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The effect of the salinity gradient on the diversity of fish assemblage in the Shatt Al-Arab River

Abdul Hussein Jaafer Abdullah and * and Mohammed A. Jasim Aldoghachi

Department of Marine Vertebrate, Marine Science Center, University of Basrah, Iraq
*Corresponding author: mohammed.aldoghachi@uobasrah.edu.iq

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Abstract:

Because there have been only a few studies on the effect of the salinity gradient on the formation of fish assemblages in the Shatt Al-Arab River, the present study was conducted on the river from Al-Deer district to the river's estuary at Al-Fao town during the period from January to December 2022. The samples were collected monthly using various fishing methods and tools. Three stations were chosen for the study: station 1 at Al-Deer city, station 2 at Abu-AlKhaseeb city, and Station 3 at Al-Fao city. Some ecological parameters were measured: water temperature, hydrogen ion, water transparency, and salinity concentration. A total of 60 fish species belonging to 48 genera and 32 families were caught affiliated to bony fishes (Osteichthyes class). The most abundant species was *Carassius gibelio* recorded at 15.00% of the total catch, followed by *Oreochromis aureus* at 13.48%, and *Planiliza abu* constituted 12.56% of the overall capture of fish. The diversity index (H) values ranged from 2.40 in January to 2.81 in May. The evenness index (J) values varied between 0.72 in December to 0.88 in January and March. The richness index (D) ranged from 2.67 in December to 4.51 in November. Resident species included 14 fish species, accounting for 78.64% of the total caught. Seasonal species comprised eight species, accounting for 14.44% of the total catch. Occasional fish species included 38 species, forming 6.92% of the total number of species. The present study concluded that salinity has a vital role in the distribution and spread of fish species, structuring the fish assemblage; this was noticed in the present three stations since fish composition differed, and there is a clear gradient in the composition of the fish population from the top of the river towards the sea.

Keywords: Salinity gradient, Composition, Fish assemblage, Shatt Al-Arab River

Introduction

Estuarine ecosystems often exhibit clear salinity gradients that contribute to the spread and distribution of organisms and can act as filters, regulating the passage of fish populations between river and seas [1]. The physiological factor is most important limiting factor for fresh and marine water species especially the osmoregulation process that represents the most impacting adjective in the distribution of estuarine fish in wide broad [2]. Generally, the salinity gradient can change daily, monthly, and seasonally due to tidal, climate, and oceanic phenomena [3]. Fish assemblages in estuarine systems respond primarily to salinity variations along a gradient, followed by structural habitat elements within the salinity-defined region [4]. The study of the environmental elements' composition, from landscape-scale salinity gradients to fine-scale habitats, has a significant impact on how fish are distributed in their environment [5]. All of these habitat components serve as work as filters for all fish species of fish fauna differ greatly between these habitats, making it difficult to predict both the temporal and spatial structure of communities [6, 7]. Salinity, work as physiological barrier between freshwater and marine water, appears to be the primary motor factor influencing organism efficiency along habitat and ecological gradients [8], and serves as an external ecological factor as well as a physiological feature of aquatic organisms in internal environments [9]. Some fish species are more dominant in brackish or salty waters because they have traits that make them more tolerant [10]. The intrusion of seawater made the organisms of the Shatt Al-Arab River vulnerable to the increasing effects of salinity due to the decline in freshwater flow rates from the Tigris and Euphrates Rivers [11]. According to [12], freshwater habitats such as rivers, lakes, and ponds have a salinity of 0.5 psu or less. A salinity ranges from (0. 5 to 5.0 psu) is known as oligohaline in estuaries habitats. The salinity ranges from (5.0-18.0 psu), is known as mesohaline water is, and the salinity range from (18.0-30.0 psu) is called polyhaline. However, salinity levels near the seawater were comparable to seawater (>30 psu). Fish species differ in salinity tolerance and exhibit rapid responses to the salinity changes in ambient habitats [13], and as a result, salinity gradient variations have a negative impact on the occurrence of freshwater fish species, which are strongly related to species biodiversity, the stability and flexibility of the ecosystem, and the structuring of fish populations [14].

Many studies have been conducted on the composition of fish communities in the Shatt Al-Arab River, but only limited studies of them dealt with the salinity gradient effect on fish assemblage structure. [15] discussed the influence of low salinity, temperature, and domestic sewage on the distribution of fish assemblages in the Shatt Al-Arab River. [16] studied the longitudinal patterns of fish community structure in the Shatt Al-Arab River, and [17] investigated the compositional change in fish assemblage structure in the Shatt Al-Arab River. [11] explained the impacts of saltwater intrusion on the fish assemblage in the middle part of the Shatt Al-Arab River. [18] reported the environmental evaluation of the middle part of the Shatt Al-Arab River after saltwater intrusion using the integrated biological index (IBI).

The present study aimed to analyze the impact of salinity gradients on fish assemblage composition, distribution, and how freshwater and marine fish species are spread with the daily variation in salinity concentrations.

Material and Methods

The study section of the Shatt al-Arab River stretches approximately 174 kilometers from the Al-Deer district to the estuary at Al-Fao city. The river's width varies from 1.5 km to 2 km at the estuary, and the depth ranges from 7 m in Al-Deer to 11 m in the estuary, according to [19]. The samples were collected on monthly from January to December 2022. To

collect data, three sites were chosen: Site 1 in Al-Deer city, Site 2 in Abu-Al-Kahseeb city, and Site 3 in Al-Fao city (Fig. 1). At the same time as the sampling was taken, some ecological factors were measured. The water temperature was measured using a mercurial thermometer (-10 to 100 ºC), and salinity and potential hydrogen (pH) were measured using a Lovibond-Sensor Direct 150, a German-made device. Fish were caught from the three sites on each month using fixed and draft gillnets, cast nets, and electro-fishing with an electric generator (400-500v, 10A). Fish were identified using [20] and the remaining species were classified using [21] The ecological indices measurement followed [22], that used to evaluate the fish assemblage in the current section of the Shatt Al-Arab River were a monthly analysis of relative abundance. The fish diversity, richness and evenness indices were calculated using the [23] method.

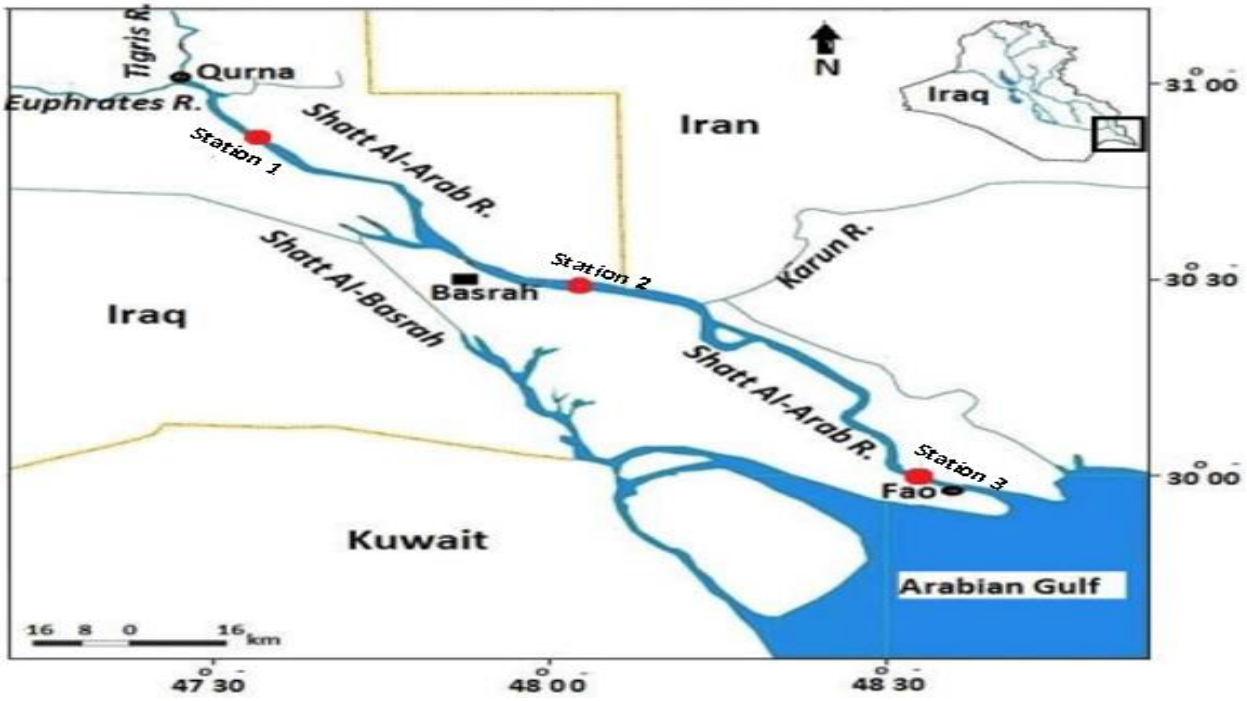

Figure 1. Map of the studying area from Al-Deer district to the estuary of the river at Al-Fao city (Mohamed and Abood, 2017).

Statistical Analysis

The Statistical Package for Social Science, Version 20 (SPSS), was used to analyze the relationships between the three sites. The Principal Component Analysis (PCA) program was used to examine the relationships between ecological parameters and the number of species and individuals.

Results

The water temperature rates showed a noticeable seasonal change ranged from 13 ºC in January to a steady rise to reaching to 33 ºC in July and August, the mean ±SD was 26±7.14 water temperatures did not show significant differences ($P > 0.05$) between the three stations. The results revealed a moderate correlation ($r = 0.623$) between temperature and the number of species in the three stations. The transparency varied from 43cm in March to 64cm in October, with a mean ±SD was 53.92 ±7 .12, while there was a significant difference ($P< 0.05$) in transparency between stations 1, and 2 and stations

1, and 3 potential hydrogen (pH) ranged from 7.43 in November to 8.37 in January, with mean ±SD 7.75 ± 0.27 are there no significant differences between the three stations in pH? Explain. (Fig. 2).

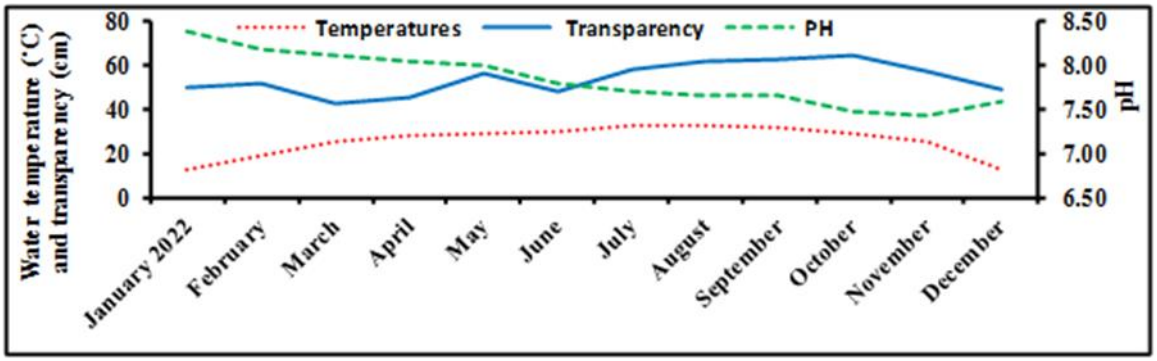

Figure 2. Monthly variations in the temperature, transparency and pH in the Shatt Al-Arab River.

The salinity concentration in station 1 fluctuated from 1.43 PSU in February to 2.97 PSU in October; the mean ±SD was 2.25± 0.48. The concentrations of salinity in station 2 varied from 1.54 PSU in March to 3.68 PSU in August, with the mean ±SD being 2.68±0.64. The salinity concentration in station 3 ranged from 4.65 PSU in March to 27.54 PSU in October, with a mean ±SD of 9.74± 7.14. The ANOVA analysis detected a significant difference ($P< 0.05$) in salinity between stations 1, and 2 and stations 1 and 3. A weak correlation ($r = 0.27$) was noticed between salinity rates in the study stations, and the number of species, whereas a strong relationship was detected between salinity rates in the selected river section and the number of species ($r = 0.854$, $r = 0.915$) in stations 1 and 2, respectively (Fig. 3).

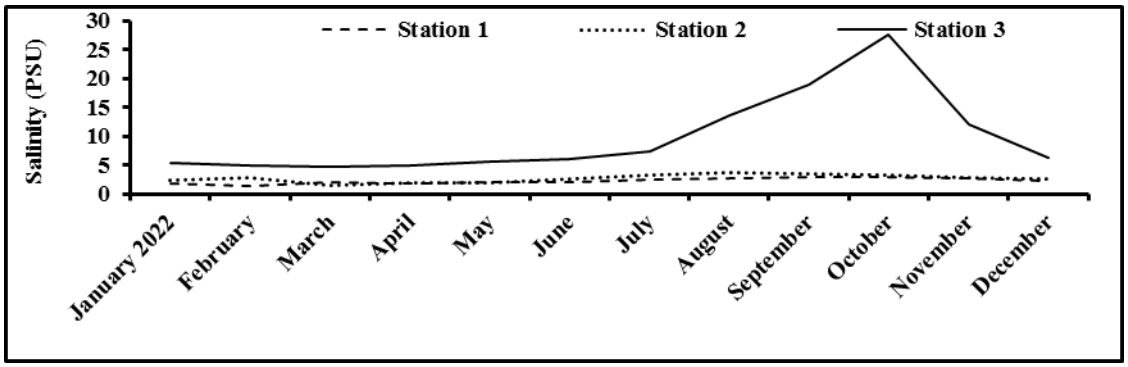

Figure 3. Monthly variations in the salinity in the three stations of the Shatt Al-Arab River.

The PCA analysis fig. (4A). shows that water temperature and salinity rates have a strong correlated with the number of individuals, while pH has a significant relationship with the number of species. Fig. (4B) showed a weak correlation between the number of individuals, and salinity, water temperature and strong relationship between pH, and the number of species. Figure 4 (A and B) showed that the eigenvalues of the studied factors totaled 5, which is a good value based on the five measured factors. The variable percentages were 36.72, 27.91, and 19.77%, respectively, while the accumulation combination percentages for the three components (F1, F2, and F3) were 36.72, 64.63, and 56.50%, respectively.

The PCA analysis Fig. (5-A) revealed that the PCs' values were 36.72% and 27.91%, respectively, with a variance of 64.63%. However, the PC1 revealed that water temperature and salinity rates were the most influential factors, positively correlated with the number of individuals. Fig. (5-B), revealed a negative relationship between the number of individuals and water temperature and salinity, as well as a negative relationship between the salinity rate and pH.

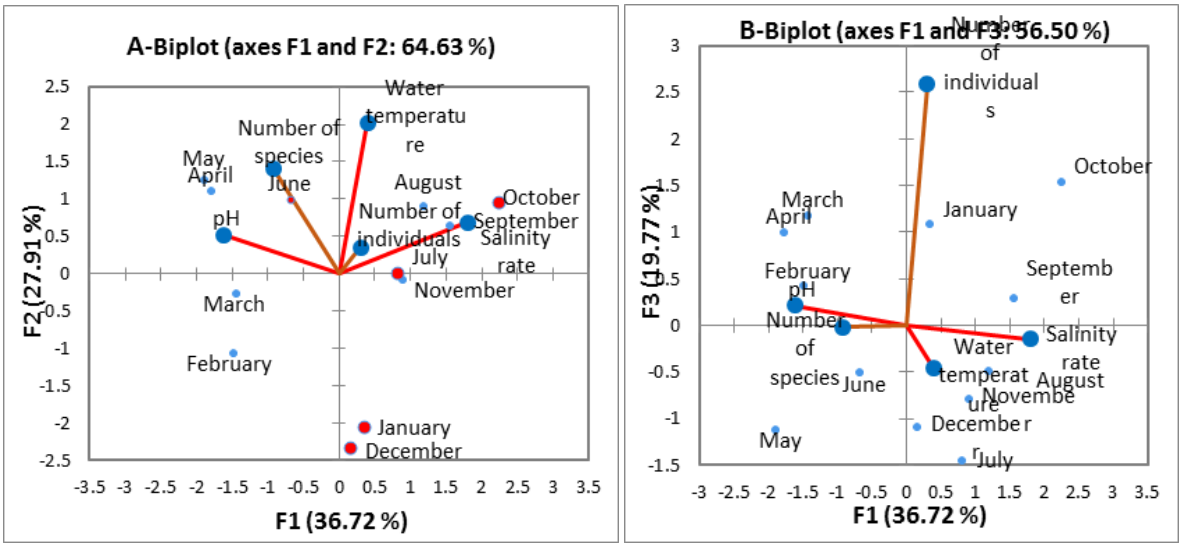

Figure 4. Principal Component Analysis Technique. The correlation among the ecological factors in the lower reach of the Shatt-Al-Arab River.

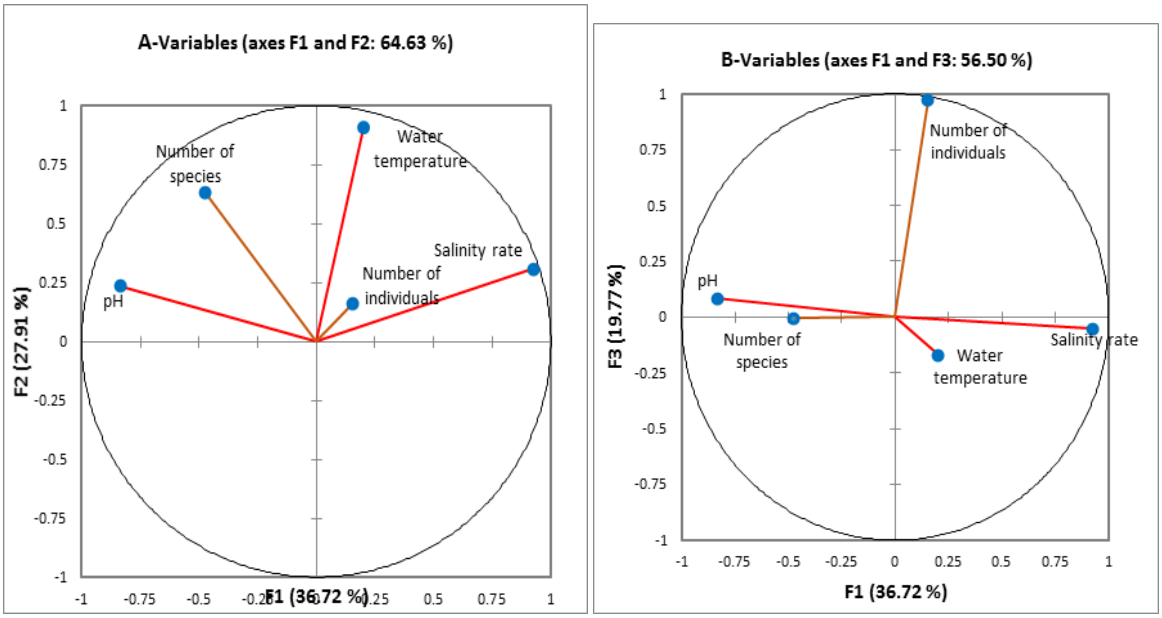

Figure 5. The influence of physicochemical parameters among the months on the lower reaches of the Shatt Al-Arab River.

Composition of fish species and distributions

A total of 60 fish species belonging to 48 genera and 32 families were caught from the Shatt Al-Arab River from Al-Deer to Al-Fao, all of which belong to the Osteichthyes class. The families Dorosomatidae and Mugilidae have five species each.

The family Cyprinidae consists of four species. The families Cichlidae, Engraulidae, Leuciscidae, and Sciaenidae are formed by three species per family. Ariidae, Carangidae, Leiognathidae, Poeciliidae, Pristigasteridae, Gerreidae, Sillaginidae, and Oxudercidae shared two species each. The remaining families included one species for each (Table 1, Fig. 6).

The species distribution in the present river section was cleared at the three stations. Station 1 participated in 24 fish species, 10 of which were native (national species), seven exotics, and seven marines. Station 2 included 29 species. 6 were native species, and eight of them were exotic species, whereas 15 were marine species. Station 3 (Al-Fao station) recorded 37 species; 35 of them were marine, and two were freshwater exotic species at the station.

Table 1. Families, fish species, and habitats of species in the Shatt Al-Arab River during the study period.

Family	Species	Station 1	Station 2	Station 3	Habitat
Dorosomatidae	*Amblygaster sirm*			+	M
	Nematalosa nasus		+	+	M
	Nematalosa persara			+	M
	Sardinella albella			+	M
	Tenualosa ilisha	+	+	+	M
Engraulidae	*Thryssa hamiltonii*	+	+		M
	Thryssa vitrirostris		+	+	M
	Thryssa whiteheadi	+	+	+	M
Cyprinidae	**Carassius gibelio*	+	+		F
	Carasobarbus luteus	+	+		F
	Carasobarbus sublimus	+	+		F
	**Cyprinus carpio*	+	+		F
Leuciscidae	*Acanthobrama marmid*	+			F
	Alburnus mossulenssis	+	+		F
	Leuciscus vorax	+	+		F
Xenocyprididae	**Hemiculter leucisculus*	+	+		F
Bagridae	*Mystus pelusius*	+			F
Siluridae	*Silurus triostegus*	+	+		F
Mastacembelidae	*Mastacembelus mastacembelus*	+			F
Cynoglossidae	*Cynoglossus arel*			+	M
Poeciliidae	**Gambusia holbrooki*		+		F
	**Poecilia latipinna*		+	+	M
Sillaginidae	*Sillago arabica*			+	M
	Sillago sihama	+	+	+	M
Heteropneustidae	**Heteropneustes fossilis*	+			F

Soleidae	***Brachirus orientalis***			+	**M**
Mugilidae	***Planiliza abu***	+	+		**F**
	Planiliza klunzingeri		+	+	**M**
	Planiliza subviridis	+	+	+	**M**
	Osteomugil speigleri			+	**M**
	Planiliza carinata			+	**M**
Leiognathidae	***Nuchequula gerreoides***			+	**M**
	Photopectoralis bindus		+		**M**
Synanceiidae	***Pseudosynanceia melanostigma***			+	**M**
Pristigasteridae	***Ilisha melastoma***		+		**M**
	Ilisha compressa			+	**M**
Gobiidae	***Bathygobius fuscus***		+	+	**M**
Mullidae	***Upeneus doriae***			+	**M**
Gerreidae	***Gerres oyena***			+	**M**
	Gerres limbatus			+	**M**
Aphaniidae	***Aphaniops dispar***	+			**F**
Cichlidae	****Cptodon zillii***	+	+		**F**
	****Oreochromis aureus***	+	+	+	**F**
	****Oreochromis niloticus***	+	+	+	**F**
Sciaenidae	***Johnius belangerii***			+	**M**
	Johnius dussumieri			+	**M**
	Otolithes ruber			+	**M**
Scatophagidae	***Scatophagus argus***		+		**M**
Sparidae	***Acanthopagrus arabicus***	+		+	**M**
	Sparidentex hasta			+	**M**
Belonidae	***Strongylura strongylura***			+	**M**
Carangidae	***Alepes vari***			+	**M**
	Scomberoides commersonnianus			+	**M**
Platycephalidae	***Platycephalus indicus***		+		**M**
Hemiramphidae	***Hyporhamphus limbatus***	+	+		**M**
Chirocentridae	***Chirocentrus nudus***			+	**M**
Oxudercidae	***Periophthalmus waltoni***			+	**M, F, B**
	Boleophthalmus dussumieri				**M, F, B**
Ariidae	***Netuma bilineata***			+	**M**
	Netuma thalassina			+	**M**

***Exotic species**

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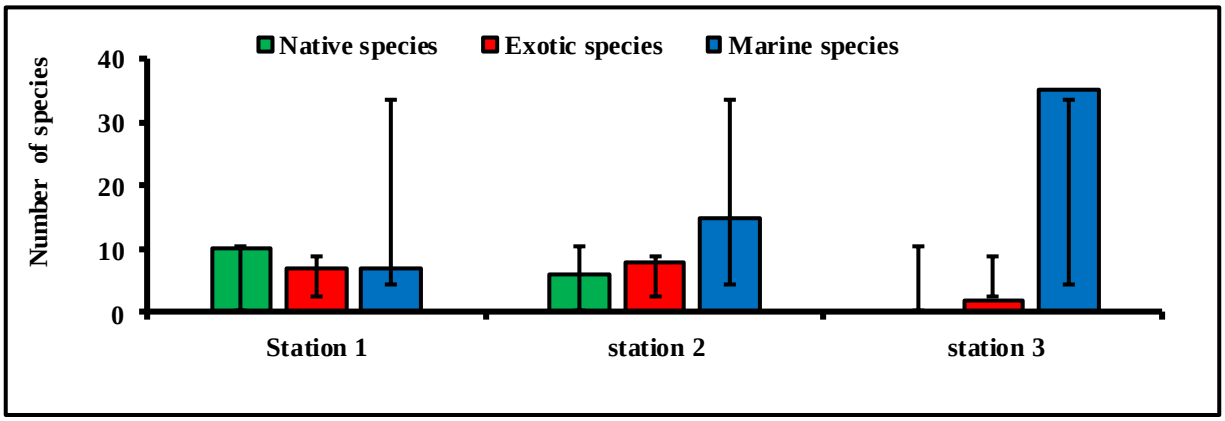

Figure 6. The number of native (national species), exotic, and marine species in the Shatt Al-Arab River with standard deviation

Species and individuals number

The number of species ranged from 21 fish species in December to 32 species captured in May from the Shatt Al-Arab River. The ANOVA analysis showed a significant difference (P< 0.05) between statin 3, and stations 1 and 2. Overall 3567 fish were collected during the study periods, differing from 211 specimens in December to 410 in October. The analysis of the results detected a significant difference (P< 0.05) in the number of individuals between station 3 and stations 1 and 2 (Fig. 7).

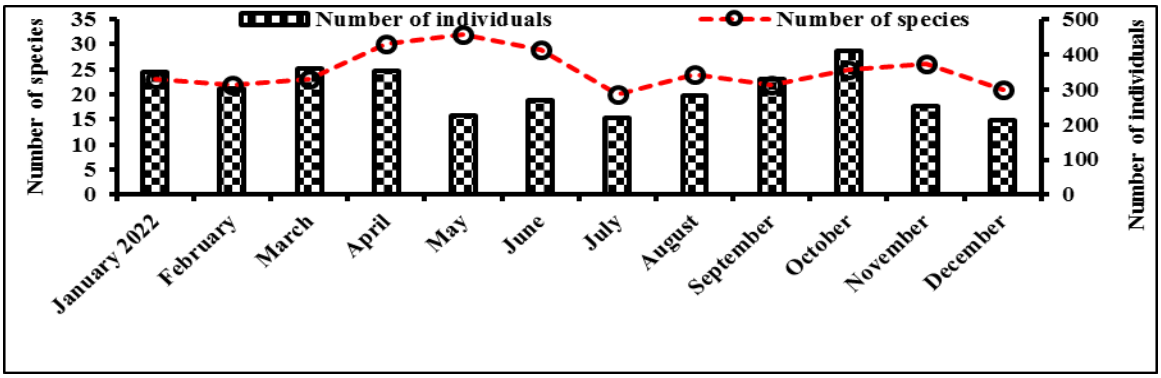

Figure 7. Monthly variations in the number of species and individuals in the three stations.

Relative abundance

Three fish species dominated the relative abundance in the Shatt Al-Arab River forming 41.04% of the total species in the study regions. The most abundant species was *C. gibelio* recorded 15.00% of the total caught ranging from 5.59% in March to 19.56% in May. The species *O. aureus* constituted 13.48% of the overall capture of fish varied from 5.94% in July to 19.71% in October. The species *P. abu* recorded 12.56% fluctuating from 4.24% in August to 21.11% in June. The D3 index of the most abundant three species attained 41.04% for the species *C. gibelio*, *O. aureus*, and *P. abu* (Table 2).

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Table 2. Monthly variations in the relative abundance in the three stations in the Shatt Al-Arab River from January to December 2022.

Species	Jan. 2022	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
C. gibelio	17.08	23.78	5.59	8.19	19.56	12.22	12.33	15.19	16.92	15.57	18.04	18.96	15.00
O. aureus	16.77	14.02	8.66	9.04	13.33	12.59	5.94	8.83	16.01	19.71	16.47	18.96	13.48
P. abu	13.35	11.89	11.17	11.58	17.33	21.11	15.07	4.24	10.57	10.95	12.16	15.64	12.56
T. whiteheadi	10.87	12.80	15.08	7.34	19.11	4.07	15.53	13.07	11.48	7.30			9.81
O. niloticus		8.23	2.79	5.37	4.89	3.70	5.02	4.59	13.60	11.19	15.29	9.48	7.04
T. ilisha			14.25	5.93	2.22	3.33	16.89	14.13	2.11	2.92			5.10
C. zillii	4.66		5.87	7.63		8.52	7.31	5.65	5.44	5.84	6.67		4.96
P. klunzingeri			4.19	6.78	3.11	2.96	3.20	8.48	8.46	4.87	5.88		4.15
P. latipinna	11.18	7.62				7.41	3.65	2.83			5.10		3.08
P. subviridis	4.97	4.27	6.70	4.52	0.89	2.22		1.77		3.16		5.69	3.03
A. arabicus			4.47	5.08	2.67	1.48	3.65	4.59	4.53	2.92			2.58
A. mossulenssis		1.22		2.26	0.44	2.22		1.06	1.81	1.95	2.75	9.95	1.79
C. luteus	3.42		3.35	1.13		1.85	1.83		0.91	1.46	0.78	1.90	1.43
B. fuscus	2.48	2.44	2.51	3.39		1.48		0.71	0.60	0.73		0.95	1.40
J. dussumieri	2.80	2.44		1.98	1.33	0.74	2.74	1.41	2.42			0.95	1.37
C. carpio	2.80		2.23	1.69	1.33	1.48	1.37	1.06	0.91	1.46	0.78		1.32
L. vorax		1.22	1.68	2.26	0.89	2.22		1.06		1.22	1.18	4.27	1.29
J. belangerii	1.86		1.12	1.69	0.44	2.22	1.37	3.53		0.73			1.09
S. triostegus	0.93			2.54	0.89	1.85		0.71		0.97	3.14	2.37	1.07
S. sihama	1.86	2.13			1.33	1.48	0.46	0.71	0.60			0.95	0.76
G. holbrooki				4.52				3.18					0.70
T. hamiltonii		1.83		0.85						2.43		0.95	0.59
A. marmid		1.83			1.33	1.11					1.57	1.90	0.56
H. leucisculus	0.93	1.22	1.40		0.44			0.71		0.97			0.53
B. dussumieri			2.23	1.13	0.89				0.60		1.18		0.53
N. nasus			2.51		0.89	0.74				1.22			0.50
B. orientalis	1.55	0.61		0.56	0.89				0.60				0.36
P. carinata										0.97		3.79	0.34
S. hasta		0.61	1.12			0.37		0.35				1.42	0.31
A. dispar											3.53		0.25
H. limbatus				1.13			0.91		0.91				0.25
O. ruber		0.30		0.56	0.89	0.37				0.24	0.39		0.22
S. albella					0.44	0.00	0.91	1.41					0.20
C. arel			0.84			0.37	0.46				0.39		0.17

P. bindus	**0.62**		**1.12**										**0.17**
P. waltoni		**0.91**					**0.00**		**0.30**		**0.78**		**0.17**
N. persara					**0.44**		**0.91**					**0.95**	**0.14**
C. sublimus				**0.85**			**0.46**				**0.39**		**0.14**
S. argus				**0.56**		**0.37**					**0.78**		**0.14**
T. vitrirostris	**1.24**												**0.11**
M. mastacembelus				**0.56**						**0.49**			**0.11**
S. arabica					**0.44**	**0.74**			**0.30**				**0.11**
H. fossilis					**0.89**				**0.60**				**0.11**
N. gerreoides	**0.62**	**0.61**											**0.11**
P. indicus				**0.28**		**0.37**			**0.30**	**0.24**			**0.11**
O. speigleri			**0.56**							**0.24**			**0.08**
P. melanostigma				**0.28**							**0.78**		**0.08**
I. compressa			**0.56**		**0.44**								**0.08**
S. strongylura					**0.89**						**0.39**		**0.08**
G. oyena					**0.44**						**0.39**		**0.06**
N. bilineata								**0.71**					**0.06**
N. thalassina											**0.78**		**0.06**
A. sirm					**0.44**								**0.03**
M. pelusius				**0.28**									**0.03**
U. doriae					**0.44**								**0.03**
A. vari												**0.47**	**0.03**
S. commersonnianus						**0.37**							**0.03**
C. nudus												**0.47**	**0.03**
G. limbatus											**0.39**		**0.03**
l. elongata										**0.24**			**0.03**

Diversity indices

The diversity ecological indices were monthly fluctuated during the study period from January to December 2022 (Figure 8). Diversity indices values ranged from 2.40 in January to 2.92 in April, with the mean ± SD, 2.64 ± 0.15. The analysis of data exhibited no significant differences ($P< 0.05$) were shown among the three stations. The values of the evenness index fluctuated between 0.69 in May to 0.88 in January and March, a mean ± SD, 0.82 ± 0.06. A significant difference ($P> 0.05$) was observed between stations 1 and 3 in the evenness index values. Richness index values varied from 2.67 in January to 4.51 in November, with an average ± SD, of 3.74 ± 0.44. A significant difference ($P<0.05$) was detected between stations 1 and 3 in the values of the richness index.

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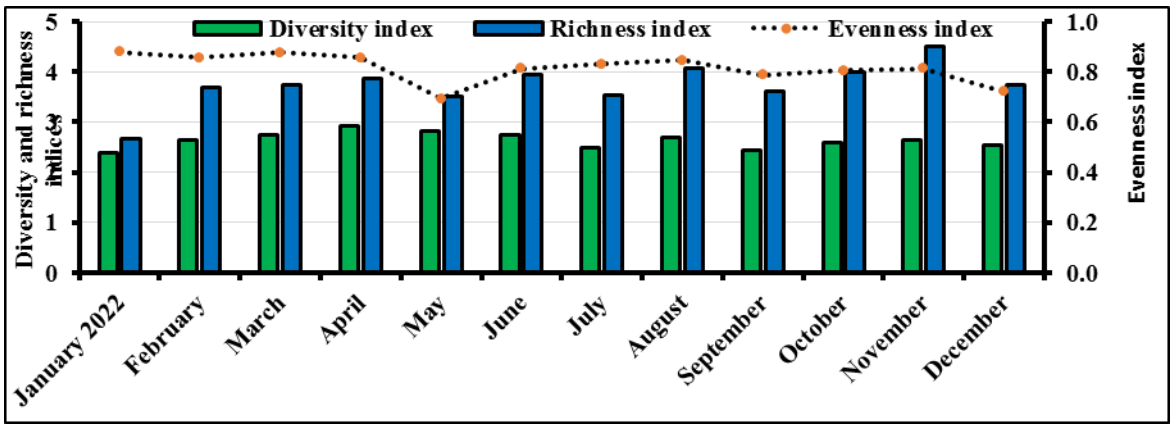

Figure 8. Monthly variations in the ecological indices values in the three stations in the Shatt Al-Arab River from January to December 2022

Species occurrence

The occurrence of species was divided into three major groups: resident fish species, formed 78.64% of species that occur in samples including 14 fish species. The seasonal species constitute 14.44% of the total caught comprising 8 species, while the occasional fish species formed 6.92% including 38 species (Figure 9).

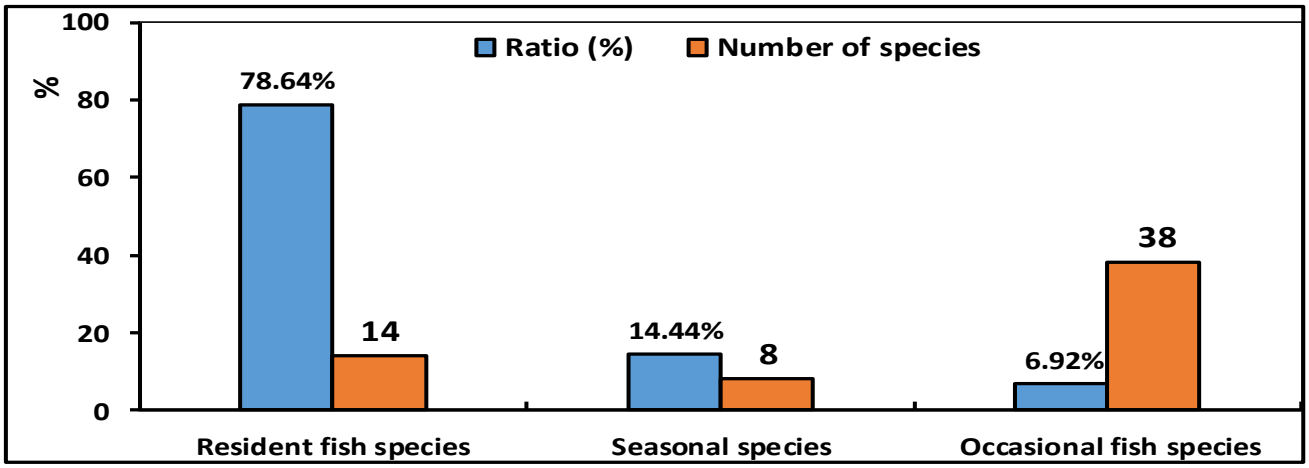

Figure 9. The occurrence of species in the present study area from January to December 2022 in the three stations in the Shatt Al-Arab River from Al-Deer to Al-Fao

Discussion

Numerous studies have investigated the role of environmental fluctuations in understanding the composition of fish assemblage. Many environmental factors influence the structure of fish assemblage downstream [24]; temperature i. e., influence spatial distributions, the nature of temporal activity, and functions of fish species and assemblages [25; 26]. Our findings showed that high values of pH in hot months is associated with higher activity and photosynthetic activity of plant organisms [12]. The current study collected 60 fish species, but the greatest number of fish species were recorded in the third station at the river estuary, which serves as a breeding, nursery, feeding, and refuge area for many marine species as

well as visited by freshwater fish species, the current findings agreed with [19] in the number of species where they recorded 58 species but didn't agree with [16] when they captured 40 fish species and [17] when they collected 111 species. These differences in the number of species caught in the same area could be attributed to differences in the fishing effort and tools as well as spatial and temporal differences [27].

Salinity was the most important factor affecting the, distribution, diversity, and abundance of fish populations; additionally, species preferences and tolerance varied from one species to another [28], this is demonstrated by the Principal Component Analysis (PCA) figures (4 and 5), which discuss the function of salinity and its effect on the composition of the fish population. Because salinity in a river section is determined by the distance to the sea and the amount of freshwater discharged into the sea during daily tides [29], therefore the first and second stations were oligohaline (0.5 to 3.0 or 5.0 PSU). Because some of the species in these stations were freshwater and others were marine, the findings agree with [30: 18]. The majority of species being rare or uncommon, there are only a few dominant species in this study, such as *C. gibelio*, *O. aureus*, *P. abu*, and *T. witeheadi*, which are represented by tolerant exotic and marine species. These findings correspond with most studies done in the same areas by [17; 18], conducted at the Shatt Al-Arab River. Station 3, designated as the mesohaline (3 to 10 PSU), includes 37 species; all species were estuarine and marine, except two were freshwater (*O. aureus and O. niloticus*). These results agree with [17] regarding the reduction in the number of freshwater species near the estuary. The estuary group represented by Gobiidae formed 1.93% of the total caught, which consists of fish that spend the majority of their lives in the estuary; the marine fish group included most of the marine families, which formed from fish that migrate between the sea and the estuary; and freshwater species that visit the estuary on occasion, such as the Cichlidae family, constituted 23.73% of species caught in the study area; and diadromous species that catch in all stations, like Dorosomatidae, Engraulidae, Mugilidae, Sparidae, Sillaginidae, and Hemiramphidae, the present finding is compatible with [31; 14] in the occurrence of different groups of fish. The formation of the fish assemblage in the various areas of the river (freshwater, brackish water, and the estuary) is due to these species' preferences differing in salinity ranges for feeding, survival, nursing, breeding, growth, and other physiological conditions [12]. Some marine species may migrate in order to breed, feed, and refuge. The abundance in station 3 differs from that in the first and second stations due to increased salinity levels and the dominance of marine species, as three marine species prevailed (*T. witeheadi*, *T. ilisha*, and *P. klunzingeri*) due to the station's proximity to the sea and the rise in water salinity [17; 12]. The freshwater fish species are present in stations 1 and 2, whereas station 3 has a different fish diversity due to the disappearance of the majority of freshwater species and the dominating of marine species, these findings are consistent with the majority of estuary studies ([17; 19].

The upper reaches of the Shatt Al-Arab River (station 1) are dissimilar in the diversity with the middle part of the river and the lower reaches of the river. It's characterized by a low range of diversity due to the abundance of freshwater species [16] and the reduction in the number of marine species [7]. The mid-part and the lower reaches are distinct in the low abundance of freshwater species and the increased abundance of marine species and types of prevailing species. However, the diversity values in the downriver were higher than in the upper and middle sectors of the river due to the abundance of marine species. Generally, the ecological indices in the present study are consistent with the range of previous studies conducted on the Shatt Al-Arb River [11; 18].

The most abundant families in the north section of the river are Mugllidae (*P. abu*) and Cichlidae (*O. aureus*, *O. niloticus*, and *C. zillii*), in addition to one Cyprinidae species (*C. gibelio*). They have a high abundance in the north and middle sections of the river, while the downstream section is dominated by anadromous species (*T. ilish*) and catadromous

species (*T. witeheadi* and *P. klunzingeri*). The occurrence of these species is compatible with [15;19]. An analysis of fish assemblage structures in the estuary and near estuarine regions is announcing a clear distinction in the functional composition of 37 species that form fish assemblage structures into three different groups. It is affiliated with marine migrating, estuarine fish species groups, and freshwater migrating groups [32; 33].

Conclusions

The current study concluded that the biotic and abiotic factors are the most important parameters that affect organisms in quantic water. Still, salinity plays a significant role in the distribution and spread of fish species and, ultimately, in formatting the composition of the fish assemblage, as evidenced by the composition of the fish assemblage in the three stations, with the composition of the third station differing from the first and second due to salinity. The study concluded that the fish assemblage composition in the river varies significantly. The abundance of freshwater fish increases upstream. As the river's estuary region approaches, the percentage of estuarine and marine fish species rises, and most become marine fish species, as seen in the third station. The temperature was the second factor that affected fish distribution, especially the reproductive process and migration.

Author Contributions Statement

All research stage: laboratory work, collection and analysis of data, research write were done by the authors

Declaration of competing interest

The authors declare that there were no competing interests.

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