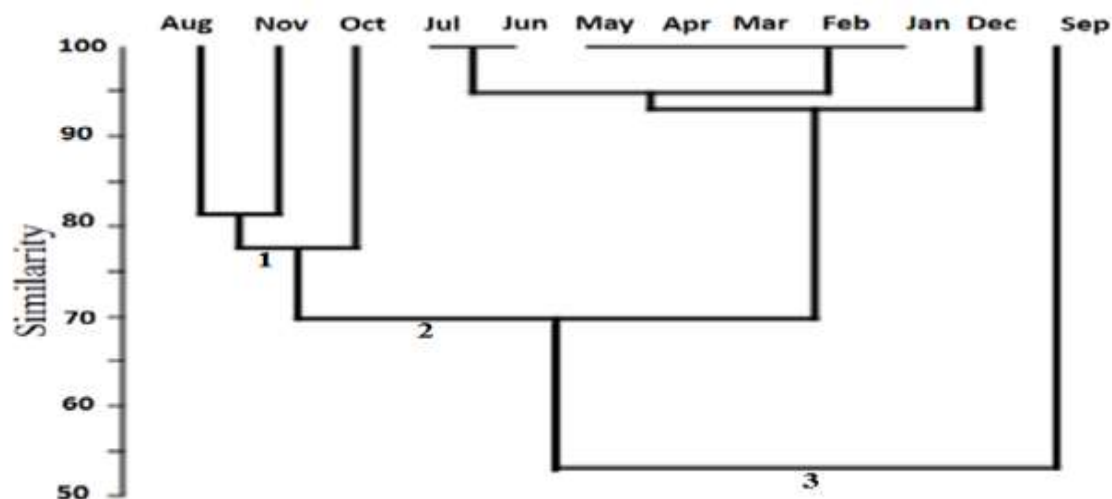
Figure-6 illustrated the canonical correspondence analysis (CCA) ordination plot which summarized the relationships between the availability of all fish species referred to in a symbol ( $\Delta$ ) and the physical and chemical properties represented by the arrow in the Al-Huwaizah marsh during the study period. The results indicate to most fish species impacted by the physical and chemical properties in the different percentages except *M.pel* species which showed positive significant correlation with water temperature and negatively correlated with water depth (Dep), dissolved oxygen (DO) and pH.



**Figure 6-** CCA ordination plots showing the relationship among fish species and ecological factors in Al-Huwaizah marsh

### Similarity degree in the species composition using Jaccard Similarity Index (%Ss)

The results of similarity in the species composition for fish in Al-Huwaizah marsh using Jaccard Similarity Index showed the presence of three main groups at a similar level of 53%. The first main group included two secondary groups, the first secondary group consisted of August and November at a similar level of 82%, and the second secondary group included October at a similar level of 77%. The second main group included three secondary groups, the first secondary have June and July at a similar level of 100%. The second secondary group included May, April, March, February, and January at a similar level of 100%, and the third secondary group consisted of December at a similar level of 93%, whereas the third main group has September only (Figure -7).



**Figure 7-** Cluster analysis of similarity degree among monthly fishing samples in Al-Huwaizah marsh using Jaccard Similarity Index (%Ss)

### Conclusions

The study revealed that the fish assemblage of Al-Huwaizah marsh was clearly altered by increase percents of alien species, and decline in native species compared with the state of the fish assemblage of this marsh before a decade as a result of the decline in the rate of discharge of freshwater during the recent years after the inundation.

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