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The Composition and Diversity Indices of the Fish Assemblage in the Tidal Mudflats of the Shatt Al-Arab Estuary in the Northwest Arabian Gulf

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Abstract: Ten thousand four hundred and thirty-five fish were collected from January 2021 to February 2022, belonging to 71 species distributed across 39 families and 20 orders. The study included the tidal zone of the Shatt al-Arab estuary in the northwest of the Arabian Gulf. Two methods used to collection the fishes; fixed gill nets and trowel nets. Various diversity indices, relative abundance, and richness were assessed. Several biodiversity indices were used to assess the area biologically and ecologically which Species diversity for Shannon and Simpson, species richness for Margalef and Menhinick, dominance for Berger-Parker, species similarity for Jaccard, numerical similarity for Bray – Curtis, and evenness for Peilou index. *Nematalosa nasus* had the highest relative abundance, which was recorded at 24.53%. However, the lowest relative abundance was observed for 20 species, with a value of 0.01% with only one individual. The Carangiformes had the highest percentage of 18.31% and the lowest percentage of 1.41 % for many orders only, with one species recorded. The Margalef index had its highest value on June 5.24 and its lowest on December 1.24. The Menhinick index had its highest value of 1.53 in October and its lowest value of 0.71 in November. The Shannon Index reached a peak of 2.69 in January 2021, and fell to 0.98 in September. The Simpson index recorded the highest value of 0.92 in January 2021 and the lowest value of 0.37 in September. The Peilou index reached its highest value of 0.965 in December, while its lowest value was 0.294 in September. The Jaccard index had its highest value of 0.667 between January 2021 and March, while its lowest value was 0.079 between December, June, and July. The highest value for the Bray-Curtis index occurred between July and August, reaching 0.644. In contrast, the lowest value observed was 0.005 between July and December.

Keywords: Diversity, Dominance, Evenness, Occurrence, Richness, Similarity.

Introduction

The Arabian Gulf is a shallow, semi-enclosed gulf (Al-Faisal & Mutlak, 2018) that is biologically poor because of its ecological and geographic characteristics. It is also geologically recent (Jabado *et al*., 2015), as it was completely dry 20000 years ago during the late Pleistocene Ice Age (Esmaeili *et al*., 2014). Its length is approximately 1000 km, and its width varies between 200 km and 300 km, with a maximum depth of 110 m and an average depth of 36 m (Evans, 2023). Due to their sedimentary nature, the most prevalent habitats in the Arabian Gulf are sandy and mud bottoms. These habitats range from intertidal salt mud marshes to the greatest depth and make up over 97% of the floor of the Arabian Gulf (Al-Ghadban, 2002). Furthermore, due to the shallowness of the waters in the Arabian Gulf and the impact of the tidal phenomenon, extensive areas are exposed during the tide period. These areas are characterized by either a short slope of a few meters or very gradual slopes that extend several kilometers from the shore (Sheppard, 1993). The northern shores of the Arabian Gulf are characterized by large-scale mud flats that may be exposed to 15 km during the fall of sea levels near the mouth of the Shatt al-Arab (Almahmood, 2023). The northwestern coast of the Arabian Gulf is also characterized by semidiurnal tides with two amphidromic points (Siddig *et al*., 2019).

Shallow intertidal habitats are essential to larvae and juvenile fish (Al-Shamary & Younis, 2022). Also, it serves as a refuge that reduces predation risk, growth, and feeding area (Haak, 2019). In contrast, feeding areas are considered large fish acclimated to shallow water and other big-body fish during high tide (Tobin *et al.,* 2014).

Many studies have been conducted on fish diversity in the intertidal zones of the Arabian Gulf and Gulf of Oman, including those by Smith (1959a, b), Murdy (1989), Wright *et al*. (1990), Abou-Seedo (1990), Springer & Williams (1994), Randall *et al.* (1994), Randall (1995), Ghanbarifardi & Malek (2006), and Ghanbarifardi & Zarei (2021), but only one study has focused on the Iraqi tidal zone by Hussain *et al*. (1999).

Aim of the study

Study of fish composition and diversity on the Shatt Al-Arab Estuary Tidal Mudflats in the Northwest Arabian Gulf.

Material & Methods

Study area description

The study was conducted from January 2021 to February 2022 for a period of 13 months in the tidal zone in the northwest Arabian Gulf. It extends from the Shatt al-Arab Estuary in the east (N:29°53'49″, E:48°38'16") to the wave breaker of Al-Faw Al-Kabir port in the west (N:29°53'21", E:48°30'17"), and in the south it reached (N:29°50'25", E:48°37'2") The study area is characterized by being a tidal area that is submerged during high tide and exposed during low tide, up to 15 km during the lowest tide near the Shatt Al-Arab estuary (Almahmood, 2023) (Fig. 1).

Two methods were used in this study to collect fish: fixed gill nets with 750 m long; 2 m height. For this purpose, five net mesh sizes were used: 20, 30, 40, 50 and 60 mm to ensure the collection of most sizes of fish coming to the area, at a distance of 150 meters for each size. The second method was trawl net with 5 m opening diameter. The study area was suitable for using a fiberglass boat that was 8m long, 120cm wide, and 75cm deep, equipped with a 28 hp Yamaha engine. Samples were collected during a single diurnal period. The samples were stored in an ice box where they were subsequently examined in the laboratory. Several biodiversity indices and relative abundances were used in this study:

Relative Abundance (Krebs, 2014)

$$i = \frac{ni}{N}$$

Margalef index of richness (Margalef, 1958)

$$D = (S - 1) / \ln(N)$$

Menhinick index of richness (Menhinick, 1964)

$$D_{Mn} = S/\sqrt{N}$$

Berger-Parker index of dominance (Berger & Parker, 1970)

$$d = n_{max} / N$$

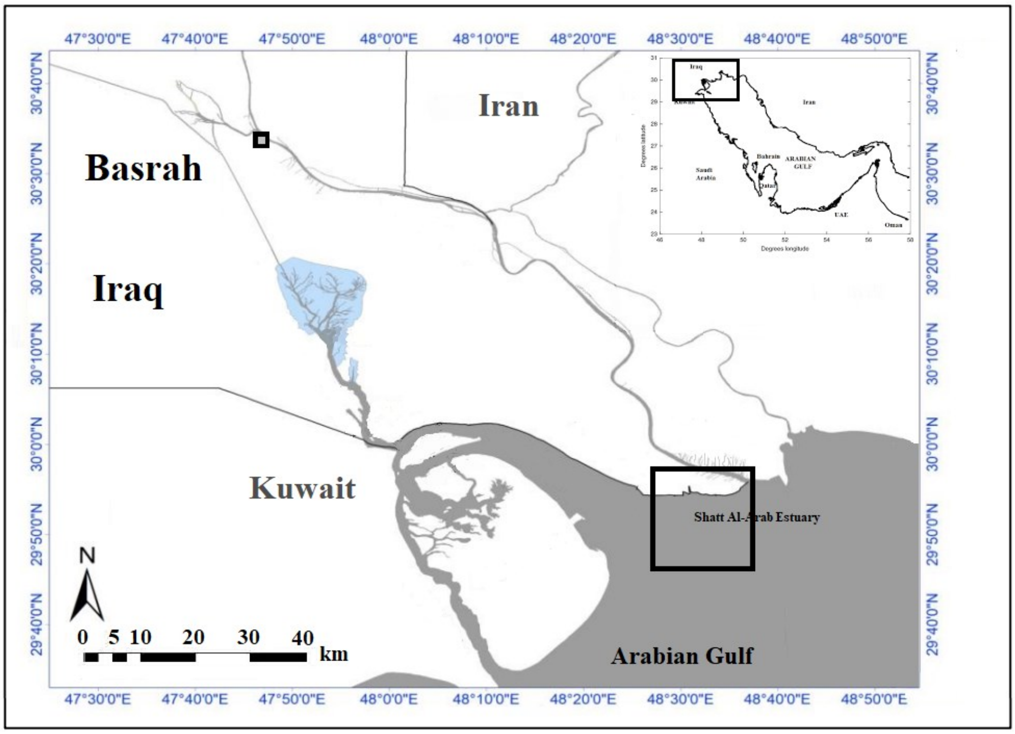

Fig. (1): Study area (modified map from google).

Shannon-Wiener index of diversity (Shannon-Wiener, 1949)

$H' = -\Sigma \text{ pi In pi}$

Simpson Index of diversity (Simpson, 1949)

$D = 1 - \Sigma \text{ pi}^2$

Peilou index of evenness (equivalence) (Peilou, 1966) $J = {H'}/{\ln s}$

Jaccard species index of similarity (Jaccard, 1912) $S_j = c / (a + b + c)$

Bray – Curtis index of numerical similarity (Bray & Curtis, 1957) $B = 1 - \frac{\sum_{i=1}^{n} |X_{ij} - X_{ik}|}{\sum_{i=1}^{n} (X_{ij} + X_{ik})}$

Tyler for resident seasonal and rare species (Tyler, 1971)

Statistical software:

1-Microsoft Excel software.

2-PAST: Paleontological Statistics Software package for education and data analysis.

The following References for identification and classification of fish:

Fischer and Bianchi (1984), Carpenter *et al.* (1997), Fricke *et al.* (2023) and Froese & Pauly (2023).

Results

A total of 10435 individuals were collected and categorized into 71 species, further classified into 39 families and 20 orders. Among these, only 54 individuals were identified as belonging to eight cartilaginous species distributed across five families and four orders (Table, 1).

Because the area has a fish population that reaches commercial numbers in some species, the relative abundance of species varied greatly, so the highest relative abundance was recorded for *N. nasus*, 24.53%, with 2560 individuals, and the lowest was for 20 species that recorded a close lot of 0.01%, due to only one individual of each species during the study period (Table, 2). The percentage of the orders also varied, as Carangiformes recorded the highest relative abundance at 18.31% with 12 species, Acanthuriformes at 16.9% with 12 species, and Clupeiformes with a relative abundance of 15.49% with 11 species.

Table. (1): The recorded fish species with orders and families Rearrange according to Frike *et al.* (2023).

Class: Elasmobranchii		
Order	**Family**	**Species**
Orectolobiformes	Hemiscylliidae	*Chiloscyllium arabicum*
Carcharhiniformes	Carcharhinidae	*Rhizoprionodon oligolinx*
Rhinopristiformes	Glaucostegidae	*Glaucostegus granulatus*
Myliobatiformes	Dasyatidae	*Brevitrygon imbricata*
		Brevitrygon walga
		Himantura uarnak
		Maculabatis randalli
	Aetobatidae	*Aetobatus flagellum*
Class: Actinopteri		
Anguilliformes	Muraenesocidae	*Muraenesox cinereus*
Clupeiformes	Engraulidae	*Thryssa hamiltonii*
		Thryssa whiteheadi
	Dorosomatidae	*Anodontostoma chacunda*
		Nematalosa nasus
		Sardinella albella
		Tenualosa ilisha
	Chirocentridae	*Chirocentrus dorab*
		Chirocentrus nudus
	Dussumieriidae	*Dussumieria acuta*
	Pristigasteridae	*Ilisha compressa*
		Ilisha melastoma
Siluriformes	Plotosidae	*Plotosus lineatus*
	Ariidae	*Netuma thalassina*
		Plicofollis layardi
Aulopiformes	Synodontidae	*Saurida tumbil*
Batrachoidiformes	Batrachoididae	*Colletteichthys dussumieri*
Scombriformes	Scombridae	*Scomberomorus commerson*
		Scomberomorus guttatus
	Trichiuridae	*Eupleurogrammus muticus*
Syngnathiforme	Mullidae	*Upeneus doriae*
		Upeneus tragula
	Callionymidae	*Callionymus erythraeus*
Gobiiformes	Gobiidae	*Acentrogobius dayi*
		Boleophthalmus dussumieri
		Trypauchen vagina
Carangiformes	Polynemidae	*Eleutheronema tetradactylum*

	Soleidae	*Brachirus orientalis* *Solea elongata*
	Cynoglossidae	*Cynoglossus arel* *Cynoglossus bilineatus*
	Carangidae	*Alepes djedaba* *Alepes kleinii* *Alepes melanoptera* *Carangoides bajad* *Scomberoides commersonnianus* *Scomberoides tol* *Trachinotus mookalee*
	Rachycentridae	*Rachycentron canadum*
Cichliformes	Cichlidae	*Oreochromis niloticus*
Beloniformes	Belonidae	*Strongylura leiura* *Strongylura strongylura*
Mugiliformes	Mugilidae	*Planiliza klunzingeri* *Planiliza subviridis* *Osteomugil speigleri*
Perciformes	Platycephalidae	*Platycephalus indicus*
	Synanceiidae	*Pseudosynanceia melanostigma*
Centrarchiformes	Terapontidae	*Terapon puta* *Terapon theraps*
Acanthuriformes	Sillaginidae	*Sillago arabica* *Sillago sihama*
	Haemulidae	*Pomadasys maculatus* *Pomadasys stridens*
	Sparidae	*Crenidens crenidens* *Sparidentex hasta* *Acanthopagrus arabicus*
	Sciaenidae	*Johnius belangerii* *Johnius borneensis* *Otolithes ruber*
	Leiognathidae	*Photopectoralis bindus*
	Scatophagidae	*Scatophagus argus*
Tetraodontiformes	Triacanthidae	*Triacanthus biaculeatus*
	Tetraodontidae	*Lagocephalus lunaris*

The percentage of the other orders continued to the lowest percentage of 1.41%, with only one species. The orders were Carcharhiniformes, Orectolobiformes, Rhinopristiformes, Anguilliformes, Aulopiformes, Batrachoidiformes, Callionymiformes, and Cichliformes (Fig. 2). The results of the common or resident fish species in the study area were only 21.13%, while seasonal species accounted for 25.35%, and occasional or rare species accounted for 53.52% (Fig. 3; Table 2).

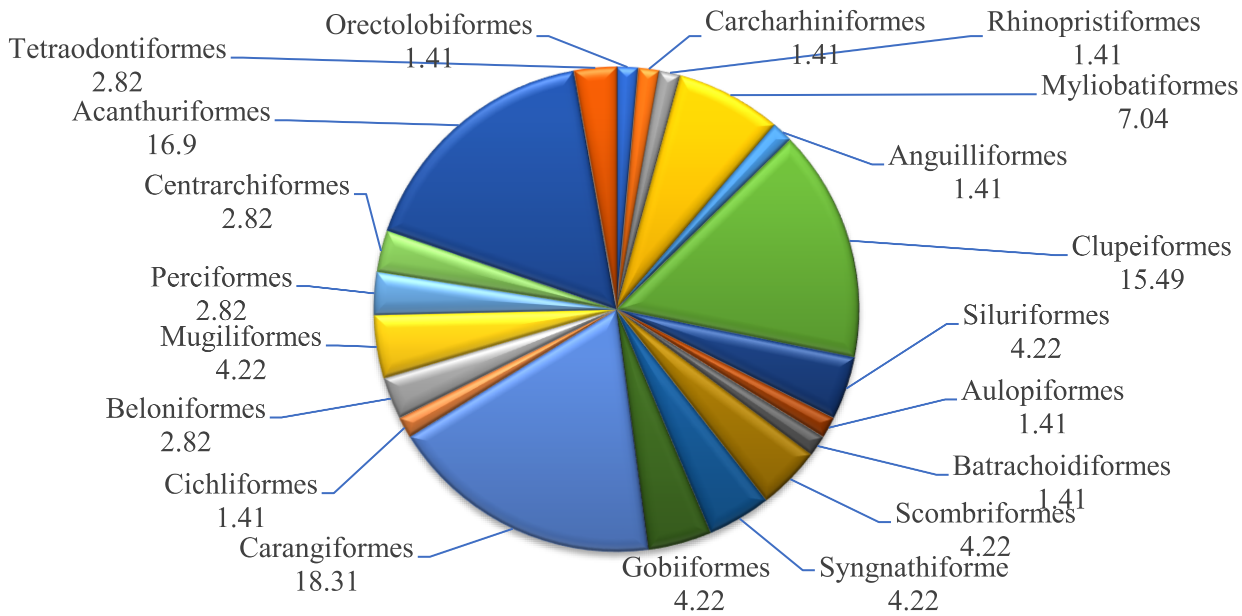

Fig. (2): The percentage values of fish orders recorded during the study period.

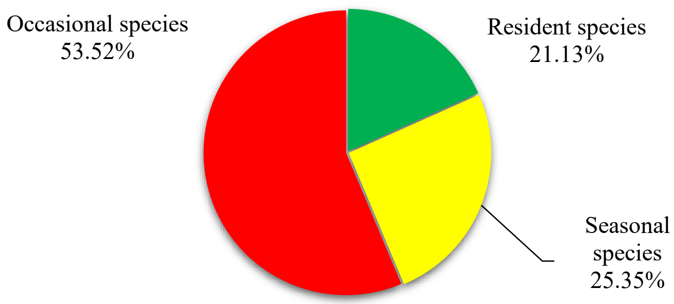

Fig. (3): Distribution of monthly occurence of fish species during the study period.

Table (2): Fish species numbers with monthly occurrence for Tyler and relative abundance during the study period.

Scientific name	Jan. 21	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan. 22	Total No.	R. A. %
Chiloscyllium arabicum	red									red				8	0.08
Rhizoprionodon oligolinx								red						1	0.01
Glaucostegus granulatus				red		red	red	red						24	0.23
Brevitrygon imbricata			red			red								5	0.05
Brevitrygon walga				red						red	red			4	0.04
Himantura uarnak							red							1	0.01
Maculabatis randalli					yellow	yellow	yellow	yellow			yellow			11	0.11

Aetobatus flagellum	1	0.01
Muraenesox cinereus	1	0.01
Thryssa hamiltonii	672	6.44
Thryssa whiteheadi	5	0.05
Anodontostoma chacunda	28	0.27
Nematalosa nasus	2560	24.53
Sardinella albella	81	0.78
Tenualosa ilisha	1528	14.64
Chirocentrus nudus	4	0.04
Chirocentrus dorab	1	0.01
Dussumieria acuta	16	0.15
Ilisha compressa	35	0.33
Ilisha melastoma	4	0.04
Plotosus lineatus	1	0.01
Plicofollis layardi	277	2.65
Netuma thalassina	51	0.49
Saurida tumbil	7	0.07
Colletteichthys dussumieri	1	0.01
Scomberomorus commerson	2	0.02
Scomberomorus guttatus	1	0.01
Eupleurogrammus muticus	10	0.1
Upeneus doriae	30	0.29
Upeneus tragula	1	0.01
Callionymus erythraeus	3	0.03
Acentrogobius dayi	5	0.05
Boleophthalmus dussumieri	23	0.22
Trypauchen vagina	1	0.01
Eleutheronema tetradactylum	6	0.06
Brachirus orientalis	89	0.85
Solea elongata	445	4.26
Cynoglossus arel	138	1.32
Cynoglossus bilineatus	49	0.47
Alepes djedaba	5	0.05
Alepes kleinii	93	0.89
Alepes melanoptera	1	0.01
Carangoides bajad	1	0.01
Scomberoides commersonnianus	206	1.97
Scomberoides tol	1	0.01
Trachinotus mookalee	1	0.01
Rachycentron canadum	1	0.01
Oreochromis niloticus	2	0.02
Strongylura leiura	4	0.04
Strongylura strongylura	12	0.12
Planiliza klunzingeri	280	2.68
Planiliza subviridis	130	1.24
Osteomugil speigleri	278	2.66
Platycephalus indicus	121	1.16
Pseudosynanceia melanostigma	121	1.16
Terapon puta	28	0.27
Terapon theraps	12	0.11

Sillago arabica	16	0.15
Sillago sihama	182	1.74
Pomadasys maculatus	1	0.01
Pomadasys stridens	1	0.01
Crenidens crenidens	1	0.01
Sparidentex hasta	1	0.01
Acanthopagrus arabicus	16	0.15
Johnius belangerii	435	4.17
Johnius borneensis	5	0.05
Otolithes ruber	19	0.18
Photopectoralis bindus	2249	21.55
Scatophagus argus	6	0.06
Triacanthus biaculeatus	75	0.72
Lagocephalus lunaris	1	0.01

Common or resident species	(9-12 months)	15 species
Seasonal species	(5-8 months)	18 species
Occasional species	(1-4 months)	38 species

Several biodiversity indices were calculated, including the Margalef and Menhinick richness indices. The study revealed that the Margalef index reached its highest value on June 5.25, with 38 species and 1145 individuals. Conversely, its lowest value was observed on December 1.24, with only three species and five individuals. On the other hand, the Menhinick index peaked at 1.53 in October, with 32 species and 445 individuals. In contrast, its lowest value of 0.71 was recorded in November, with 27 species and 141 individuals (Fig. 4).

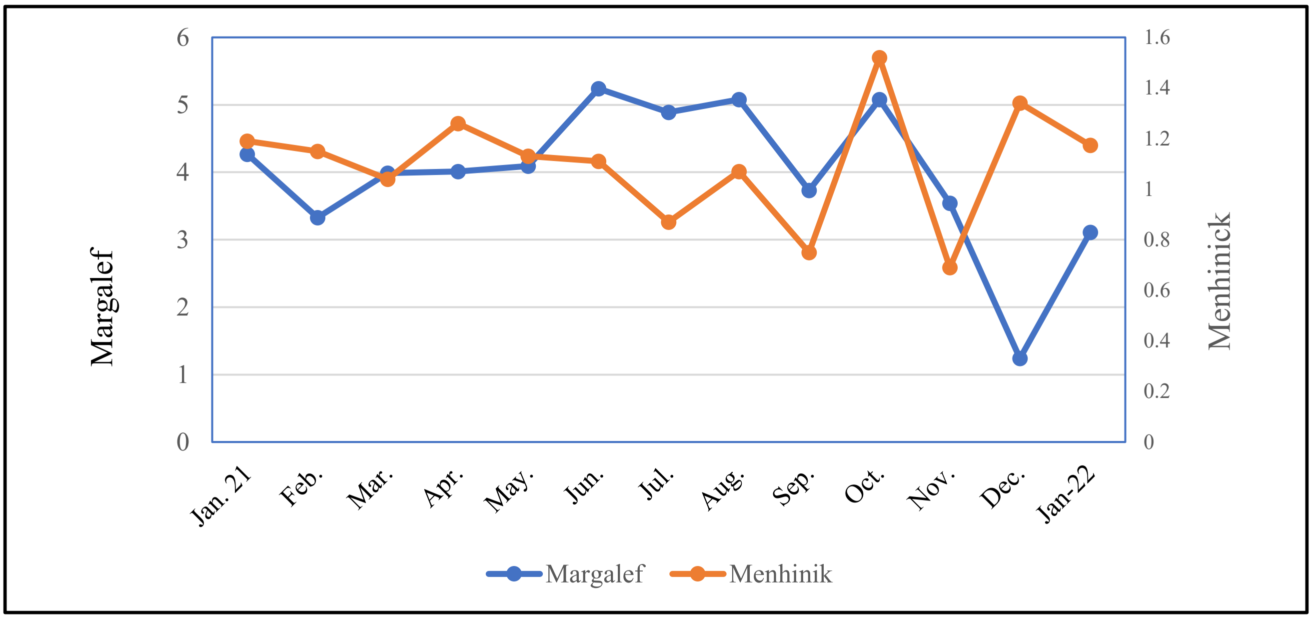

Fig. (4): The Margalef and Menhinick richness indices values of fish assemblage during the study months.

The Berger-Parker index was used to calculate dominance, and the results indicated uneven dominance among fish species. In January 2021, the dominance was for *T.*

hamiltonii with a value of 0.143. In February, the dominance was for *T. ilisha* with a value of 0.245. In March, the dominance was for *T. hamiltonii* with a value of 0.0.395. In April and May, the dominance was for *P. bindus*, with a value of 0.264 and 0.348, respectively. In June, the dominance was for *S. elongate* with a value of 0.232. In July, the dominance of *T. ilisha*, with a value of 0.459. In August, the dominance also returned to *P. bindus* with a value of 0.269. In September and October, the dominance of *N. nasus* with a value of 0.789 and 0.384, respectively. In November, the dominance of *P. bindus* returned with a value of 0.527. In December 2021 and January 2022, the dominance of *P. klunzingeri* was observed with values of 0.4 and 0.44, respectively (Fig. 5).

The Shannon-Wiener Index reached its highest value of 2.69 in January 2021, with 28 species and 581 individuals and its lowest value of 0.98 in September, with 28 species and 1441 individuals. In same condition The Simpson Index reached a high of 0.92 in January 2021 and a low of 0.37 in September (Fig. 6).

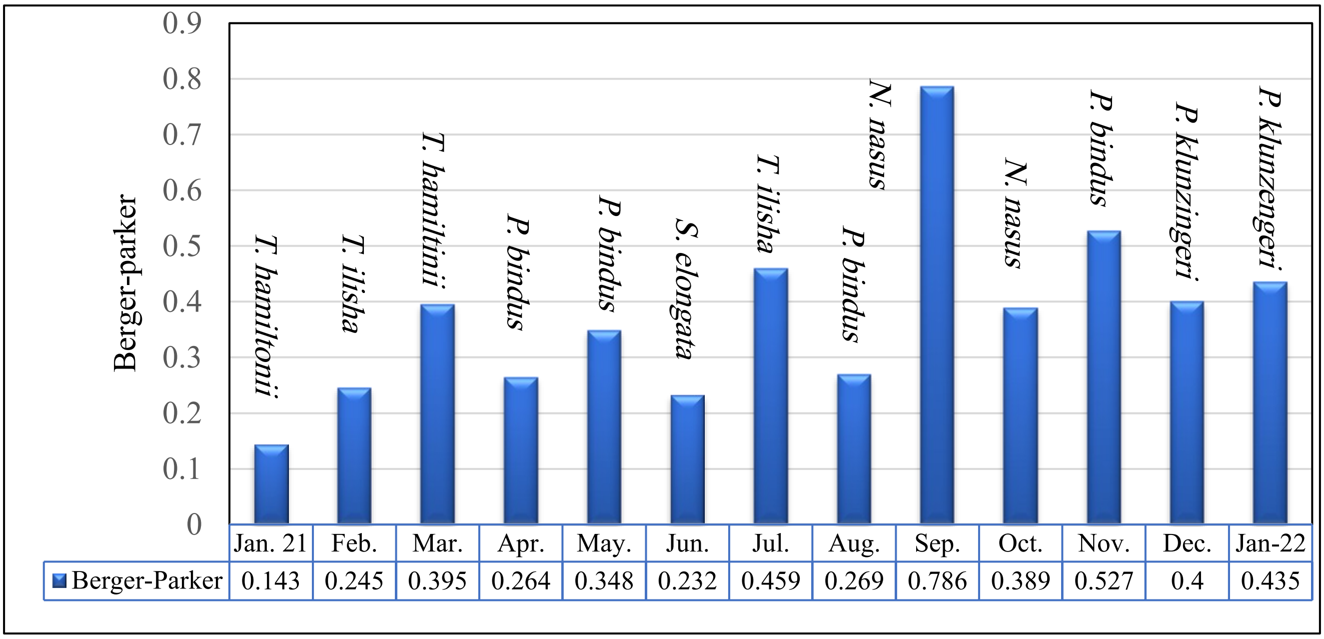

Fig. (5): Berger-Parker dominance values of fish assemblage during the study months.

The Shannon-Wiener Index reached its highest value of 2.69 in January 2021, with 28 species and 581 individuals and its lowest value of 0.98 in September, with 28 species and 1441 individuals. In same condition The Simpson Index reached a high of 0.92 in January 2021 and a low of 0.37 in September (Fig. 6). The Peilou index was found that the highest value was 0.965 in December, when the number of species was three and the number of individuals was five, while the lowest value of the index was 0.294 in September, when the number of individuals was 1441 distributed over 28 species (Fig. 7).

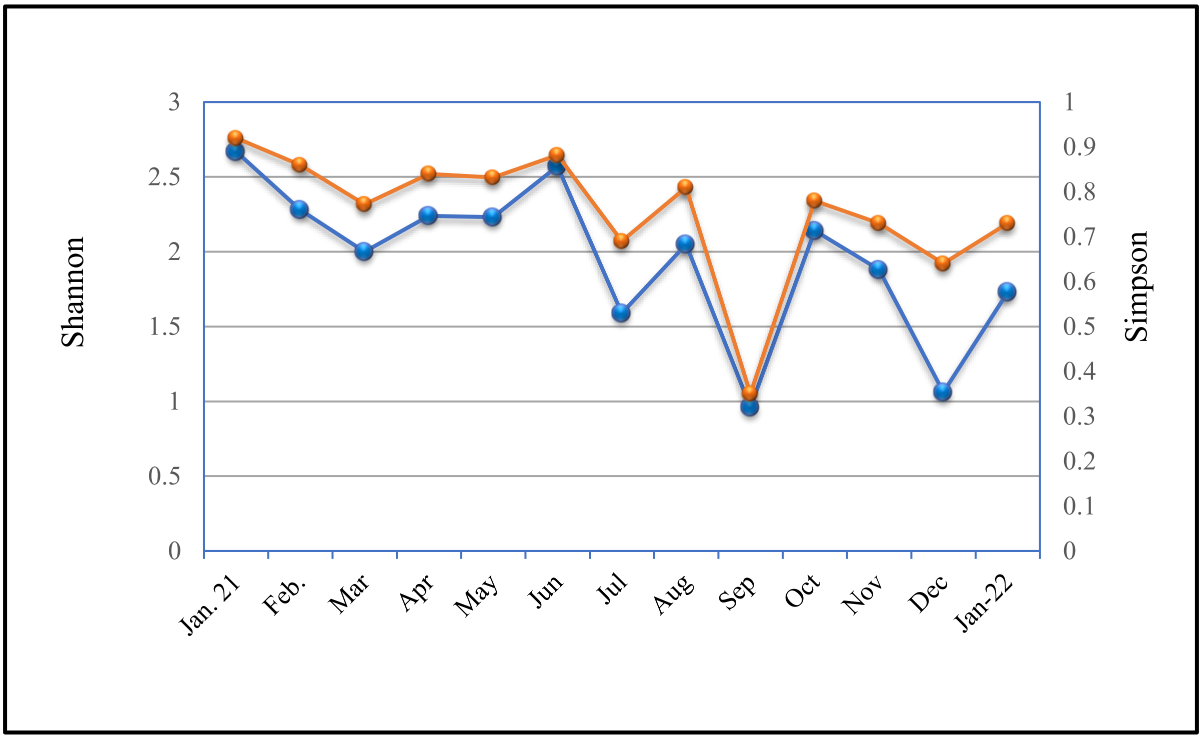

Fig. (6): Shannon and Simpson diversity values of fish assemblage during the study months.

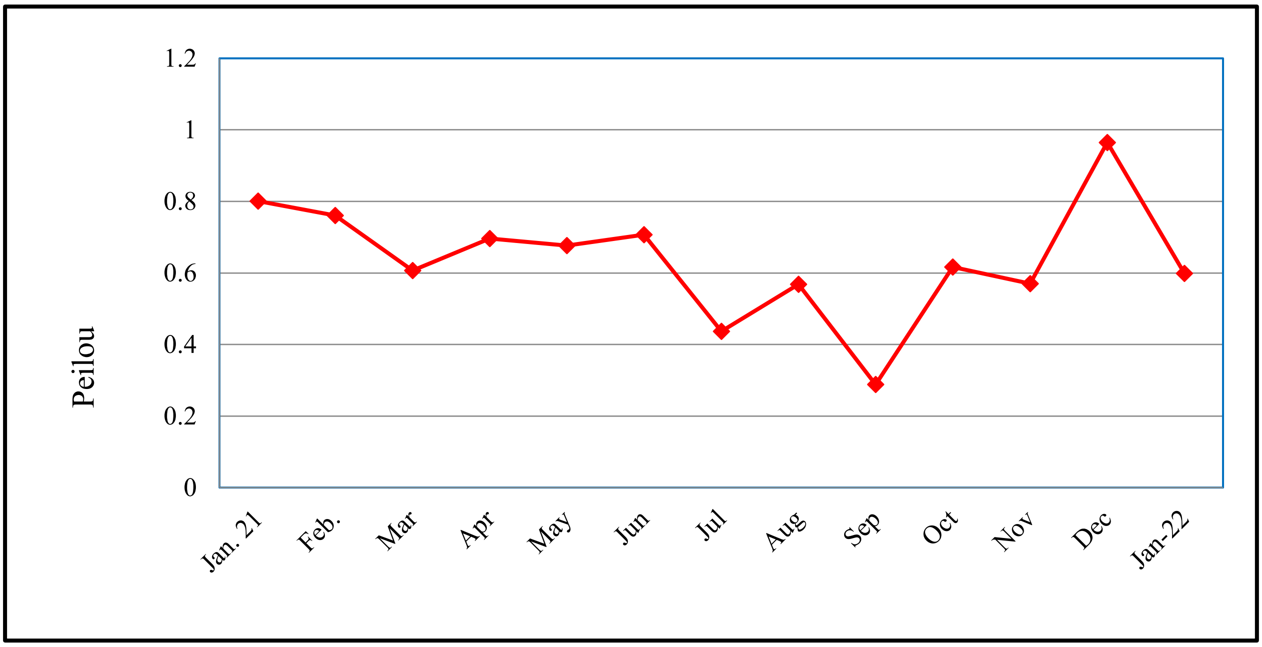

Fig. (7): Peilou evenness values of fish assemblage during the study months.

According to the species similarity between the months as measured by the Jaccard index. The highest value was recorded between January and March 2021, when it reached 0.667 with a total of 32 species and 21 common species; whereas the lowest value was 0.079 with a total of 38 species and three common species between December, June, and July (Table 3).

Table (3): Jaccard species similarity values of fish assemblage during the study months.

	Jan.1	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.2
Jan. 21	1												
Feb.	0.600	1											
Mar.	0.667	0.567	1										
Apr.	0.432	0.364	0.368	1									
May	0.410	0.306	0.317	0.625	1								
Jun.	0.535	0.381	0.548	0.400	0.444	1							
Jul.	0.435	0.289	0.413	0.432	0.444	0.551	1						
Aug.	0.512	0.390	0.455	0.476	0.524	0.531	0.596	1					
Sep.	0.514	0.371	0.410	0.432	0.486	0.500	0.467	0.512	1				
Oct.	0.429	0.333	0.341	0.462	0.457	0.489	0.489	0.533	0.538	1			
Nov.	0.486	0.516	0.421	0.529	0.500	0.512	0.477	0.561	0.571	0.639	1		
Dec.	0.107	0.150	0.111	0.120	0.111	0.079	0.079	0.081	0.107	0.094	0.111	1	
Jan. 22	0.406	0.480	0.364	0.355	0.333	0.279	0.273	0.317	0.361	0.289	0.375	0.167	1

Regarding the Bray-Curtis index of numerical similarity, the highest value was recorded between July and August, with 0.644, while the lowest value was recorded between July and December, with 0.005 (Table 4).

Tab. (4): Bray – Curtis numerical similarity values of fish assemblage during the study months.

	Jan.1	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.2
Jan. 21	1												
Feb.	0.553	1											
Mar.	0.445	0.369	1										
Apr.	0.441	0.181	0.306	1									
May	0.267	0.100	0.166	0.626	1								
Jun.	0.368	0.270	0.390	0.325	0.293	1							
Jul.	0.212	0.146	0.253	0.240	0.292	0.287	1						
Aug.	0.296	0.219	0.394	0.355	0.399	0.387	0.644	1					
Sep.	0.208	0.089	0.113	0.286	0.264	0.253	0.341	0.397	1				
Oct.	0.335	0.214	0.235	0.583	0.511	0.357	0.321	0.475	0.391	1			
Nov.	0.285	0.131	0.152	0.248	0.351	0.322	0.364	0.402	0.212	0.327	1		
Dec.	0.018	0.026	0.012	0.020	0.017	0.008	0.005	0.008	0.006	0.018	0.006	1	
Jan. 22	0.389	0.250	0.177	0.286	0.109	0.123	0.063	0.102	0.089	0.133	0.172	0.033	1

Discussion

Estuarian mudflats are very limited in the Arabian Gulf to the northwestern delta of the Shatt Al-Arab River in Iraq and the Zohreh River in Iran. Previous studies on fish in the intertidal zones of the Iraqi coast were limited. One study by Hussain *et al.* (1999) on fish tidal migration in the western mudflats of the Shatt Al-Arab Estuary and Khor Abdullah.

Several other studies have focused on the biodiversity of fishes in open waters that are located away from intertidal mudflats. Several previous studies were conducted on fish migration in non-estuarine mudflats in Kuwait and Iran (Wright *et al*., 1990; Abou-Seedo *et al*., 1990; Ghanbarifardi & Malek, 2006).

There is a difference in the number of species collected in the present study (71), and that reported (29) by Hussain *et al*. (1999). This could be because the sampling area was located west of the Shatt Al-Arab estuary, which included Khore Abdullah, and had a higher salinity level with 19 common species recorded. There is also a difference between the number of species and the number of non-estuarine fish studies, primarily conducted on Kuwaiti mudflats, as mentioned by Wright *et al.* (1990). In the present study, 19 common species were identified, 43. Abou-Seedo *et al*. (1990) mention 14 as common out of 35.

A total of 109 fish species were recorded in current and previous studies in the intertidal mudflats. Only 32 species were found in the estuarine mudflats, while the remaining were observed in the non-estuarine mudflats (Table 5).

Table (5): Species recorded in current and previous studies in Iraq and Kuwait.

Order	Family	Species	Abou-Seedo *et al*. (1990)	Wright *et al*. (1990)	Hussain *et al*. (1999)	Current study
Orectolobiformes	Hemiscylliidae	*Chiloscyllium arabicum*	-	-	-	+
Carcharhiniformes	Carcharhinidae	*Rhizoprionodon oligolinx*	-	-	-	+
		Scoliodon laticaudus	-	+	-	-
Rhinopristiformes	Rhinidae	*Rhynchobatus djiddensis*	-	+	-	-
	Glaucostegidae	*Glaucostegus granulatus*	-	-	-	+
Myliobatiformes	Dasyatidae	*Brevitrygon imbricata*	-	+	-	+
		Brevitrygon walga	-	-	-	+
		Himantura uarnak	-	-	-	+
		Maculabatis randalli	-	-	-	+
	Gymnuridae	*Gymnura poecilura*	+	+	-	-
	Aetobatidae	*Aetobatus flagellum*	-	-	-	+
Anguilliformes	Muraenesocidae	*Muraenesox cinereus*	-	-	-	+
Clupeiformes	Engraulidae	*Thryssa hamiltonii*	+	+	-	+
		Thryssa whiteheadi[a]	-	+	+	+
	Dorosomatidae	*Anodontostoma chacunda*	-	-	-	+
		Nematalosa nasus	+	+	+	+
		Sardinella albella	-	-	+	+
		Sardinella gibbosa	+	-	-	-
		Tenualosa ilisha	-	-	+	+
	Chirocentridae	*Chirocentrus dorab*	-	-	+	+
		Chirocentrus nudus	-	-	+	+
	Dussumieriidae	*Dussumieria acuta*	-	-	-	+
	Pristigasteridae	*Ilisha compressa*	-	-	-	+
		Ilisha megaloptera	-	-	+	-

		Ilisha melastoma	+	+	-	+
Siluriformes	Plotosidae	*Plotosus lineatus*	-	+	-	+
	Ariidae	*Netuma thalassina*	-	-	-	+
		Netuma bilineata	-	-	-	-
		Plicofollis layardi	+	-	-	+
Aulopiformes	Synodontidae	*Saurida tumbil*	-	-	-	+
Batrachoidiformes	Batrachoididae	*Colletteichthys dussumieri*	-	-	-	+
		Allenbatrachus grunniens	+	-	-	-
Scombriformes	Stromateidae	*Pampus argenteus*	-	-	+	-
	Scombridae	*Scomberomorus commerson*	-	-	-	+
		Scomberomorus guttatus	-	-	-	+
	Trichiuridae	*Eupleurogrammus muticus*	-	-	-	+
		Eupleurogrammus glossodon	+	+	-	-
Syngnathiforme	Mullidae	*Upeneus doriae*	-	-	-	+
		Upeneus tragula	-	-	-	+
	Callionymidae	*Callionymus erythraeus*	-	-	-	+
		Callionymus hindsii	-	+	-	-
Kurtiformes	Apogoninae	*Apogonichthyoides uninotatus* [b]	+	+	-	-
Gobiiformes	Gobiidae	*Acentrogobius dayi*	-	-	-	+
		Bathygobius fuscus	+	-	-	-
		Periophthalmus barbarus [c]	+	+	-	-
		Periophthalmus dentatus	-	-	+	-
		Boleophthalmus dussumieri	-	-	-	+
		Istigobius ornatus	+	+	-	-
		Trypauchen vagina	-	-	-	+
		Acentrogobius cyanomos	-	+	-	-
		Apocryptodon madurensis [d]	+	+	-	-
		Scartelaos histophorus	+	+	-	-
		Cryptocentrus lutheri	-	-	+	-
		Yongeichthys criniger	+	-	-	-
Carangiformes	Polynemidae	*Eleutheronema tetradactylum*	-	-	+	+
		Polydactylus sextarius	-	+	-	-
	Paralichthyidae	*Pseudorhombus arsius*	-	+	+	-
	Soleidae	*Brachirus orientalis*	-	+	+	+
		Solea elongata	+	+	-	+
	Carangidae	*Caranx sexfasciatus*	-	+	-	-
	Cynoglossidae	*Cynoglossus arel*	-	+	+	+
		Cynoglossus bilineatus	-	-	-	+
	Carangidae	*Alepes djedaba*	-	-	+	+
		Alepes kleinii	-	-	-	+
		Alepes melanoptera	-	-	-	+
		Carangoides bajad	-	-	-	+
		Scomberoides commersonnianus	-	-	-	+
		Scomberoides tol	-	-	-	+
		Trachinotus mookalee	-	+	-	+

	Rachycentridae	*Rachycentron canadum*	-	-	-	+
Cichliformes	Cichlidae	*Oreochromis niloticus*	-	-	-	+
Cyprinodontiformes	Cyprinodontidae	*Aphaniops stoliczkanus*[e]	+	-	-	-
Beloniformes	Belonidae	*Strongylura leiura*	-	-	-	+
		Strongylura strongylura	+	-	-	+
		Hemiramphus marginatus	+	+	-	-
Mugiliformes	Mugilidae	*Planiliza klunzingeri*	-	-	-	+
		Planiliza carinata	+	+	+	-
		Planiliza subviridis	+	-	+	+
		Osteomugil speigleri	-	-	-	+
Perciformes	Platycephalidae	*Platycephalus indicus*	-	+	+	+
		Grammoplites scaber	-	+	-	-
	Synanceiidae	*Pseudosynanceia melanostigma*	+	+	+	+
Centrarchiformes	Terapontidae	*Terapon puta*	+	+	+	+
		Terapon theraps	-	-	-	+
Acanthuriformes	Sillaginidae	*Sillago arabica*	-	-	-	+
		Sillago sihama	+	+	+	+
	Gerreidae	*Gerres oyena*	+	-	-	-
	Haemulidae	*Pomadasys argenteus*	+	-	-	-
		Pomadasys maculatus	-	+	-	+
		Pomadasys stridens	+	+	-	+
	Sparidae	*Crenidens crenidens*	-	-	-	+
		Sparidentex hasta	-	-	-	+
		Acanthopagrus arabicus	+	+	+	+
		Acanthopagrus berda	+	+	-	-
		Diplodus kotschyi	+	-	-	-
	Sciaenidae	*Pennahia aneus*	-	+	-	-
	Sciaenidae	*Johnius belangerii*	+	+	+	+
		Johnius borneensis	-	-	+	+
		Protonibea diacanthus	-	-	+	-
		Otolithes ruber	+	+	+	+
	Leiognathidae	*Nuchequula gerreoides*	+	+	-	-
		Photopectoralis bindus	-	-	+	+
	Ephippidae	*Ephippus orbis*	-	-	+	-
	Scatophagidae	*Scatophagus argus*	-	+	+	+
		Scatophagus tetracanthus[C]	-	+	-	-
Tetraodontiformes	Triacanthidae	*Pseudotriacanthus strigilifer*	+	+	-	-
		Triacanthus biaculeatus	-	-	-	+
	Tetraodontidae	*Lagocephalus lunaris*	-	-	-	+
		Chelonodontops patoca	+	+	-	-
Total number of species			35	43	29	71

[a] *T. mystax* considered here *T. whiteheadi* (See Carpenter *et al*., 1997; Ali *et al*., 2018)
[b] Record from the Persian (=Arabian) Gulf needs confirmation (Froese & Pauly, 2023)
[c] This species is not distributed in the Arabian Gulf (Froese & Pauly, 2023)
[d] questionable record from Kuwait (Froese & Pauly, 2023).
[e] *Aphaniops stoliczkanus* reported as *Aphanius dispar* in Shatt Al-Arab river and marine waters (Freyhof *et al*., 2021)

The main reasons for attracting fish species to the Shatt Al-Arab Estuary are the mudflats' high productivity and shallowness. The results obtained in this study indicate that estuary mudflats serve as nursery grounds for several species. They also provide shelter from big predators such as *T. hamiltoni*, *P. bindus, S. elongata*, and *P. layardi*. Additionally, these mudflats serve as feeding grounds for commercial species like *N. nasus, T. ilisha,* and Mugillidae species (Al-Shamary & Younis, 2022). The abundance of commercial species resulted in a dominance of certain species in the area, such as *N. nasus* in September, with 1134 individuals out of 1441 and a Burger-Parker index of 0.786.

Applying various biodiversity indices for fish populations in the intertidal zone of the northern Arabian Gulf aims to quantify the nature and seasonal changing components of fish populations in shape of mathematical numbers to facilitate the comparison during study months and also with future studies in the same or close to the area that are concerned with the diversity of species, their richness, and the dominance of individuals during daily ,monthly and yearly movements to the tidal zone by inhabiting marine fish species.

The intertidal mudflats of Shatt Al-Arab displayed a monthly and seasonal dominance of one or several species. This dominance, in turn, impacted the Shannon-Wiener and Simpson diversity indices. Monthly or seasonal dominance has a negative impact on the Shannon-Wiener and Simpson diversity indices, resulting in lower values in September (0.98 and 0.37, respectively). These shared values may be attributed to dominance (Berger-Parker, 0.786). Similarly, the Palou evenness index exhibits a low value (0.294) due to the same effect. Despite collecting many species and individuals, moderate diversity values were generally recorded. This was due to the dominance of certain species over several months.

The results of the Jaccard index of similarity confirmed that the study area attracts different species, which vary depending on the month and season. The similarity values were high between the close months, and very low between the distant months. This value difference resulted from the season's effect on the area's fish species. Furthermore, the results of the Bray-Curtis index of numerical similarity indicated a significant reversal of seasonality between consecutive months. During the summer months, fishing, mainly commercial fishing, was more significant than in other months, but the total number of individuals was comparable. July and August exhibited the highest numerical similarity, reaching 0.644, while July and December exhibited the lowest, 0.005.

Conclusions

1-Only small sizes were found in predatory commercial fish species, such as Carangidae and Scombridae.

2 -The species and number of fish in the region are significantly impacted by seasonality.

3-The commercial fishing process continues, with the species varying according to the seasons.

4-The low diversity index values are a result of differences in the distribution of individuals among species and the emergence of extreme dominance of certain species, despite there being a good number of species.

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Contributions of authors

A.F. A: Field work, specimens' collection and wrote the manuscript.

A.H.A: Wrote and revised the manuscript.

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Conflicts of interest

The authors declare that they have no conflict of interest.

Ethical approval

All ethical guidelines related to fish and care issued by national and international organizations were implemented in this work.

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تركيبة وتنوع التجمعات السمكية في مسطحات المد والجزر الطينية لمصب شط العرب شمال غرب الخليج العربي

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المستخلص: جمع 10435 نموذج من الاسماك خلال الفترة من كانون الثاني 2021 إلى شباط 2022، تعود إلى 71 نوعا موزعة على 39 عائلة و20 رتبة من منطقة المد والجزر عند مصب شط العرب شمال غرب الخليج العربي. استخدمت وسيلتين لصيد الأسماك هما الشباك الخيشومية الثابتة وشباك الجر. قيس العديد من مؤشرات التنوع والوفرة النسبية، منها مؤشري Margalef وMenhinick للغنى، وShannon وSimpson للتنوع النوعي، وBerger–Parker للسيادة، وJaccard للتشابه النوعي، وBray – Curtis للتشابه العددي لتقييم المنطقة أحيائنا وبيئيًا. وكان *Nematalosa nasus* أعلى وفرة نسبية حيث بلغت 24.53%. في المقابل، سجلت أقل وفرة نسبية لـ 20 نوعا بقيمة 0.01% بتسجيل فرد واحد فقط لكل منها. سجلت رتبة Perciformes أعلى نسبة مئوية بمقدار 18.31٪ وأقل نسبة سجلت 1.41٪ لعدد من الرتب سجلت نوع واحد فقط. سجل مؤشر Margalef أعلى قيمة له في 5.24 حزيران وأدنى قيمة له في 1.24 كانون الأول. وبالمثل، سجل مؤشر Menhinick أعلى قيمة له عند 1.53 في تشرين الاول وأدنى قيمة له عند 0.71 في تشرين الثاني. وفي كانون الاول 2021، تم تسجيل أعلى قيمة لمؤشر Shannon عند 2.69 في كانون الثاني 2021، بينما سجلت أدنى قيمة في ايلول عند 0.98. سجل مؤشر Simpson أعلى قيمة 0.92 في كانون الثاني 2021 وأدنى قيمة 0.37 في ايلول. وصل مؤشر Peilou إلى أعلى قيمة له عند 0.965 في كانون الاول، بينما كانت أدنى قيمة له عند 0.294 في ايلول. سجل مؤشر Jaccard أعلى قيمة له عند 0.667 بين كانون الاول 2021 واذار، بينما كانت أدنى قيمة له 0.079 بين كانون الأول وشهري حزيران وتموز. أعلى قيمة سجلت لمؤشر Bray – Curtis للتشابه العددي بين شهري تموز وآب حيث بلغت 0.644. وفي المقابل، كانت أدنى قيمة لوحظت هي 0.005 بين شهري تموز وكانون الاول.

الكلمات المفتاحية: التنوع، السيادة، التكافؤ، الظهور، الغنى، التشابه.