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Investigation of changes in the fish assemblage building and abundance in the Garmat Ali River, Southern Iraq

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Abstract
The current study was conducted to study fish assemblage composition and population structure changes from Garmat Ali River from January to December 2020. Some ecological variables, including temperature, salinity, pH, and dissolved oxygen, were estimated. Altogether, 2168 fish specimens represented 32 species, 26 genera, and 17 families. There were eleven freshwater species, three in June and nine in May. The exotic species ranged from five to seven in June, October, and December. Fourteen species were marine, ranging from one in December to eight in June. Four species preceding the numerical relative abundance in the Garmat Ali River *Ttrayssa whiteheadi*, *Carassius gibelio*, *Planiliza abu*, and *Orechromis aureus* formed 15.50, 15.18, 12.82, and 10.79%, respectively. The diversity index (H) ranged from 1.97 (June) to 2.77 (May), with an overall value of 2.29. The evenness index (J) varied from 0.70 (November) to 0.88 (May and December), with overall values of 0.81. The richness index (D) fluctuated between 2.24 (June) and 3.41 (May), with overall values of 2.98. The study concluded that the composition of the fish assemblage and abundance has changed compared to previous studies, particularly older studies, due to the introduction of many exotic species into the river's fish community, the occurrence of marine species due to increased salinity concentrations, and the departure of sensitive freshwater native species.

Keywords: Fish Community, Tigris, Assemblage, distribution, Inland water.
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Introduction
Fish are well-known vertebrates, having the most diverse group (Mouludi-Saleh et al. 2020), with marine and freshwater species inhabiting diverse ecological systems in various habitats and regions (Yang et al. 2021). Many freshwater fish species are typically threatened by the demolition and fragmentation of their habitat (Heidari et al. 2013), and their diversity is affected by exotic fishes (Çiçek et al. 2022). The occurrence and increased abundance of fish in the river's ecosystems reflect the health status of the river, especially the sensitive species that are considered indicators of the stability of the riverine ecosystem (Wu et al. 2019). The freshwater fish group includes about 15935 species, constituting less than 1% of the earth's surface. The marine fish species, numbering about 15940 species, occupy 71% of the planet, whereas 3149 species inhabit brackish water or are diadromous (Froese and Pauly 2022). In contrast to marine and terrestrial ecosystems, freshwater ecosystems are suffering from species threats due to climate change, which has caused declines in water quantity and quality and increased pollutant concentrations from human activities (He et al. 2021).

The Garmat Ali River is a short river north of Basrah, southern Iraq, and empties into the Shatt Al-Arab River. It originates at the confluence of the Al-Mashab and Al-Salal branches. Before the meeting, the two branches pass for about 20 km through the Al-Hammar Marsh. The river continues for about 6 km before joining the Shatt Al-Arab River at the northern tip of Sinbad Island, north of Basrah City (Mohamed et al. 2017; Aldoghachi and Abdullah 2021). Like other rivers and aquatic habitats, the river under investigation suffers from human influences due to waste spilling into the river from anthropogenic activities.

The last studies mentioned that several fish species became scarce or were subjected to extinction from the habitats of Basrah Province due to human activities, climate change, increased salinity, and pollutants

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(Mohamed and Hammed 2019; Chea et al. 2020). Furthermore, the salinity concentrations in the Garmat Ali and Shatt Al-Arab rivers fluctuate due to low water discharge from the Tigris and Euphrates rivers, which are insufficient to push or prevent the salt front from the sea, causing an increase in salinity concentrations in the Shatt Al-Arab and Garmat Ali rivers (Mohamed et al. 2017; Hameed et al. 2022). Reduced discharges caused by the construction of several impoundments at the Tigris and Euphrates river heads, as well as changes in water quantity and quality, reduce freshwater biodiversity in river ecosystems that are heavily influenced by anthropogenic activities when compared to marine and terrestrial ecosystems (Huang et al. 2019; Zhu et al. 2019). The characteristics and composition of the fish assemblage in the Karma Ali River are determined by the relationship between the river ecosystem and water, as well as the nature of the lands surrounding the river, rather than by factors such as ecological functions in freshwater systems, the food web, the nutrient system, and the dynamics of energy flow (Wang et al. 2018; Yang et al. 2021).

Fish populations are an important component of the Garmat Ali River and contribute to the river's assessment environment. They are always used as an indicator to evaluate river habitat and can play a key role in the recycling of elements and energy flow (Grizzetti et al. 2016; Mohamed et al. 2017). Several studies have been conducted on the Garmat Ali River and other adjacent rivers. Younis et al. (2010) performed a study on the Shatt Al-Arab and Garmat Ali Rivers that dealt with the ecological assessment of fish assemblages using an integrated biological index (IBI). Mohamed et al. (2013) studied the fish assemblage of the Garmat Ali River, north of Basrah, and collected 26 fish species. Mohamed et al. (2017) investigated the status of the fish assembly structure in the Garmat Ali River and reported 34 species belonging to 16 families. Aldoghachi and Abdullah (2021) executed a study titled Petroleum hydrocarbons, heavy metals, physicochemical parameters, and impacting factors on diversity and abundance of fish species in the Garmat Ali River, leading to collect 29 fish species. Given that biodiversity and its study play an important role in conservation issues (Ghasemi et al. 2015), the current study aimed to assess changes in the composition and abundance of fish assemblages in the Garmat Ali River.

Material and Methods

The current study examines the structure and abundance of fish populations in the Garmat Ali River. The river's length is 6 km, and its width ranges from 280 to 300 m, with a depth of 9 m. The samples were obtained monthly from January to December 2020. For collecting data, three stations were chosen: station 1 was at the confluence of the Al-Mashab and Al-Selal branches that consist of the Garmat Ali river (N 30°35' 31.05, E 47° 42' 54); station 2 was near the Garmat Ali Bridges (N 30°34' 29.28, E 47°44' 42); station 3 was near the confluence of the Garmat Ali and Shatt Al-Arab rivers (N 30°34' 55.2, E 47° 46' 30) (Fig. 1).

Some ecological parameters were measured during sampling: water temperature (°C) was measured with a mercury thermometer. Salinity and hydrogen ions were measured using a Lovibond-Sensor Direct 150 (made in Germany). The YSI-55 device measures dissolved oxygen. Fish samples were collected monthly from the three stations using fixed and draft gillnets, cast nets, and an electrofishing device with an electric generator (400-500 volts, 10 amps). Fricke et al. (2022), Froese and Pauly (2022), and Eagderi et al. (2022) were used to classify the collected species. The ecological indices used to evaluate the fish assemblage in the Garmat Ali River were monthly analyses of the relative abundance, according to Walag et al. (2016), as well as their occurrence by Tyler (1971). Fish diversity was measured following Huang et al. (2019) and richness and evenness Nyitrai et al. (2012).

Statistical analysis: The Statistical Package for Social Science (SPSS) version 20 program was used to analyze the data from three studied stations. Statistical differences in ANOVA and correlations among the stations were determined in SPSS software. The principal component analysis (PCA) program was used to determine the

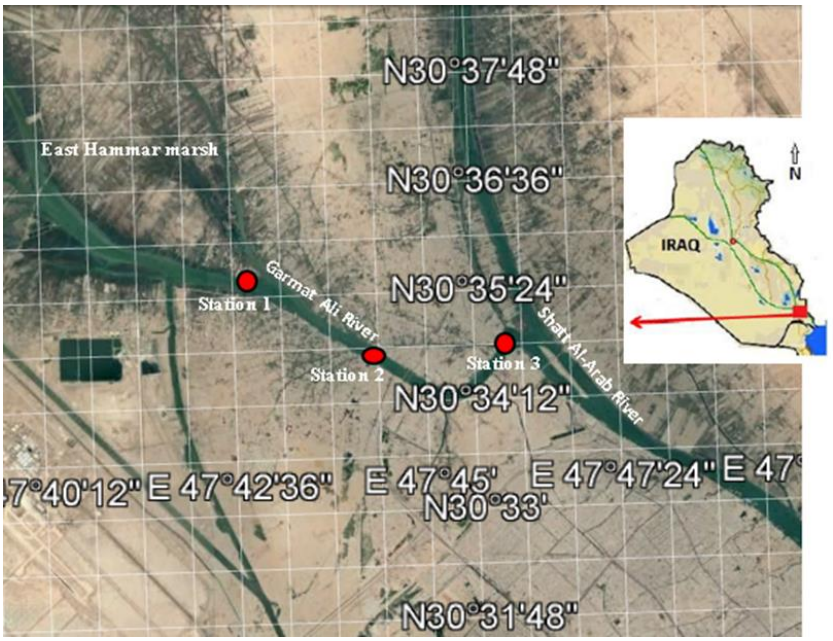

Figure 1. Map of Garmat Ali River (red circle: sampling stations).

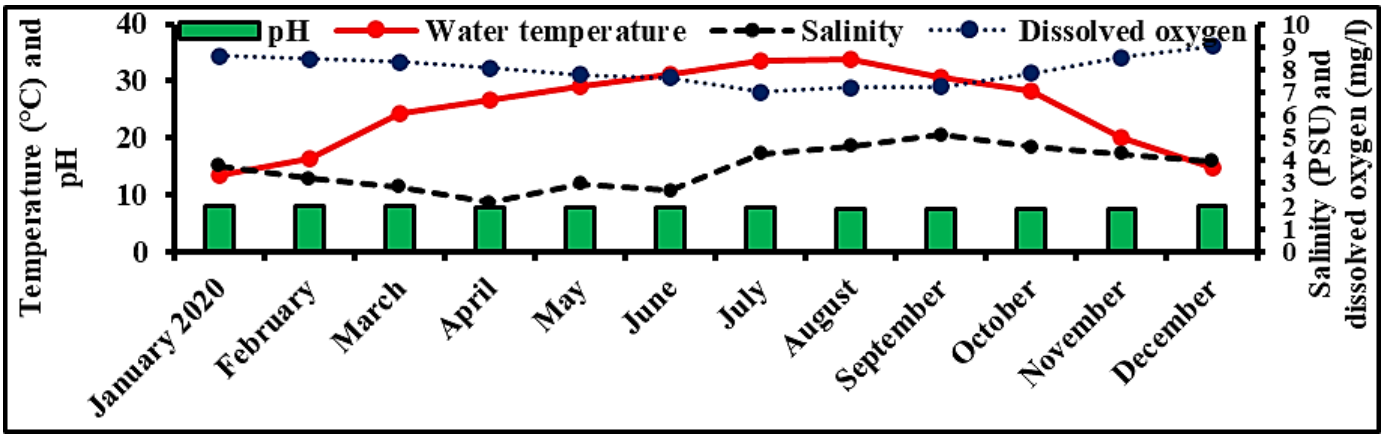

Figure 2. Monthy variations in some ecological variables in the Garmat Ali River.

relationships between the ecological variables and months.

Results and Discussion

Ecological variables: The water temperature fluctuated from 13.50ºC in January to 33.66ºC in August, then started to decline gradually, recorded 14.65ºC in December with a mean of 25.14±7.28ºC. The salinity ranged from 2.16 PSU during April to 5.12 PSU in September, with a mean value of 3.17±0.93. The Ph varied from 7.34 in November to 8.07 in December, with a mean value of 7.73±0.26. Dissolved oxygen values differed from 7.02 in July to 9.04 mg/l in December, with a mean of 7.98± 0.63 (Fig. 2). A weak correlation (r= 0.305) was found between temperature and the number of species. Salinity and the number of species were found to have a weak negative relationship (r= -0.313). The relationship between hydrogen ions and the number of species was r= -0.247. A weak negative correlation was found between dissolved oxygen and the number of species. The three stations showed no significant differences among the present stations in temperature, salinity, hydrogen ions, and dissolved oxygen ($P \leq 0.05$).

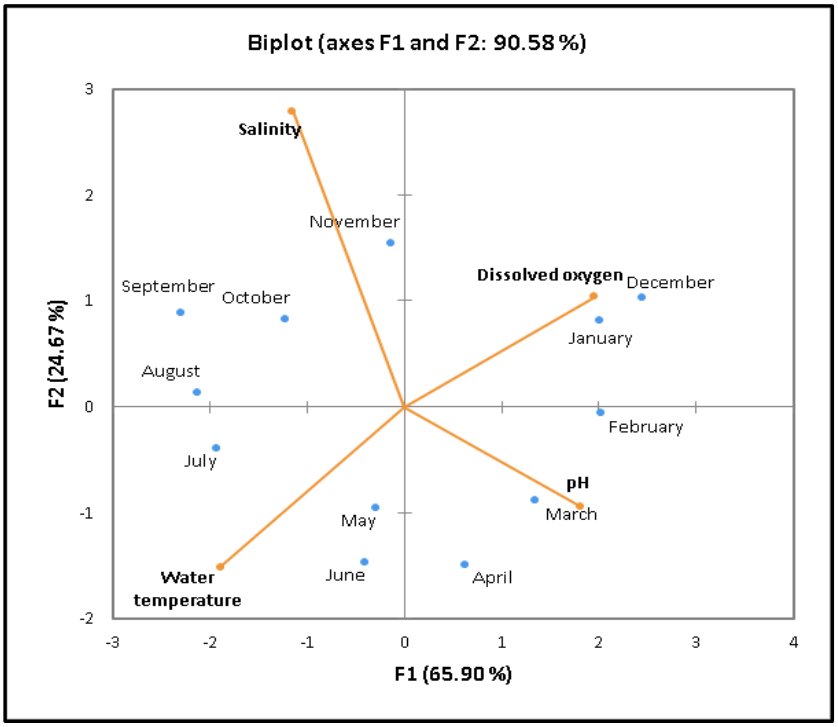

Figure 3. Principal Component Analysis (PCA) graph between the ecological variables and months in the Garmat Ali River.

The principal component analysis (PCA) showed the two PCs' values were 65.90 and 24.67%, respectively (a total of 90.58% variance). The PC1 is generally formed from dissolved oxygen, including the correlation between December and January. The factor of water temperature is positively correlated with May, June, and July. There was a positive correlation between salinity and August, September, October, and November (Fig. 3).

Ecological factors play an important role in the structuring, distribution, and abundance of fish assemblage species in river habitats (Leitao et al. 2018). The temperature in shallow waters tends to subject the fish to thermal stress, but in riverine habitat, the fish leave toward the deep region to avoid the thermal stress (Hendy et al. 2020). Seasonal temperature variations, in conjunction with salinity, may be strongly contributing to the composition, prevailing differences, and distribution of the fish assemblage in the environment of rivers (Lazem and Attee 2016; Hammed et al. 2022). Mohamed and Hameed (2019) found that higher salinity increased the percentage of marine and occasional species; salinity is strongly linked to changes in fish assemblage composition. PH in the present study was within the range of the previous studies in the Iraqi inland waters, and the river water was well-buffered during the study period, which agrees with Abdullah et al. (2022). Southern Iraq, in general, and the province of Basrah, in particular, have a hot, semi-tropical climate with temperatures that do not decrease except for a few days per year due to climate change. As a result, with a high presence of exotic species tolerant of the Cichlidae and Cyprinidae families, the temperature has only a minor impact on sampling operations throughout the year. For these reasons, the study discovered a weak correlation between temperature and the number of species (Ghazi et al. 2018).

Species composition: Altogether, 2168 specimens represented 32 fish species, 26 genera, and 18 families, all of them affiliated with bony fishes. The most abundant family was Cyprinidae, which had four species, followed by Cichlidae, Mugilidae, and Luciscidae, having three species, while Clupeidae, Gobiidae, Sillaginidae, Poecilidae, and Engraulidae had two species each. Ten families have one species each: Aphaniidae, Sparidae, Mastacembelidae, Hemiramphidae, Sulridae, Xenocyprididae, Bagridae, Leiognathidae, and Heteropneustidae (Table 1). Most studies on the Garmat Ali and Shatt Al-Arab rivers focus on the presence of certain families,

Table 1. Families and fish species with referring to native, exotic, and marine species

Family	Species	Native	Exotic	Marine
Mugilidae	*Planiliza abu*	+		
	Planiliza subviridis			+
	Planiliza klunzingeri			+
Cyprinidae	*Carassius gibelio*		+	
	Cyprinus carpio		+	
	Carasobarbus luteus	+		
	Carasobarbus sublimus	+		
Cichlidae	*Orechromis aureus*		+	
	Coptodon zillii		+	
	Orechromis niloticus		+	
Sulridae	*Silurus triostegus*	+		
Poecilidae	*Gambosia holibrooki*		+	
	Poecilia latipinna			+
Leuciscidae	*Leuciscus vorax*	+		
	Alburnus mossulenssis	+		
	Acanthobrama marmid	+		
Mastacembelidae	*Mastacembelus mastacembelus*	+		
Sillaginidae	*Silago sihama*			+
	Sillago arabica			+
Hemiramphidae	*Hyporhamphus limbatus*			+
Aphaniidae	*Aphaniops dispar*	+		
Gobiidae	*Bathygobius fuscus*			+
	Periophthalmus waltoni			+
Clupeidae	*Tenualosa ilisha*			+
	Nematalosa nasus			+
Engraulidae	*Thrayssa whiteheadi*			+
	Thryssa vetrirostris			+
Bagridae	*Mystus pelusius*	+		
Leiognathidae	*Photopectoralis bindus*			+
Sparidae	*Acanthopagrus arabicus*			+
Xenocyprididae	*Hemiculter leucisculus*		+	
Heteropneustidae	*Heteropneustes fossilis*		+	

such as Cyprinidae, Cichlidae, Mugilidae, and Luciscidae, because these families contain tolerant species, some of which are native and others are migratory or exotic (Mohamed et al. 2017; Aldoghachi and Abdullah 2021; Mohamed and Hameed 2022).

Number of species and individuals: The number of species increased from 17 in January to a peak of 23 in May before declining to a low of 12 in December, with a mean of 17.17±2.44. The results revealed no significant (P>0.05) differences in the number of fish species across the selected Garmat Ali River stations. The number of individuals began with 177 specimens in January, varied to a high of 262 in May, and then began to decline to a low of 82 in December, with a mean of 37.42±49.64 (Fig. 4). A moderate correlation (r = 0.50) was noticed between temperature and the number of individuals. A weak negative relationship (r = -0.222) was detected

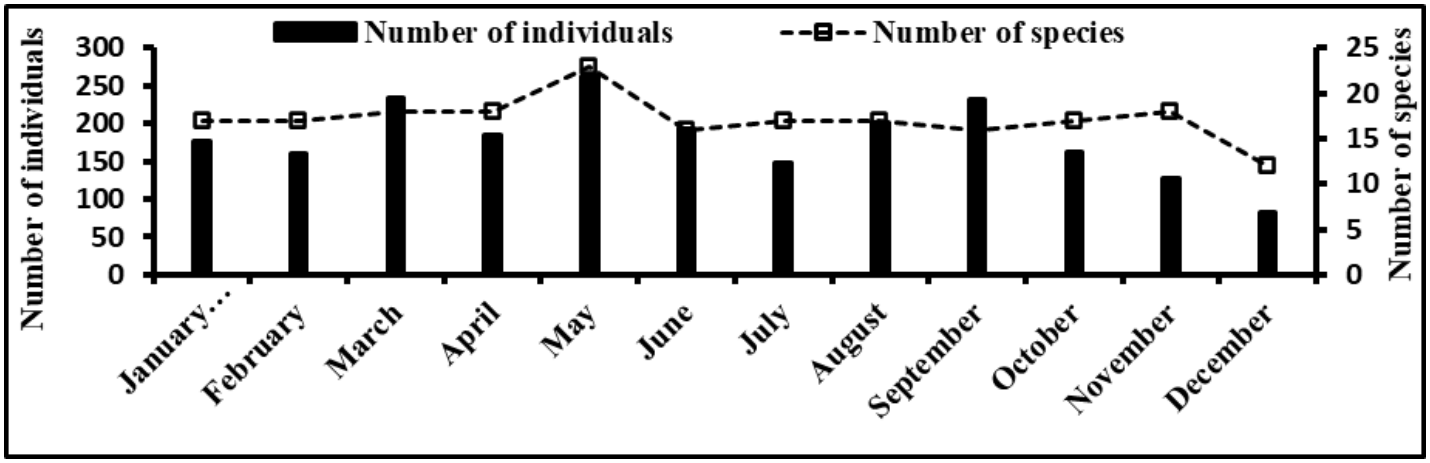

Figure 4. Monthly variations in the number of species and individuals in the Garmat Ali River.

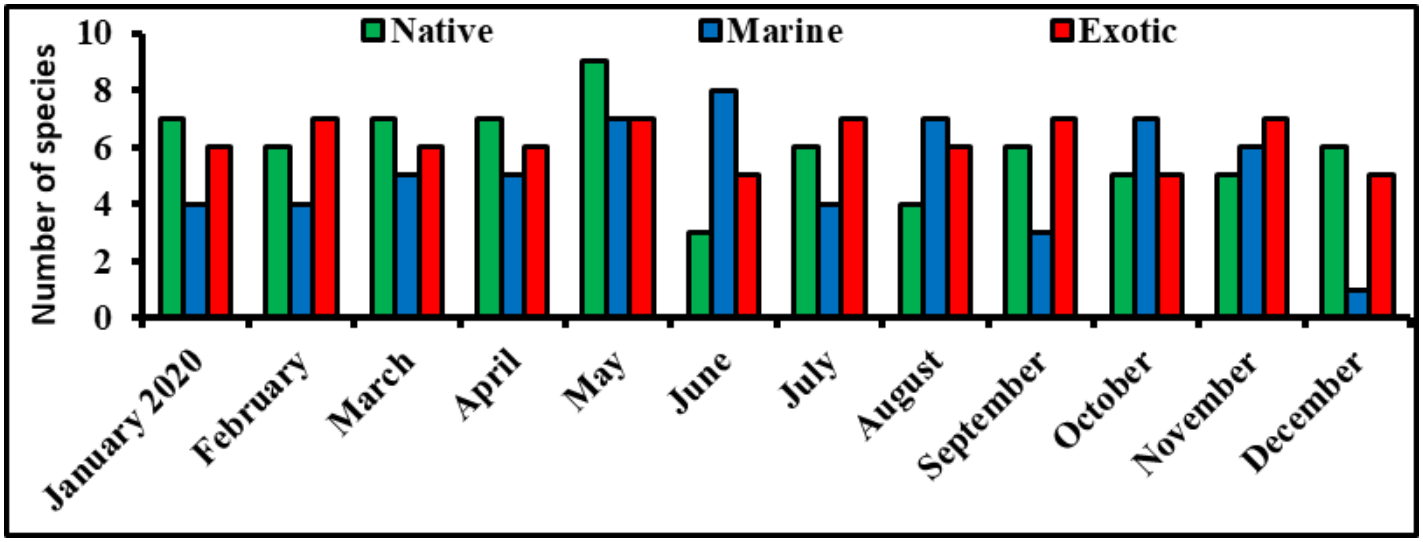

Figure 5. Monthly changes of native, marine and exotic fish species in the Garmat Ali River.

between salinity and the number of individuals. A weak negative correlation (r = -0.145) was observed between hydrogen ions and the number of species. The results of the ANOVA analysis revealed that there are no significant (P>0.05) differences in the number of individuals between studied stations (Fig. 4).

The current study included 32 fish species, which differed slightly from previous studies that included Garmat Ali River. Younis et al. (2010) collected 28 fish species; Mohamed et al. (2017) documented 34 species, and Aldoghachi and Abdullah (2021) recorded 29 species. The slight variation could be attributed to differences in catch effort (Lazem and Attee 2016).

Fish diversity: The river's fish diversity is divided into three categories: Native fish species formed 11 species, accounting for 24.35% of the total catch, with a mean±SD of 5.9±1.56, ranging from three in June to nine in May. The marine represented 14 species ranging from one in December to eight in June, with the mean±SD, 5.10±2.02, constituting 31.37% of the total number of species, while the exotic, including seven species, ranged from five in June, October, and December to seven in February, May, July, and November, with the mean±SD, 6.20±0.83, constituting 44.28% of the total number of species (Fig. 5).

The current study found a significant shift in the composition of the fish assemblage in the Garmat Ali River when compared to previous studies conducted in the same river, particularly in the proportions of marine, exotic, and native species, with these differences explained by spatial and temporal variations in the fish assemblage

Table 2. Families, the species and relative abundance of fish assemblage in the Garmat Ali River.

Engraulidae	*T. whiteheadi*		26.09	14.10	16.30	14.50	25.91	18.92	14.85	23.71	15.34	2.36	2.44	15.50
Cyprinidae	*C. gibelio*	20.00	16.77	7.26	12.50	11.07	15.54	16.89	10.40	19.83	20.86	22.05	15.85	15.18
Mugilidae	*P. abu*	28.33	19.25	1.71	9.78	16.41	8.81	8.78	11.88	7.33	13.50	14.96	23.17	12.82
Cichlidae	*O. aureus*	17.78	3.73	20.09	10.33	4.20	6.22	13.51	2.97	10.78	14.72	16.54	13.41	10.79
Clupeidae	*T. ilisha*	1.11		21.37		15.65	24.87	8.78	17.82	9.91	6.13	0.79		10.33
Poeciliidae	*P. latipinna*		4.35	6.84	16.30	8.40	4.66	5.41	19.31	4.74	5.52	14.96		7.84
Cichlidae	*C. zillii*	3.89	4.35	11.11		4.58	1.55	6.08	4.46	6.47		3.15	3.66	4.38
Leuciscidae	*A. mossulenssis*	1.67		2.14	2.72	4.58		3.38	3.96		3.68	4.72	13.41	2.81
Sulridae	*S. triostegus*	1.67	3.73	4.27	2.17	2.67	1.55	4.73		3.02	3.68	3.15	2.44	2.72
Poecilidae	*G. holibrooki*	3.33	2.48	1.71	2.72	0.76	1.04		3.96	3.88			10.98	2.26
Cichlidae	*O. niloticus*	3.89	1.86		3.26	1.91		2.03		3.02	3.68	2.36		1.85
Leuciscidae	*L. vorax*	2.78	3.73	0.85	2.17	1.15		4.05	1.98	1.29			7.32	1.80
Cyprinidae	*C. carpio*	1.67	4.35	2.56		1.15		0.68	1.98	1.72	2.45	3.15		1.66
Gobiidae	*B. fuscus*	1.11			14.67	0.76	1.55					0.79		1.61
Cyprinidae	*C. luteus*	2.78	2.48		1.63	1.91	1.04	1.35		1.29		2.36	3.66	1.38
Mugilidae	*P. klunzingeri*		1.24		1.63		3.63		1.49	1.72	2.45			1.06
Aphaniidae	*A. dispar*	3.33				2.29					3.68			0.83
Sparidae	*A. arabicus*					1.91	1.04	2.03	0.99		1.23	3.15		0.83
Sillaginidae	*S. sihama*	1.67		2.14	1.09	0.76			0.99		0.61	1.57		0.78
Leuciscidae	*A. marmid*	2.22		1.28		1.91				0.43			2.44	0.69
Cyprinidae	*C. sublimus*		1.86	0.85		1.53				0.86	1.23			0.60
Mastacembelidae	*M. mastacembelus*	1.11	1.86	0.43	0.54	1.15			0.50			0.79		0.55
Hemiramphidae	*H. limbatus*	1.67		0.85			1.04		0.99		0.61			0.46
Mugilidae	*P. subviridis*		1.24		1.09				1.49					0.32
Xenocyprididae	*H. leucisculus*				0.54			2.03				2.36		0.32
Gobiidae	*P. waltoni*		0.62			0.38		0.68						0.14
Sillaginidae	*S. arabica*			0.43								0.79		0.09
Bagridae	*M. pelusius*				0.54			0.68						0.09
Clupeidae	*N. nasus*					0.38					0.61			0.09
Engraulidae	*T. vetrirostris*						1.04							0.09
Leiognathidae	*P. bindus*						0.52							0.05
Heteropneustidae	*H. fossilis*												1.22	0.05
17	32													

and variations in the catch effort (Azzurro et al. 2019; Aldoghachi and Abdullah 2021).

Relative abundance: Four species preceding the numerical relative abundance in the Garmat Ali River formed 54.29% of the overall caught: *T. whiteheadi*, *C. gibelio*, *P. abu* and *O. aureus* (15.50, 15.18, 12.82, and 10.79%), respectively. Three species obtain the lowest percentages represented by *Thryssa vetrirostris*, *Photopectoralis bind*us and *Heteropneustes fossilis* recorded (0.09, 0.05, and 0.05), respectively (Table 2). The most abundant (D3) were *T. whiteheadi*, *C. gibelio*, and *P. abu*, representing 43.50% of the total catch.

The results of the present study documented the dominance of three small, tolerant species; *T. whiteheadi* was the most abundant species; it is marine, brackish, and pelagic-neritic (Froese and Pauly 2022), feeds primarily on planktonic crustaceans found in the river's water column, with no competition from other species in inland waters. The small size of this species and the abundance of its food give it features to dominate the study area. Furthermore, because there is no competitor for this species when it feeds through filter feeding, the species has the advantage of dominance (Aldoghachi and Abdullah 2021). The exotic *C. gibelio* has a high tolerance and feeds on a wide range of food items (Zhang et al. 2020). The *P. abu* native species is characterized by its small size. This characteristic contributes to the fish's adaptation to living under extreme conditions, in addition to available food, which consisted of diatoms and organic detritus. However, the majority of studies that evaluated fish populations in the Karmat Ali and Shatt Al-Arab Rivers confirmed the abundance of these

Table 1. Occurrence of fish species, ratio, months of appearance, and number of species

Category	%	Species	Occurrence months	No. of species
Common fish species	89.48	*C. gibelio*, *P. abu*, *O.aureus, T. ilisha* *P. klunzingeri*	12	3
		T. whiteheadi, S. triostegus	11	2
		C. zillii, P. latipinna	10	2
		T. ilisha, *A. mossulenssis*, *G. holibrooki*, *L. vorax*, *C. carpio*, *C. luteus*	9	6
Seasonal species	5.07	*O. niloticus*	8	1
		P. klunzingeri, *S. sihama, M. mastacembelus*	7	3
		A. arabicus	6	1
Occasional fish species	5.45	*A. marmid*, *B. fuscus*, *C. sublimus*, *H. limbatus*		
		A. marmid, *B. fuscus*, *C. sublimus*, *H. limbatus*		
		A. dispar, *P. subviridis*, *H. leucisculus*, *P. waltoni*		
		H. fossilis, P. bindus, T. vetrirostris		

species (Mohamed et al. 2017; Abdullah et al. 2022; Hameed et al. 2022). The majority of studies conducted in southern Iraq in general and Basrah province in particular, such as Al-Thahaibawi et al. (2019) and Aldoghachi and Abdullah (2021), refer to the dominance of the species *O. aureus* because it is a tolerant invasive species that feeds on a variety of food elements and has a reproductive strategy that provides care for the young by incubating eggs and young in the mouth. Comparing the results of the current study to those from Younis et al. (2010) and Muhammad et al. (2013), it was found that the dominant species had changed (in terms of its relative abundance).

Fish size spectrum: Fish abundance in ecosystems varies expectedly with body size, usually decreasing with increasing size. The species *P. abu* length ranged from 4-17 cm, with the dominance of length group 10 cm in 47 fish out of 278 individuals that were caught. *Tenualosa ilisha* length groups fluctuated from 14-26 cm, with the prevailing length group of 17 cm in 61 specimens of the overall species catching 224 specimens. The commercial species *P. klunzingeri* length groups varied from 12-23 cm, with the length group 17 cm in eight specimens of the overall number of individuals 23 fish. The length groups of *L. vorax* ranged from 12-30 cm, with the dominant length group being 19 cm in six fish out of an overall catch of 39 individuals. The length groups of the *C. carpio* range from 11-29 cm, with the top length group being 14 cm in seven of the total 36 fish. The length groups of *C. luteus* ranged from 8-23 cm, with the prevailing length group of 13 cm in eight individuals of the overall 30 fish (Figs. 6-8).

Consumers may prefer small commercial fish species such as *P. abu*, *P. klunzingeri*, and *C. luteus*, or large commercial fish species such as common carp and skeleton fish. Nonetheless, as salinity and pollutant concentrations increased, fishing pressure reduced the density and size spectrum of these species, particularly with open access to river fisheries and fishing during the breeding season, as well as illegal fishing methods and tools. All of these factors contributed to population compression in the species, which is consistent with Zhang et al. (2018) and the study is an approximation of what Mohamed et al. (2017) found, which refers to the occurrence of some common marine, exotic, and native species. However, the occurrence in the current corresponds to Aldoghachi and Abdullah (2021) in the same river.

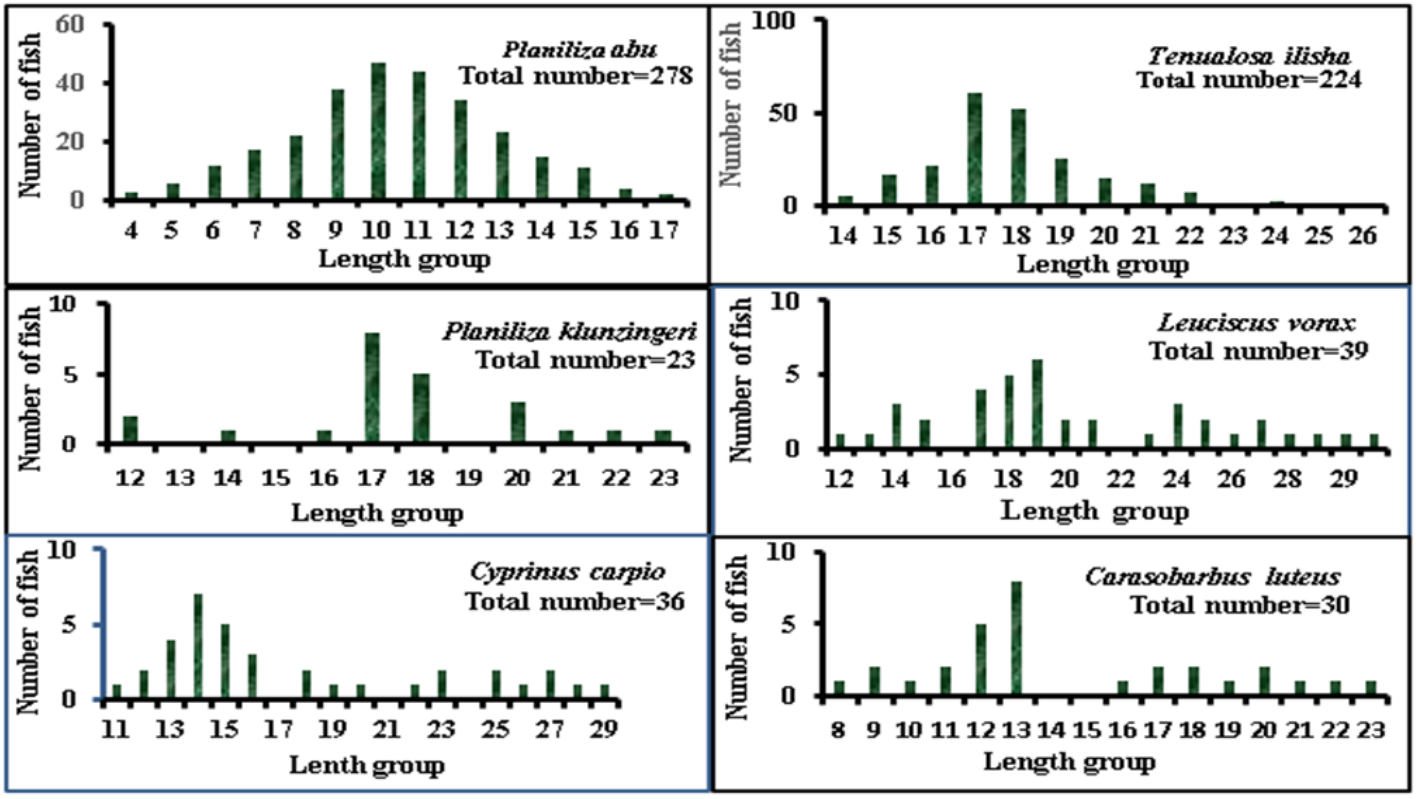

Figure 6. Length groups distribution of fish size-spectrum for the most economic fish species in the Garmat Ali River.

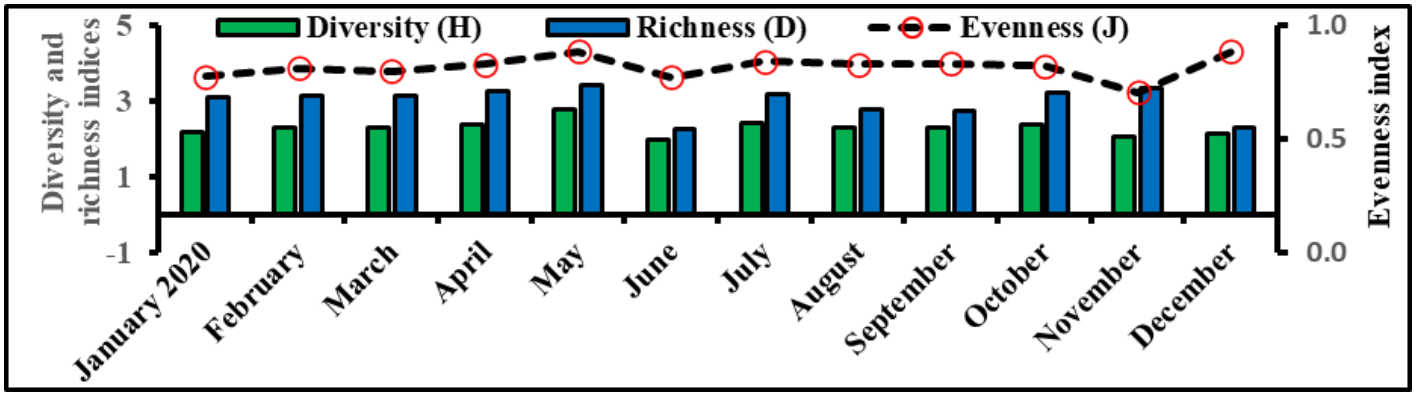

Figure 7. The monthly variations in the ecological indices, Garmat Ali River.

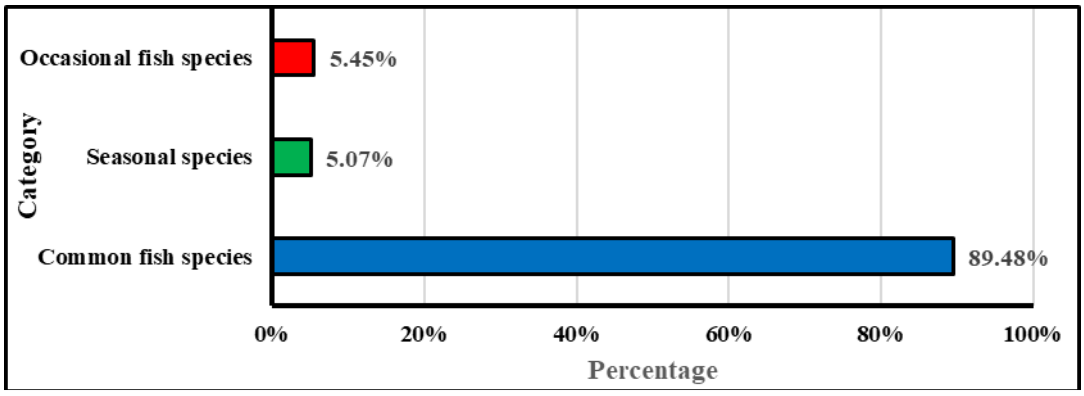

Figure 8. Fish categories occurrence rates according to their presence in the monthly samples.

Conclusion

The current study concluded that the composition of the fish assemblage has changed compared to previous studies, especially the rather old studies, due to the entrance of many exotic species to the fish community in the river and the occurrence of marine species due to the increase in salinity concentrations and the departure of sensitive freshwater native species.

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