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Spatiotemporal variability of fish assemblage in the Shatt Al-Arab River, Iraq

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PEER REVIEW

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Comments

This is a good report in coastal science on the fish population from Gulf of Iraq. This report contains new knowledge and information from the area which is still an unknown foci of the world. The work can be further referenced in the field. This work also shows some interesting new technique that can be the model for further study in fish study in other areas of the world.

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ABSTRACT

Objective: To study spatial and temporal variability of fish assemblage in the Shatt Al-Arab River.

Methods: This study was conducted from December 2011 to November 2012. Water temperature, salinity, dissolved oxygen and transparency were measured from three sites in the river. Several fishing methods were adopted to collect fish including gill nets, cast net, electro-fishing and hook and lines. Associations between the distribution of fish species and the environmental variables were quantified by using canonical correspondence analysis.

Results: The results showed that the fish assemblage consisted of 58 species representing 46 genera and 27 families belong to Osteichthyes except one (*Carcharhinus leucas*) relate to Chondrichthyes. Number of species increased in summer and autumn months and sharply decreased in winter. *Tenualosa ilisha* was the most abundant species comprising 27.4% of the catch, followed by *Carassius auratus* (23.7%) and *Liza klunzingeri* (10.6%). The dominance (D_3) value for the main three abundant species was 61.7%. Nine species were caught for the first times from the river include eight marine. The overall values of diversity index ranged from 0.67 in March to 2.57 in October, richness index from 2.64 in January to 3.71 in September and evenness index from 0.22 in March to 0.73 in August.

Conclusions: Spatially, the fish assemblages of Shatt Al-Arab River can be divided into three ecological fish guilds, namely, common species, seasonal species and occasional species.

KEYWORDS

Fish assemblage, Fish guilds, Ecological factors, Shatt Al-Arab estuary, Iraq

1. Introduction

Analysis of fish community structure is widely considered as an integrative indicator of the ecological status of water bodies[1]. These communities showed a dynamic structure that reflects characteristics and alterations interact with biotic processes, specially predation and competition[2]. Therefore, changes in parameters of water quality and their relation with biodiversity indices are crucial to evaluate fish biodiversity in riverbed[3]. Myers *et al.* stated that the five major threats to biodiversity are invasive alien species, climatic changes, nutrient leading to pollution, habitat changes and overexploitation of the stock[4].

The Shatt Al-Arab River locates in northwest corner of the Arabian Gulf and formed by the confluence of the Tigris and

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Euphrates Rivers at Al-Qurna, north of Basrah, south Iraq. Therefore, it is affected by the tide of the Gulf as well as discharging rates of the Mesopotamian Rivers. This river was suffered during the last years from penetration of the salt water from the gulf further upstream, due to decline in the discharge rates of the Tigris and Euphrates Rivers as a result of several hydrological projects constructed in neighbor countries and control of water sources coming over the borders.

A handful studies carried out on fish community structure of Shatt Al-Arab River. The pioneer study was of Al-Nasiri *et al.* who executed a survey on bony fishes in the River, for the stretch from Abu Al-Khasib to Garmat Ali[5]. They concluded that 32 species were introduction including 12 marine species. Some other studies focused on penetration and spread of some marine species into the Shatt Al-Arab River[6,7]. Hussain *et al.* investigate seasonal variations of fish populations in the Shatt Al-Arab, 33 species were described including 14 marine and diversity index ranged from 3.06-0.92[8]. Moreover, Hussain *et al.* recorded 25 species in the river Shatt Al-Arab involving seven marine, but diversity varied from 0.3-1.75[9]. Younis *et al.* applied integrated biological index in the Shatt Al-Arab River at Garmat Ali, who collected 28 species, and found *Liza abu* (*L. abu*) as dominating species[10]. Species diversity ranged from 0.12 to 1.5. Mohamed *et al.* studied the effects of ecological parameters on fish assemblage of Garmat Ali River, north of Basrah, by applying Canoco program[11]. Twenty-six species belong to 13 families were caught and the diversity index ranged from 1.84 to 2.79. Mohamed *et al.* described the longitudinal patterns of fish community structure in the Shatt Al-Arab and suggested the present of three seasonal ecological fish guilds in Shatt Al-Arab River, each representing unique species associations, habitat characteristics, and spatial fish distributions[12].

The aim of the present study is to describe the spatial and temporal variability of fish assemblages of the Shatt Al-Arab River, to evaluate the changes in the fish assemblage and their relation to some ecological factors of the river during the period from December 2011 to November 2012.

2. Materials and methods

The Shatt Al-Arab River run about 204 km, and varies in width from 250 m to more than 2 km in the estuary. Its depth ranged from 4.2 m to 15.0 m. Several branches are penetrating the river from both sides, their number approximate 637[13]. The river has three main tributaries, Sweeb River, Garmat-Ali River and Karun River. Karun River has been recently diverted into Iranian terrene[14]. The Shatt Al-Arab River is affected by tidal current penetrating from the Arabian Gulf twice daily. Water level varies from 3.0 m near estuary to 0.5 m at the confluence[15].

Three stations were chosen to execute the study from the Shatt Al-Arab River (Figure 1). Station 1 locates near Al-Dair Bridge (746907 E, 3410824 N m), station 2 near Ashalha Island north of the Sindbad Island (764452 E, 3386729 N m) and station 3 locates near Al-Sahel Land in Abu Al-Khasib (786725 E, 3373365 N m).

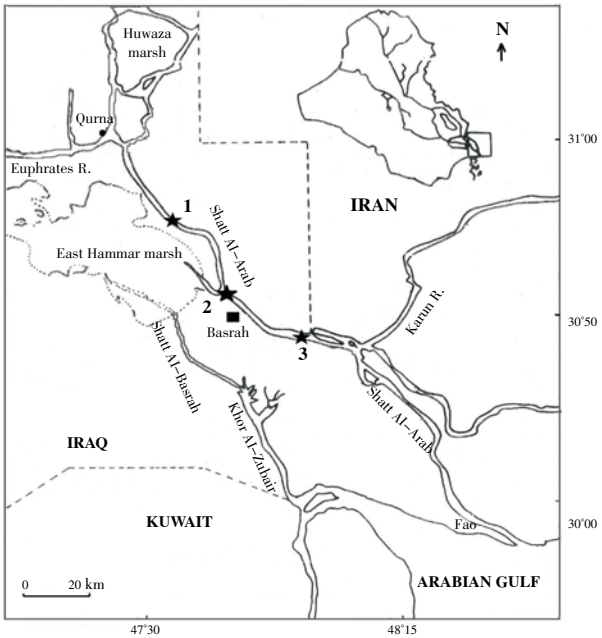

Figure 1. Map of Shatt Al-Arab showing the study sites.

Fish samples were regularly collected from each station from December 2011 to November 2012. Several fishing methods were adopted to collect fishes including gill nets (100 m to 500 m with 1.5 cm to 15 cm mesh size), cast net (7 m diameter with 2.5 cm to 4.0 cm mesh size), hook and line, hand net and electro-fishing by generator engines (provides 300-400 V and 10 A) were used to collect fishes. Catches of other anglers in the locations were also counted. Fish species identified and counted, and classified by consulting[16-19].

Water temperature, salinity and dissolved oxygen were measured by YSI 556 MPS models 2005. Transparency of water was measured by Secchi disk of 25 cm in diameter. At each location, the GPS waypoint was collected for spatial reference using GPSMAP 78s model 2010 type Garmin.

The analysis of the nature of the fish assemblage in the three sites was carried out by the following methods and indices: relative abundance[20], dominance, D3[21] and occurrence[22]. The fish diversity, richness, and evenness were calculated by using CANOCO 4.5 Package[23]. The multiple linear correlation analysis was carried out on water parameters and fish to verify if there is any significant relationship by applying the multivariate analysis of ecological data using CANOCO program.

3. Results

3.1. Ecological factors

Monthly variations in some ecological factors in the Shatt Al-Arab River are shown in Figure 2. Water temperature, transparency and dissolved oxygen exhibited no significant differences between the three stations (F=0.073, 0.074 and 0.162, $P \leq 0.05$), respectively. Water temperature ranged from 11.3 ˚C in January to 35.7 ˚C in August. The overall values of dissolved oxygen ranged from 6.1 mg/

L in June to 9.5 mg/L in January. Transparency values varied from 38.3 cm in August to 72.3 cm in May. Salinity in station 1 ranged from 0.75‰ in July to 1.48‰ in February, from 1.09‰ in July to 2.27‰ in August in station 2 and from 1.4‰ in March to 6.19‰ in September in station 3. Significant differences (F=15.65, P>0.05) in salinity values were found between station 3 and the other stations. However, the overall value of water salinity in the river differs from 1.37‰ in March to 3.13‰ in September.

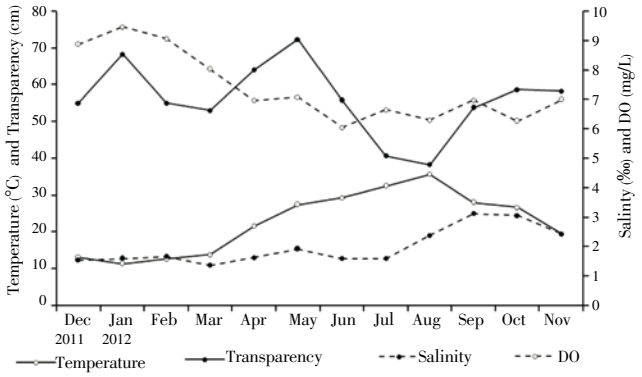

Figure 2. Monthly variations in the ecological factors in Shatt Al-Arab River.

3.2. Fish community structure

A total of 58 fish species belonging to 46 genera and 27 families were collected from the study stations in Shatt Al-Arab River, including 16 native, 10 alien and 32 marine species. All species belonged to Osteichthyes except one species (*Carcharhinus leucas*) related to Chondrichthyes. Eight marine and one freshwater species were recorded for the first time from the river (Table 1). Cyprinidae was a dominated family regarding number of their genera, species and individuals. It was represented by 15 species and 10 genera.

Monthly fluctuations in number of species in the study stations were detected (Figure 3). Thirty six fish species were recorded from station 1. They ranged from seven in December to 23 species in May and June. Thirty five species were encountered in station 2. They varied from 10 in January and February to 24 species in September. In station 3 fifty three species were found. They ranged from eight in January to 33 species in September. Insignificant differences (F=1.52, P>0.05) were detected in number of species among stations. Fifty eight species were encountered in the Shatt Al-Arab River, varied from 14 in January to 41 in September (Table 1).

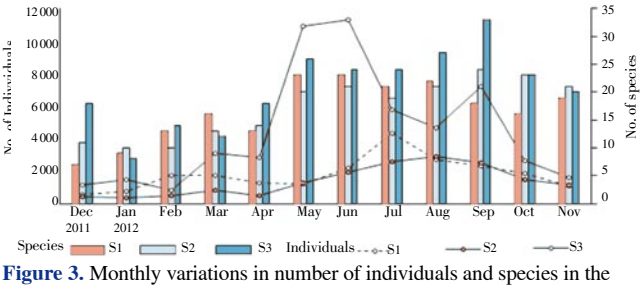

Figure 3. Monthly variations in number of individuals and species in the study stations.

Monthly variations in number of individuals recorded from the investigated stations are represented in Figure 3. A total of 21 727 fish were recorded in station 1, they ranged from 540 in December to 4 302 fish in July. A total of 16 441 fish were caught in station 2; they varied from 385 in January to 2 894 fish in August. Meanwhile, 53 480 fish were recorded from station 3, they ranged from 783 in February to 11 319 fish in June. Significant differences in number of individuals (F=6.58, P>0.05) were observed between station 3 and other locations.

3.3. Relative abundance of fish species

Figure 4 shows the relative abundance of the most abundant fish species (>2%) in the study stations during 2011-2012. *Carassius auratus* (*C. auratus*) was the most abundant species in station 1, comprised 27.2% of the total number, followed by *Tilapia zilli* (*T. zilli*) 21.7% and *Liza klunzingeri* (*L. klunzingeri*) 14.9%. Also, *C. auratus* was the most abundant species in station 2 constituted 25.9% of the total catch, followed by *L. klunzingeri* 22% and *T. zilli* 11%. *Tenualosa ilisha* (*T. ilisha*) was the most dominate species in station 3, formed 43.1% of the total number, followed by *C. auratus* 21.6% and *L. klunzingeri* 5.4%.

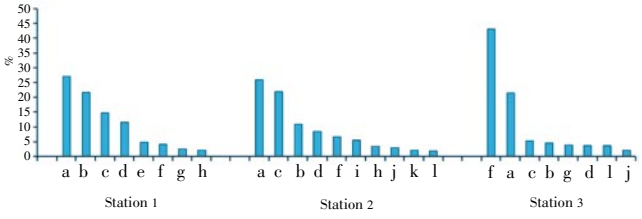

Figure 4. Relative abundance of the most abundant fish species (>2%) in the study stations.
a: *C. auratus*; b: *T. zilli*; c: *L. klunzingeri;* d: *L. abu*; e: *B. luteus*; f: *T. ilisha*; g: *C. carpio*; h: G. holbrooki; i: P. latipinna; j: *T. whiteheadi*; k: T. hanmiltonii; l: *A. latus*;

Table 1 shows the relative abundance of fish species in the Shatt Al Arab River during the study period. It has been found that the fish assemblage was dominated by *T. ilisha* (27.4%), it varied from 0.1% in March to 73.8% in May. *C. auratus* comprising 23.7% of the assemblage, it fluctuated from 7.1% in May to 87.6% in March. *L. klunzingeri* was formed 10.6% and relative abundance ranged from 0.3% in June to 33.8% in July. These three species formed 61.7% of the total number of species according to dominance index (D3). *T. zilli* constituted 9.8% from the total assemblage, it varies from 1% in March to 26.9% in November. *L. abu* was formed 6.5%, ranging from 1.4% in July to 28.7% in February.

3.4. Fish diversity indices

Monthly variations in diversity, richness and evenness indices of fish assemblage in the Shatt Al-Arab River were illustrated in Figure 5. The diversity index of fish assemblage in station 1 fluctuated from 0.61 in March to 2.20 in August, from 0.91 in January to

Table 1

Monthly variations in relative abundance of fish species collected from the Shatt Al Arab River during 2011-2012.

Species	Code	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Total
T. ilisha[*]	Til	-	-	-	0.10	37.10	73.80	66.70	10.20	11.00	4.90	1.70	-	27.400
C. auratus[+]	Cau	71.10	70.10	48.70	87.60	21.80	7.10	10.40	20.30	16.70	13.80	17.60	36.70	23.700
L. klunzingeri[*]	Lkl	0.50	1.30	0.80	0.60	1.10	0.70	0.30	33.80	14.50	27.50	4.90	2.60	10.600
T. zilli[+]	Tzi	5.60	2.50	6.30	1.00	12.60	2.70	4.50	11.80	17.50	13.50	16.50	26.90	9.800
L. abu	Lab	12.90	12.50	28.70	2.00	6.70	2.30	7.40	1.40	5.10	5.00	14.90	10.80	6.500
C. carpio[+]	Cca	-	1.40	2.90	0.20	0.50	0.10	1.10	6.20	4.80	4.60	8.40	3.90	3.100
A. latus[*]	Ala	0.70	-	-	-	1.50	0.10	0.20	3.00	6.30	6.40	6.10	3.40	2.600
Gambusia holbrooki[+]	Gho	0.40	0.10	1.40	1.30	1.50	0.60	0.90	0.60	3.10	5.20	5.00	4.00	2.100
Poecilia latipinna[+]	Pla	0.20	-	0.20	1.30	1.40	1.20	1.10	-	2.90	2.00	8.80	3.40	1.800
T. whiteheadi[*]	Twh	-	-	-	-	0.80	5.10	2.20	0.60	3.50	0.80	1.30	0.20	1.800
L. subviridis[*]	Lsu	1.00	4.90	3.80	2.60	1.40	1.40	0.70	1.60	0.80	0.60	1.50	0.80	1.400
B. luteus	Blu	0.20	0.60	4.30	0.40	1.30	0.30	0.00	3.30	-	2.70	2.20	0.20	1.300
T. hamiltonii[*]	Tha	-	-	-	-	0.10	1.30	0.80	0.50	3.70	1.40	0.30	0.10	1.000
Aphanius dispar	Adi	0.50	0.04	0.50	0.50	0.60	0.40	0.50	-	1.90	1.70	2.20	1.40	0.900
Nematalosa nasus[*]	Nna	-	-	-	-	9.60	1.20	0.70	0.40	0.30	-	-	-	0.900
Aspius vorax	Avo	2.70	5.10	0.80	0.10	0.10	0.10	0.00	0.50	1.10	1.50	1.40	0.80	0.800
Oreochromis aureus[+×]	Oau	-	-	-	-	0.30	0.10	0.20	2.10	0.90	1.60	0.20	0.10	0.700
A. marmid	Ama	0.60	-	0.40	0.20	-	0.00	0.50	1.10	0.60	0.60	1.50	1.10	0.600
Hemiculter leucisculus[+]	Hle	1.10	0.10	0.10	0.10	-	0.30	0.20	0.70	0.60	0.80	1.10	0.70	0.500
Aphanius mento	Ame	0.70	0.20	0.30	1.00	0.50	0.20	0.50	-	1.00	0.60	0.30	0.40	0.500
A. mossulensis	Amo	0.60	0.60	0.10	0.60	0.30	0.10	0.30	0.30	0.50	0.00	0.40	1.00	0.300
Acanthopagrus berda[*]	Abe	-	-	-	-	0.26	0.03	0.05	0.30	0.50	1.00	0.60	0.40	0.300
B. fuscus[*]	Bfu	-	-	-	-	0.04	0.10	0.01	-	0.70	1.40	0.00	0.20	0.300
Hyporhamphus limbatus[*×]	Hli	-	-	-	-	-	-	-	0.20	1.20	0.50	-	-	0.200
S. hasta[*]	Sha	0.10	-	-	-	0.04	0.01	0.03	0.30	0.00	0.40	1.00	0.30	0.200
Silurus triostegus	Srt	0.90	0.50	0.50	0.30	--	0.03	0.15	0.20	0.10	0.10	0.30	0.20	0.200
Johnius dussumieri[*]	Jdu	-	-	-	-	-	0.08	-	-	-	0.30	0.50	-	0.100
Thryssa vetrirostris[*×]	Tve	-	-	-	-	0.04	0.27	0.08	0.17	-	-	-	-	0.100
Ilisha compressa[*]	Ico	-	-	-	-	-	-	-	0.02	-	0.04	0.65	0.08	0.100
Scatophagus argus[*]	Sar	-	-	-	-	0.06	0.07	0.11	0.11	0.01	0.01	-	0.05	0.100
Boleophthalmus dussumieri[*]	Bdu	-	-	-	-	-	-	-	0.04	0.21	0.02	0.22	-	0.050
Leiognathus bindus[*×]	Lbi	-	-	-	-	-	0.19	-	-	0.11	0.02	-	-	0.040
B. orientalis[*]	Bor	-	-	-	-	-	0.01	0.03	0.07	0.02	0.17	-	-	0.040
Alburnus caeruleus	Aca	-	-	-	-	-	-	-	0.15	-	-	0.20	0.10	0.040
Barbus xanthopterus	Bxa	-	-	0.13	0.02	0.02	0.06	0.05	-	0.05	0.01	0.02	0.08	0.030
Eleutheronema tetradactylum[*]	Ete	-	-	-	-	-	-	-	-	-	0.12	-	-	0.020
Alepes vari[*×]	Ava	-	-	-	-	-	-	-	-	-	0.12	-	-	0.020
Mystus pelusius	Mpe	-	-	-	0.02	0.06	-	-	0.06	0.01		0.02	-	0.010
Barbus kersin	Bke	-	-	0.03	-	-	0.02	0.02	-	-	0.02	0.02	0.03	0.010
Ctenopharyngodon idella[+]	Cid	0.05	-	-	-	-	0.01	0.03	0.02	-	-	-	0.03	0.010
Barbus sharpeyi	Bsh	0.05		0.17	-	-	-	0.02	-	0.01	-	-	-	0.010
Cyprinion kais	Cka	-	-	-	-	0.09	-	0.01	-	-	0.01	0.02	0.03	0.010
Hypophthalmichthys molitrix[+]	Hmo	-	-	-	-	0.04	0.01	-	0.02	0.01	-	-	0.03	0.010
Barbus grypus	Bgr	-	-	0.03	0.04	-	-	-	0.01	-	-	-	0.03	0.010
Carcharhinus leucas[*]	Cle	-	-	-	-	-	-	0.02	0.01	-	-	-	-	0.004
Alepes djedaba[*]	Adj	-	-	-	-	-	-	-	-	-	0.02	-	-	0.003
Sardinella albella[*×]	Sal	-	-	-	-	-	0.02	-	-	-	-	-	-	0.003
Scomberoides commersonnianus[*]	Sco	-	-	-	-	-	-	-	-	-	0.02	-	-	0.003
Gerres limbatus[*]	Gli	0.05	-	-	-	-	-	0.01	-	-	-	-	-	0.002
Mastacembelus mastacembelus	Mma	-	-	-	-	-	0.01		-	-	-	0.02		0.002
Strongylura strongylura[*]	Sst	-	-	-	-	0.02	-	0.01	-	-	-	-	-	0.002
Upeneus doriae[*]	Udo	-	-	-	-	-	-	-	-	0.02	-	-	-	0.002
Anodontostoma chacunda[*]	Ach	-	-	-	-	-	-	-	0.01	-	-	-	-	0.001
Carangoides malabaricus[*×]	Cma	-	-	-	-	-	0.01	-	-	-	-	-	-	0.001
Heteropneustes fossilis[+]	Hfo	-	-	-	-	-	0.01	-	-	-	-	-	-	0.001
Lagocephalus guentheri[*×]	Lgu	-	-	-	-	-	-	-	-	-	0.01	-	-	0.001
Sillago sihama[*]	Ssi	-	-	-	-	-	-	-	-	-	0.01	-	-	0.001
Trachinotus mookalee[*×]	Tmo	-	-	-	-	-	-	-	-	-	0.01	-	-	0.001
Number of individuals		2125	2601	3006	5666	4626	13442	15461	12633	10270	12002	6006	3810	91648
Number of species		20	14	20	20	29	38	36	34	34	41	33	32	58

[*]: Marine species; [+]: Alien species; [×]: First record.

2.40 in October in station 2 and from 0.46 in March to 2.62 in September. The overall value of diversity index fluctuated from 0.67 in March to 2.57 in October. The richness index ranged from 1.95 in December to 3.14 in June in dtation 1, from 2.20 in February and January to 3.18 in September in station 2 and from 2.08 in January to 3.50 in September in station 3. The overall value of richness index in Shatt Al-Arab River varied from 2.64 in January to 3.71 in September. The peaks of evenness (0.78, 0.77 and 0.80) were recorded in October at the three stations, respectively, while the lowest values were 0.22 and 0.18 noticed in March at stations 1 and 3, respectively and 0.40 in January at station 2. The overall value of evenness index ranged from 0.22 in March to 0.73 in August.

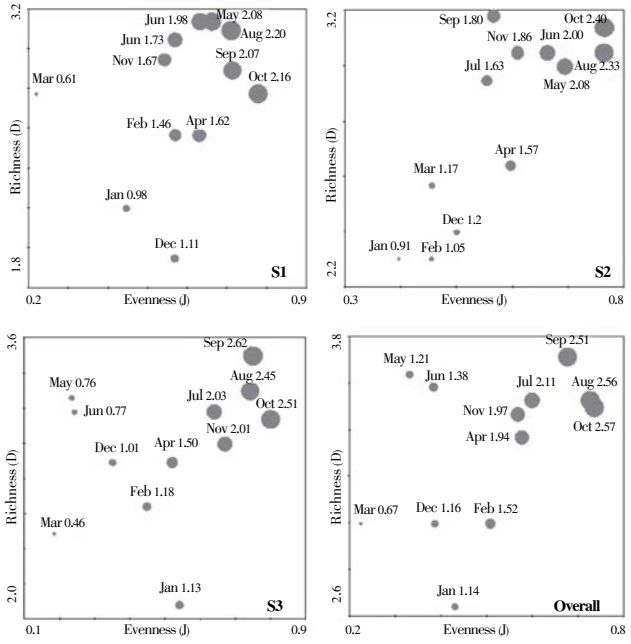

Figure 5. Distribution of the values of diversity, richness and evenness indices in the Shatt Al-Arab River.

3.5. Fish species occurrence

Fish species found in the Shatt Al-Arab River can be classified into three categories (Figure 6). Namely, the common species represented by 19 species and formed 66.8% of the total catch. The second category was seasonal species comprised of eight species and constituted 31.6% of the total number of species. Finally, thirty-one species were designated as occasional and formed 1.6% of the total number of species. All categories contained native, marine and alien species.

3.6. Fish and ecological factors

The environmental habitat vectors on the canonical correspondence analysis (CCA) ordination plot represent the relationships between the distribution of fish species and the environmental variables in the Shatt Al-Arab River are given in Figure 6. Water temperature was a greater impact factor on the total number of species and the total number of individuals compared with other factors. It was power positive correlated with number of species (r=0.8) and number of individuals (r=0.77), while dissolved oxygen (DO) was negative correlated with total number of species (r=-0.79) and total number of individuals (r=-0.63). The CCA analysis omitted 17 rare (occasional) species. Fish species were divided into three groups. First one (1) include 22 species, contain 11 common species [*L. klunzingeri, T. zilli, G. holbrooki, Cyprinus carpio* (*C. carpio*), *Barbus luteus* (*B. luteus*), *Aphanius dispar, Hemiculter leucisculus, Poecilia latipinna, Acanthobrama marmid* (*A. marmid*), *Acanthopagrus latus* (*A. latus*) and *Sparidentex hasta* (*S. hasta*)], Four seasonal [*Thryssa hamiltonii* (*T. hamiltonii*), *Oreochromis aureus, Acanthopagrus berda* and *Bathygobius fuscus* (*B. fuscus*)], and seven occasional species [Brachirus orientalis (*B. orientalis*), *Mystus pelusius, Ilisha compressa, Boleophthalmus dussumieri, Hyporhamphus limbatus, Johnius dussumieri* and *Alburnus caeruleus*) were correlated with salinity and in less level with water temperature. Second group (2) was comprised seven common species [*C. auratus, L. abu, Liza subviridis (L. subviridis*), *Aspius vorax, Alburnus mossulensis* (*A. mossulensis*), *Aphanius mento* and *Silurus triostegus*], and one occasional species (*Barbus sharpeyi*), which in particular correlated with dissolved oxygen. While the third group (3) contained nine species, one was common (*Barbus xanthopterus*), four were seasonal [*T. ilisha, Thryssa whiteheadi* (*T. whiteheadi*), *Scatophagus argus* and *Barbus kersin*) and four occasional (*Nematalosa nasus, Ctenopharyngodon idella, Thryssa vetrirostris* and *Leiognathus bindus*]. The species of this group was correlated with water transparency.

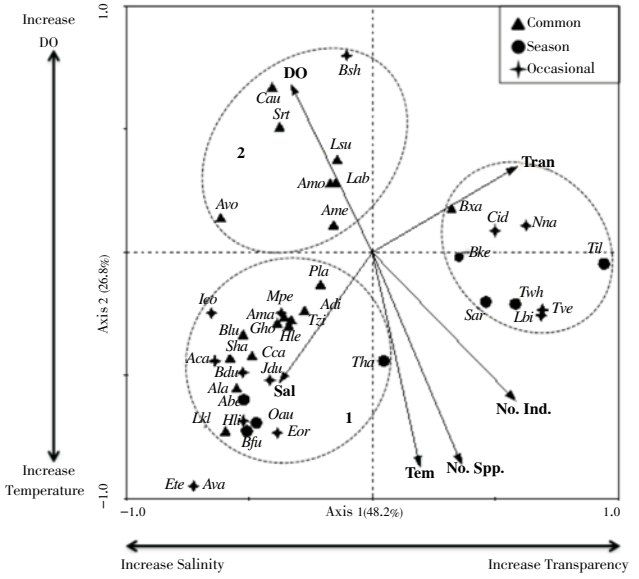

Figure 6. CCA ordination plots showing the relationship among fish species and various ecological factors in the Shatt Al-Arab River (species abbreviations as in Table 1).
DO: dissolved oxygen; Sal: salinity; Tran: water transparency; Tem: Water temperature; No. Spp.: total number of species; No. Ind.: total number of individuals.

4. Discussion

Fish assemblage structure and composition were distinctly varied among study stations, which correspond to hydrological differences. However, fish distributions found to be closely corresponding to habitat features[24]. Water temperature regulate behavior attitude of aquatic organisms, for instance, fish migration and distribution[25]. Mohamed *et al.* deduced that salinity might also participate in differences of distribution and abundance of species and their composition along the Shatt Al-Arab River[12]. Moreover, fish presence, distribution and movement along aquatic environments are influenced by overlapping of living and non-living factors, either directly or indirectly. Many fish species adapt to environmental changes to varying extent and continue to exist at different abundance[26].

Spatially, the fish assemblages of Shatt Al-Arab River can be divided into three ecological fish guilds, the first represent the upper Shatt Al-Arab River (station 1) which characterized by low values of salinity. Freshwater and marine species found to constitute 79.5% and 20.5% of this assemblage, respectively. *C. auratus*, *T. zilli*, *L. klunzingeri* and *L. abu* were most dominated species, and accounted for 75.4% of the entire count of individuals in this site. Results in this site were clearly unlike those of[12] due to difference of fishing methods. They collected 18 fish species, 7 of them (*L. subviridis, T. ilisha, T. hamiltonii, T. whiteheadi, A. latus, S. hasta* and *B. orientalis*) were marine constituting 38.9% of fish assemblage in the site. On the other hand, the dominated species found to consist 85.8% including *L. abu* (25.9%), *T. ilisha* (24.3%), *C. auratus* (23.1%) and *A. marmid* (12.5%). The overall values of diversity, richness and evenness indices in this site were all compatible with[13]. They recorded 1.91, 2.98 and 0.66 respectively. Marine species ascend toward the upper reaches of Mesopotamian rivers, Mohamed *et al.* encountered 23 fish species, eight of them were marine in the artisan fisheries of the lower reaches of Euphrates and Tigris rivers, at Al-Qurna, north of Basrah during 2005[27].

The second ecological fish guild was at station 2 in the Shatt Al-Arab River. It was characterized by increase values of salinity and decline in number of species and individuals compared to previous site, which are contained 35 species, 14 of them were marine (37.9%). The most dominated species were *C. auratus, L. klunzingeri, T. zilli* and *L. abu*. They all constitute 67.5% of the total count of individuals in this site. Comparison of species composition with[28], concerning fish assemblage at the Shatt Al-Arab River (Sindbad Island Station) during 1992-1993, can be concluded that the guild of this site of the River was clearly varied in abundance of marine species, dominated species and in diversity indices. They found 21 fish species, 6 of them were marine (*L. carinata, T. ilisha, B. fuscus*, *T. hamiltonii, Sillago sihama* and *L. subviridis*) constituting 28.6% of fish assemblage in this station. In addition, *A. marmid* come first (59.2%), followed by *L. abu* (11.2%), *A. mossulensis* (8.6%) and *B. luteus* (7.5%). However, *T. ilisha* formed only 0.18% of fish assemblage in this station. They found that the overall values of diversity, richness and evenness were 1.19, 2.50 and 0.37, respectively.

The third ecological fish guild was in station 3 that characterized with highest levels of salinity, number of species and individual counts. Marine species dominated the guild and formed 60.9% and freshwater species consisted 39.1%. The most dominant species were *T. ilisha, C. auratus*, *L. klunzingeri* and *T. zilli*, forming 74.8% of the total number of individuals in this site. Comparing the species composition in this guild with[12] conclusions fish assemblage at the Shatt Al-Arab River in Hamdan site during 2010-2011, it can be conclude that fish guild was also varied in freshwater and marine species abundance, and also the prevail species. They captured 23 species, 12 were marine constituted 56.5% of the fish assemblage in this station. They recorded relative abundance of most abundant species in this site; *C. auratus* was 37.3%, followed by *T. ilisha* 19.4%, *L. abu* 9.8% and *L. subviridis* 7.7%. The overall values of diversity, richness and evenness indices in this location were less than[12]. They recorded 2.13, 3.45 and 0.79 respectively. This may relate to detectable decline in abundance of several species during the whole study period.

Al-Hassan *et al.* stated that marine species are limited to the middle and the lower reaches of the Shatt Al-Arab River, but their numbering decreased leading to the upper reaches of the river[29]. However, freshwater fish fauna exhibited a reverse trend of distribution in the river. As environmental conditions change, some fish species migrate in response to variation in salinity and moving up and down the estuary[30,31]. A few fishes either move back from shallow water to greater depths, in response to changes in temperature, or move towards the sea where conditions are less variable[32]. Moreover, fish species move alone seasonally due to ontogenetic development[33].

It deserves watching that *T. zilli* an alien species invade all the three locations and augment in numbers, acquire considerable position in composition of fish community. This may relate to their ability to adapt themselves to new environments with rapid reproduction and easy distribution[34]. *T. zilli* initially recorded in Euphrates River at Al-Musaib district[35]. *T. ilisha* is an anadromous species ascend during spring and early summer to the upper reaches of the Shatt Al-Arab River for a spawning migration[36-38]. This species distributed along the river and its proportion increased heading towards the river mouth. However, it is considered as the prevailing species in the station 3. Mohamed *et al.* stated that *T. ilisha* constituted 10.1% of the total catch in Hammar marsh during 2006-2007[38], and formed 13.3% in the Shatt Al-Arab River during 2010-2011[12].

According to Jorgensen *et al.*, the overall status of diversity index in Shatt Al-Arab River is considered as poor and evenness and evenness indices as semi-balanced in all stations[39]. The diversity, richness and evenness of fish assemblage in the Shatt Al-Arab River were calculated during the eighties of the last century to be 3.06, 4.37 and 0.87, respectively and these were mainly due to the abundance of migratory marine species[8].

Results indicate that the ecological properties, in particular salinity might provide some possible explanations for the differences in distribution, abundance and species composition along the Shatt Al-Arab River. Spatially and monthly changes in salinity appeared to be the main parameter structuring fish assemblage in the River, coincided with temperature. In CCA plots it can be observed in the first group, the majority of marine species and several numbers of common species that forming the bulk of the fish community resisting salinity fluctuations, all may be affected by these factors[40]. However, most surveys previously investigated fish fauna in the stretch of the Shatt Al-

Arab River situated between Garmat Ali and Abu Al-Khasib districts[5,6,8,9]. All those surveys indicated occurrence of several marine species. Mohamed *et al.* listed 40 species, 25 of them were marine fish and 6 are foreign[12]. However, the present work reported higher proportion of marine species (32 species) and alien (10 species) in this location compared to previous works. Detectable number of migratory marine species found to enter the river to feed, reproduce or nursing. This phenomenon coincides with the most researchers as[8-10].

Conflict of interest statement

We declare that we have no conflict of interest.

Comments

Background

Changes in parameters of water quality and their relation with biodiversity indices are crucial to evaluate fish biodiversity in riverbed. Five major threats to biodiversity are invasive alien species, climatic changes, nutrient leading to pollution, habitat changes and overexploitation of the stock.

Research frontiers

This is a research on the fish situation from the area of gulf which has been limited touched by previous investigations. The work is original and warranted for publication.

Related reports

There are some similar reports from the other regions of the world but it is extremely limited in the studied area, the Gulf of Iraq.

Innovations and breakthroughs

The present study provides new data and information from the area where there is extremely limited data.

Applications

The work can be a good database and applied for citation in the future study in this field.

Peer review

This is a good report in coastal science on the fish population from Gulf of Iraq. This report contains new knowledge and information from the area which is still an unknown foci of the world. The work can be further referenced in the field. This work also shows some interesting new technique that can be the model for further study in fish study in other areas of the world.

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