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Assessment of marine fish species diversity in the Shatt Al-Arab River and Al-Hammar Marsh: a comparative study before and during salt intrusion

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Abstract:

The present study aimed to evaluate the effect of salt intrusion on the presence of marine species in the Shatt Al-Arab River and Al-Hammar Marsh. Thirty-five species of marine fish belonging to 24 genera and 17 families were recorded during the salt intrusion period entering the selected study stations: Abu Al-Khaseeb (first station), Sindbad (second station), and Al-Hammar marsh (third station), of which 28 species were in the first station, 18 species in the second station, and 21 species in the third stations for the period from January 2018 to December 2018, the highest similarity percentage (64.3%) was between the first and second stations, and the lowest (40%) was between the first and third stations.

The total number of marine fish entering the Shatt Al-Arab and the Al-Hammar Marsh before and during the salt intrusion period were: Forty species were recorded entering Abu Al-Khasseb station, twenty-six were obtained at Sindbad

station, and twenty-seven were obtained at Al-Hammar Marsh station. Thirteen common species appeared in the three stations, namely: *Thryssa whiteheadi, Planiliza subviridis, Teunalosa ilisha, Bathygobius fuscus, Planiliza klunzingeri, Hyporhamhus limbatus, Boleophthalmus dussumieri, Brachirus orientalis, Sillago sihama, Planiliza caranata, Nematalosa nasus, Scatophagus argus*, and *Acanthopagrus arabicus*.

The results showed that the composition of the fish population in the Shatt Al-Arab and the Al-Hammar Marsh is greatly affected by the salinity height during the salt intrusion period; the marine species recorded complete dominance in numerical abundance, reaching 82.8% in Abu Al-Khaseeb station, and 71.1% in Sinbad stations, and a complete dominance 100% in the Al-Hammar marsh station.

Keywords: marine fishes, salt intrusion, Shatt Al-Arab River, Al-Hammar Marsh

Introduction

The river of Shatt Al-Arab is one of Iraq's great rivers; it's the first water source in Basrah city with varied utilizations, like drinking, watering plants and vegetation, industrial and commercial usages, transference, electric generation stations, and recreational areas. The main uses of agriculture extend along both banks of the river, especially the large groves of palm trees [1]. The water level of Shatt al-Arab is affected by the Arabian Gulf tides. This impact depends on how much freshwater flows from the Tigris, Euphrates, and Karun Rivers. The Shatt Al-Arab River water faced a hard increase in salt values, which indicates that it is one of the types of physical pollution. It coincides with climate change and the intensity of demand and storage in Turkey, Iran, and central and northern Iraq [2].

Under these conditions, numerous studies concentrated on the entry of marine fishes and fish assemblages composition in different parts of the River of Shatt al-Arab, including [3] recorded the occurrence of 11 species of marine fish in the River of Shatt Al-Arab (from Abu Al-Khaseeb to Karmat Ali), [4] recorded 16 marine fish species, in comparison [5] described the existence of 21 species of marine fish, The study of [6] reviewed the composition of the fish assemblage in this River and the seasonal changes for this assemblage, as they recorded 14 marine species. [7] investigated the fish assemblage composition in this River's central and northern parts, and they collected 25 species, including seven marine species. During the 2000s, [8] found the occurrence of eight marine species, and [9] investigated nine marine species. Following that, the species numbers of marine fish in the River of Shatt Al-Arab increased significantly, reaching 25 species [10], 32 species [11], and 19 species in the station of Abu Al-Khaseeb [12]. In comparison, [13] informed the occurrence of 83 marine fish species in the Shatt Al-Arab River downstream.

The present study aims to prepare a list of marine fish species entering the river of Shatt Al-Arab through the stations of Abu Al-Khaseeb, Sinbad, and Al-Hammar Marsh during the salinity intrusion period and compare it with previous studies of the same regions for the periods preceding that.

Material and Methods

Data collection and analysis

Two studies, [14] and [15], were adopted to determine the marine species entering the Shatt Al-Arab in the stations of Abu A-Khaseeb, Sindbad, and the Al-Hammar marsh from January 2018 to December 2018 due to their coincidence with the period of salinity incursion. The salinity values at this period were in Abu-Al-Khaseeb station 2.0-25.0 PSU, Sinbad 2.3-16.2 PSU, and Al-Hammar Marsh 3.43-29.9 PSU.

The studies [16] and [17] were also adopted for comparison at Abu Al-Khaseeb station, as they are the period before the salinity intrusion from November 2014 to October 2015 for the first study and from November 2015 to October 2016 for the second study, where the values of salinities for the two studies are 1.8–12.5PSU and 1.6–4.6PSU, respectively. The studies [9] (August 2003-July 2004), [18] (November 2007-October 2008), [16] (November 2014-October 2015), [19] (November 2015- October 2016) and [20] (August 2016- July 2017) were adopted for comparison at Sinbad station, where salinity values were (1.54-2.35, 1.2-3.3, 1.8-9.2, 1.5-6.0, and 0.92-2.13 PSU), respectively.

The studies of [21] (January2009-May2010), [22] (November 2006-November 2007), and [23] (November 2012-October 2013) were adopted for comparison in Al-Hammar Marsh; the salinity values for these studies were 1.24-7.67, 1.0-2.0 and 1.7-7.3PSU respectively.

The Jccared similarity index was used for making comparisons among the marine species in the three different sites during the salt intrusion period and for comparison with other studies before this period by [24] equation:

$$IS_J = [a/ (a+b+c)] \times 100$$

a = total common marine species in samples A, B

b = total marine species in sample A and absent in sample B

c = total marine species in sample B and absent in sample A

Description of Study Areas

The Abu Al-Khaseeb site (first station) is located (30° 46′ 37″ N, 47° 77′ 11″ E) south of the Abu Al-Khaseeb city in Basrah Governorate. In contrast, the Sindbad location (second station) is found at (30° 58′ 16″ N, 47°77′ 11″ E) north of the Island of Sindbad; these sites are affected by the tidal current of the Arabian Gulf. Both sites are proper for fishing processes, and many fishermen practice fishing [14].

The third station, Al-Hammar Marsh, is located between latitudes (30 º 33´- 30º 58´N) and longitudes (46 º 24´ - 47 º 39´ E) on the right side of the Euphrates River. It expands from the west, near Al-Nasiriyah city, to the Shatt Al-Arab River in Basrah city and the East. It is considered the largest water body in the south of Iraq. Its water depth ranges from 1.8 to 3 m [25] (Fig. 1).

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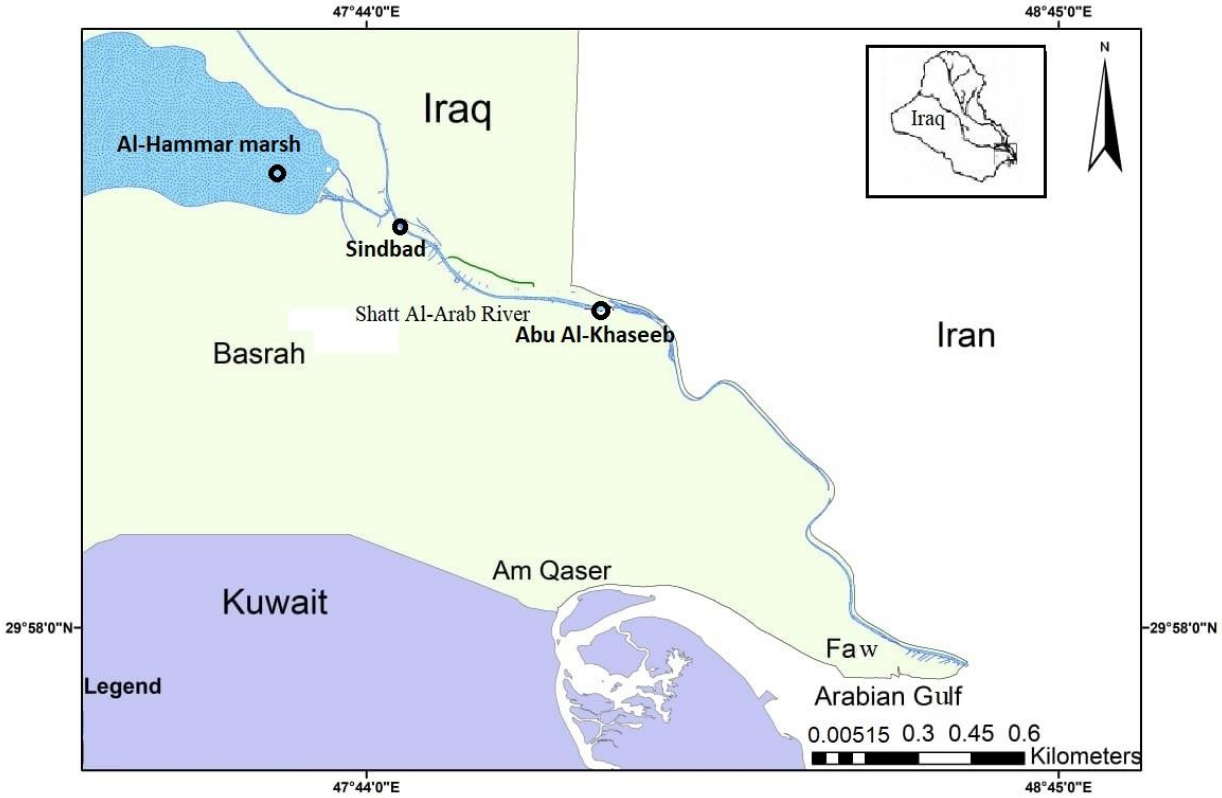

Figure 1. Location of study stations in the Shatt Al-Arab River and Al-Hammar Marsh (program Arc Map GIS 10.7.1)

Results

Marine fish species entered during the salt intrusion

According to [14] and [15] studies, thirty-five species of marine fish belonging to 24 genera and 17 families were recorded entering the stations selected in the study: Abu Al-Khaseeb (first station), Sindbad (second station), and Al-Hammar marsh (third station), of which 28 were in Abu Al-Khaseeb station, and 18, 21 species in the Sindbad and Al-Hammar marsh stations, respectively (Table 1).

Table 1. List of marine fish species entering Shatt Al-Arab River and Al-Hammar marsh during the period of salinity intrusion.

Family	**Species**
Engraulidae	*Thryssa vitrirostris* (Gilchrist & Thompson, 1908)
	Thryssa malabarica (Bloch, 1795)

	Thryssa hamiltonii (Gray, 1835)
	Thryssa dussumieri (Valenciennes, 1848)
	Thryssa whiteheadi Wongratana, 1983
Clupeidae	*Nematalosa nasus* (Bloch, 1795)
	Tenualosa ilisha (Hamilton, 1822)
	Sardinella albella (Valenciennes, 1847)
Pristigasteridae	*Ilisha compressa* Randall, 1994
Ariidae	*Plicofollis layardi* (Günther, 1866)
	Plicofollis dussumieri (Valenciennes, 1840)
	Netuma bilineata (Valenciennes, 1840)
Gobiidae	*Boleophthalmus dussumieri* Valenciennes, 1837
	Bathygobius fuscus (Rüppell, 1830)
Soleidae	*Solea elongata* Day, 1877
	Brachirus orientalis (Bloch & Schneider, 1801)
	Solea stanalandi Randall & McCarthy, 1989
Cynoglossidae	*Cynoglossus kopsii* (Bleeker, 1851)
	Cynoglossus arel (Bloch & Schneider, 1801)
Belonidae	*Strongylura strongylura* (van Hasselt, 1823)
Hemiramphidae	*Hyporhamphus limbatus* (Valenciennes, 1847)
Mugilidae	*Planiliza subviridis* (Valencinnes, 1836)
	Planiliza klunzingeri (Day, 1888)
	Planiliza carinata (Valenciennes, 1836)
Sciaenidae	*Otolithes ruber* (Bloch & Schneider, 1801)

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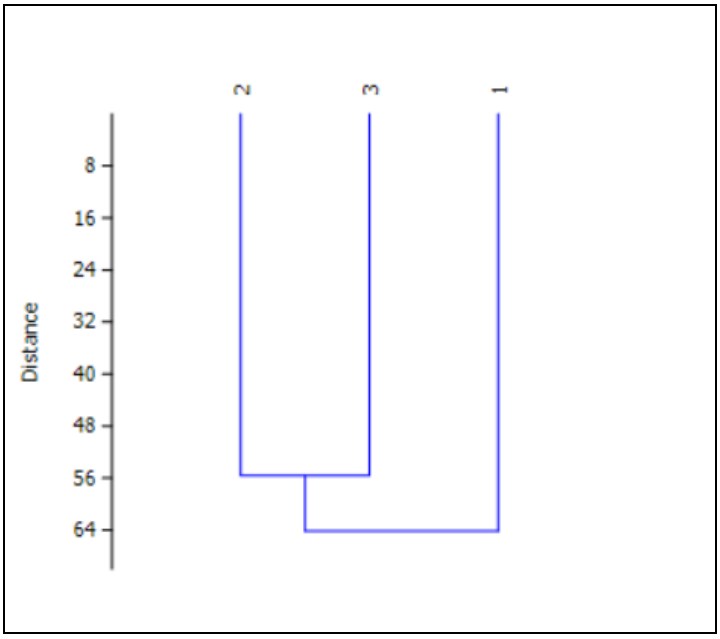
	Johnius belangerii (Cuvier, 1830)
Platycephalidae	*Platycephalus indicus* (Linnaeus, 1758)
Sillaginidae	*Sillago attenuata* McKay, 1985
	Sillago sihama (Forsskål, 1775)
	Sillago arabica McKay & McCarthy, 1989
Sparidae	*Sparidentex hasta* (Valenciennes, 1830)
	Acanthopagrus arabicus Iwatsuki, 2013
Leiognathidae	*Photopectoralis bindus* (Valenciennes, 1835)
Scatophagidae	*Scatophagus argus* (Linnaeus, 1766)
Triacanthidae	*Triacanthus biaculeatus* (Bloch, 1786)

The results of the similarity in qualitative composition employing the Similarity Index of Jaccared showed that the second and third stations were linked at a similarity level of 56%, and the first station was linked to them at a similarity level of 64.3% (Fig. 2).



1-Abu Al-Khaseeb (first station)

2-Sindbad (second station)

3- Al-Hammar Marsh (third station)

Figure 2. Cluster analysis of degree of similarity in the composition of species to marine fishes in the three stations using the similarity index of Jaccard (%)

Figure (3) showed the similarity results in species composition of marine fish using the Similarity Index of Jaccared. Two main groups were found in a similarity level 64%. The first major group was the Abu Al-Khaseeb station. At the same time, the second main group involved of Sindbad and Al-Hammar Marsh stations in a similarity degree of 55%.

Thirteen common species appeared in the three stations, namely: *T. whiteheadi, P. subviridis, T. ilisha, B. fuscus, P. klunzingeri, H. limbatus, B. dussumieri, B. orientalis, S. sihama, P. caranata, N. nasus, S. argus* and *A.arabicus,* and nine species were shown in the Abu Al-Kaseeb station and did not found in the Sindbad and Al-Hammar Marsh stations, which are *O. ruber, T. biaculeatus, P layavdi, S. strongylura, P. indicus, S. stanalandi, S. elongta, C. kopsii, P.dussumieri,* and seven species *J. belangeri, S. hasta, I. compressa, T. malabarica, T. hamiltonii, S.albella, N.bilineatus* were found in the Al-Hammar Marsh station and did not recognized in the other two stations.

Abu Al-khaseeb (Station 1)

forty species of marine fish were recorded entering Abu Al-Khasseb station before and during the salinity intrusion, twenty- eight species of marine fish were recorded in the study of [14] (January 2018- December 2018) (first study) during the salinity intrusion period, compared to 18 species recorded in the [16] study (November 2014- October 2015) (second study) and 29 species in the [17] study (November 2015-October 2016)(third study) at this station (Table, 2).

Thirteen species appeared in the three studies, which are *T. whiteheadi, P.bindus, P.subviridis, T.ilisha, B. fuscus, P. klunzingeri, B. dussumieri, B. dussumieri, B.orientalis, S. sihama, P. indicus, N. nasus, S. argus, A. arabicus,* and eight species were shown in the first study and did not found in other two studies, namely *T. biaculeatus, S. stanalandi, S. elongate, O. ruber, C. kopsii, T. dussumieri, P.layardi, C. arel,* and three species appeared in second study *H. unicuspis, T. crocodilus, P. melanostigma.* Seven species *J.belangerii, I. compressa, N.bilineata, I.melastoma, S.commersonnianus, Johnius* sp., *E.tetradactylum* appeared in third study and did not appear in the other two studies.

Table 2. List of marine fish species recorded in the three studies before and during the salinity intrusion at Abu Al-Khaseeb station a comparison among the three studies.

Species	**Mohamed and Hameed, (2019)**	**Yaseen, (2016)**	**Abood, (2018)**
Thryssa whiteheadi	/	/	/
Photopectoralis bindus	/	/	/
Planiliza subviridis	/	/	/
Thryssa vitrirostris	/		/
Tenualosa ilisha	/	/	/

Bathygobius fuscus	/	/	/
Triacanthus biaculeatus	/		
Planiliza klunzingeri	/	/	/
Hyporhamphus limbatus	/		/
Strongylura strongylura	/		/
Solea stanalandi	/		
Boleophthalmus dussumieri	/	/	/
Solea elongate	/		
Sillago Arabica	/		/
Otolithes ruber	/		
Cynoglossus kopsii	/		
Brachirus orientalis	/	/	/
Sillago sihama	/	/	/
Platycephalus indicus	/	/	/
Planiliza carinata	/		/
Nematalosa nasus	/	/	/
_Plicofollis dussumieri	/		
Scatophagus argus	/	/	/
Sillago attenuata	/		/
Acanthopagrus arabicus	/	/	/
Thryssa dussumieri	/		
Plicofollis layardi	/		

Cynoglossus arel	/		/
Johnius belangerii			/
Sparidentex hasta		/	/
Ilisha compressa			/
Netuma bilineata			/
Ilisha melastoma			/
Hyporhamphus unicuspis		/	
Tylosurus crocodilus		/	
Pseudosynanceia melanostigma		/	
Scomberoides commersonnianus			/
Johnius sp.			/
Johnius dussumieri		/	/
Eleutheronema tetradactylum			/

The highest degree of similarity using the Jaccared similarity index was between the first and third studies which amounted to 54.1%, and the lowest was between the first and second studies which amounted to 39.4%.

In Abu Al-Khaseeb station, the results explained the occurrence of two main groups in a similarity degree of 62%. The first main group was the second study. In comparison, the second main group were the two other studies, the first and third, with a similarity degree of 38% (Fig. 3).

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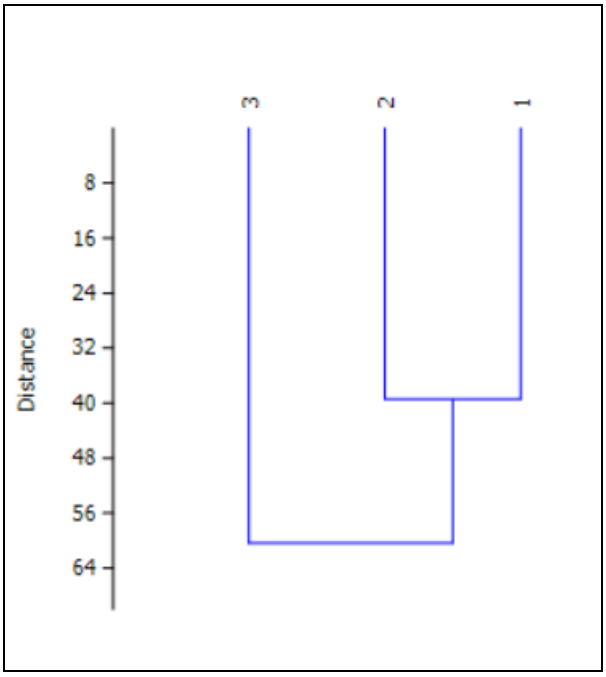

1-Abu Al-Khaseeb (first station)

2-Sindbad (second station)

3- Al-Hammar Marsh (third station)

Figure 3. Cluster analysis of degree of similarity in the composition of species to marine fishes in the Abu Al-Khaseeb station. using the similarity index of Jaccared (%)

Sindbad (Station two)

Twenty-six species of marine fish were obtained at this station, including eighteen species in a study by [14] during the salinity intrusion period (first study) and nine species in two studies [9] (second study) and [18] (third study) and sixteen, eighteen, and eleven species in studies by [16] (fourth study), [19] (fifth study), and [20] (sixth study) respectively. Three species appeared in all studies *T. ilisha, B. fuscus, A. arabicus,* and the species *Periophthalmus waltoni* appeared in the second study and species *T.mystax* in the third study and the species *Upeneus doriae, Hyporhamphus unicuspis, Ilisha compressa, Johnius belangerii* in the fourth study (Table,3).

Table 3. List of marine fish species recorded in the three studies before and during the salinity intrusion at Sindbad station compared with other studies.

Species	**Mohamed and Hameed, (2019)**	**Younis, *et al.* (2010)**	**Lazem (2009)**	**Yaseen (2016)**	**Hameed, (2017)**	**Ahmed (2017)**
Thryssa whiteheadi	/			/	/	/
Photopectoralis bindus	/			/	/	/

Planiliza subviridis	/	/	/		/	/
Thryssa vitrirostris	/				/	
Tenualosa ilisha	/	/	/	/	/	/
Bathygobius fuscus	/	/	/	/	/	/
Planiliza klunzingeri	/		/	/	/	/
Hyporhamphus limbatus	/				/	/
Boleophthalmus dussumieri	/			/	/	
Sillago arabica	/				/	
Brachirus orientalis	/			/	/	
Sillago sihama	/	/		/	/	/
Planiliza carinata	/	/		/	/	
Nematalosa nasus	/			/	/	
Scatophagus argus	/	/	/	/	/	
Sillago attenuata	/				/	/
Acanthopagrus arabicus	/	/	/	/	/	/
Thryssa dussumieri	/				/	
Johnius belangerii				/		
Ilisha compressa				/		
Thryssa malabarica			/			
Thryssa hamiltonii		/	/			/
Periophthalmus waltoni		/				
Thryssa mystax			/			

Upeneus doriae				/		
Hyporhamphus unicuspis				/		

The results of the similarity in the qualitative composition using the Jacccared similarity coefficient showed that the highest similarity ratio (%100) was between the first and fifth studies and the lowest similarity rate (%28.6) between the first and third studies and the third and fifth studies.

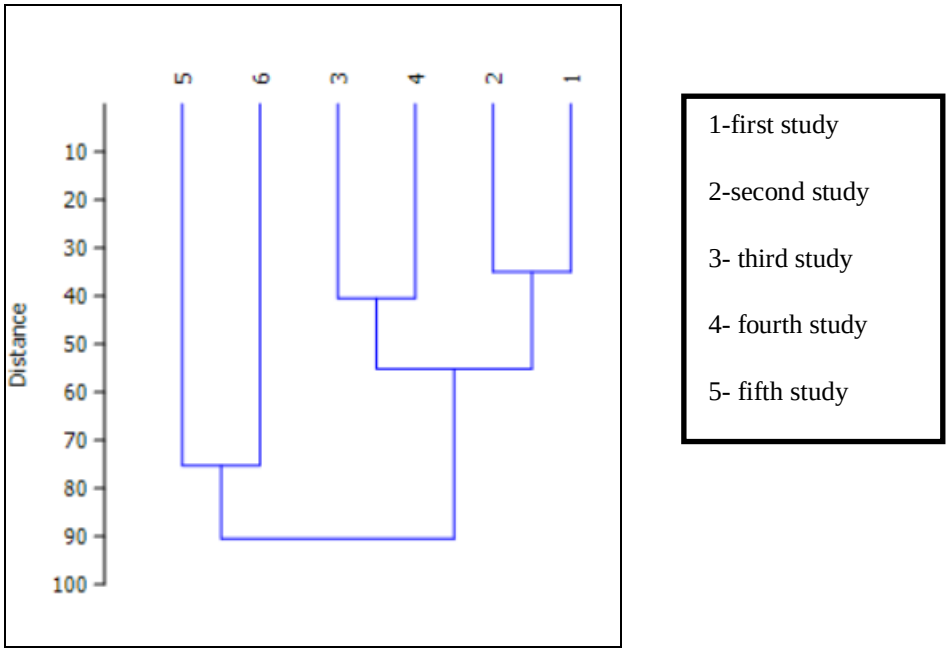

Figure 4. Cluster analysis of degree of similarity in the composition of species to marine fishes in the Sindbad station using the similarity index of Jaccared (%)

In station two, the results explained the existence of two main groups in a similarity degree of 75% and considered as the first main group which comprised the fifth and sixth studies in a similarity level of 75%. Whereas the second main group comprised two secondary groups in a similarity level of 55%; the first secondary group had first and second studies in a similar dgree of 35%, the second secondary group contained third and fourth studies in a similarity level of 40% (Fig. 4).

Al -Hammar marsh (Station three)

Twenty-seven species of marine fish were obtained at this station, including twenty one species in the study of [15] during the salinity intrusion period (first study), and twenty three, nine, and ninteen species in the studies of [21] (second study), [22] (third study) and [8] (fourth study) respectively, in the period preceding the salinity intrusion (Table 4).

Table 4. List of marine fish species recorded in the three studies before and during the salinity intrusion at Al-Hammar Marsh station compared with other studies.

Species	**Al-Najar (2020)**	**Mutlak (2012)**	**Al-Shammary (2008)**	**Mohammed *et al.*(2015)**
Thryssa whiteheadi	/	/		/
Photopectoralis bindus		/		/
Planiliza subviridis	/	/	/	/
Thryssa vitrirostris				/
Tenualosa ilisha	/	/	/	/
Bathygobius fuscus	/	/		/
Planiliza klunzingeri	/	/	/	/
Hyporhamphus limbatus	/	/		/
Boleophthalmus dussumieri	/	/		/
Sillago arabica		/		
Brachirus orientalis	/	/		/
Sillago sihama	/	/		/
Planiliza carinata	/	/		
Nematalosa nasus	/	/	/	/
Scatophagus argus	/	/	/	
Acanthopagrus arabicus	/	/	/	/
Cynoglossus arel	/			
Johnius belangerii	/	/		/
Sparidentex hasta	/	/	/	/
Ilisha compressa	/	/		/

Thryssa malabarica	/	/		
Thryssa hamiltonii	/	/		/
Sardinella albella	/	/		/
Netuma bilineata	/	/		
Thryssa mystax			/	
Acanthopagrus berda		/		/
Rhynchorhamphus georgii			/	

Six common species appeared in all studies, namely *P. subviridis*, *T. ilisha*, *P. klunzingeri*, *N. nasus*, *A. arabicus*, and *S. hasta*. The species *C.arel* appeared only in the first study, the species *S. arabica* in the second study, and the species *T.mystax* and *R.georgii* in the third study as well as the species *T.vitrirostris* in the fourth study (table 4).

The results of similarity in species composition applying the similarity index of Jaccared showed that highest rate (83.3%) was between the first and second studies and the lowest (27.3%) between the third and fourth studies.

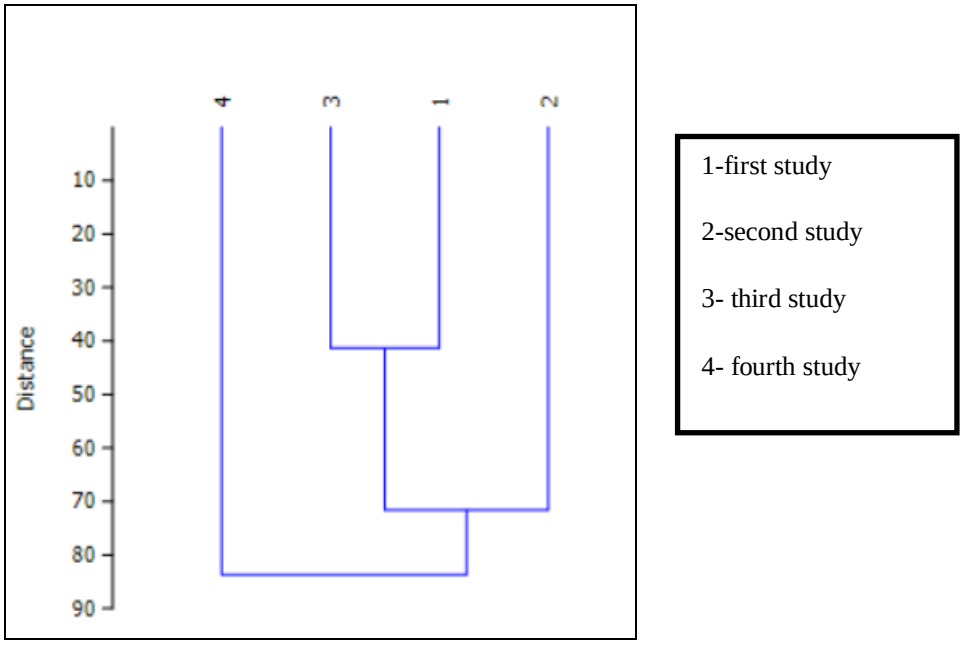

Figure 5. Cluster analysis of degree of similarity in the composition of species to marine fishes in the Al-Hammar marsh station using the similarity index of Jaccared (%).

There are three main groups found in station 3 in a similarity degree of 84%. The first major group was the fourth study. The second main group consisted of the first and third studies in a similarity degree of 40%, while third main group comprised the second study of [21] only in a similarity level of 70%. (Fig. 5).

Discussion

The waters of the River of Shatt Al-Arab suffer from severe salinity due the unfair water policies of the countries of the upper two rivers, which led to an absence of water imports to the columns of Tigris and Euphrates Rivers, and policy of building dams, diversion of common riverbeds by the neighboring state of Iran toward Iranian region, this led to the deterioration of environmental situation in the province of Basrah, especially the areas (the center of the province of Basra, Al-Faw district, Abu Al-Khaseeb district, Al-Bahar district, and Al-Seeba area) due to the high concentrations of salts, the total dissolved solid (TDS) and salinity (to double what it was previously and the scarcity water, which led to the drying up of agricultural lands and orchards (especially palm groves) in addition to the death of domestic animals that feed on these water sources as well as destroying more than (35) fish farming pond [26] and [27] indicate the entry of salinity from the Gulf and its mixing with the pollutants present in the river itself - which comes from the internal channels, sewers, sewage water, agricultural soils, industrial workshops, etc. - works to form a toxic chemical mixture and makes the water unfit for life.

The results of the current study exposed that the number of marine species entering the River of Shatt Al-Arab and the Al-Hammar marsh during the period of salinity intrusion amounted to twenty eight and eighteen species for Abu Al-Khaseeb and Sinbad stations in the River of Shatt Al-Arab, respectively, and twenty one species in the Al-Hammar marsh, and this number is almost higher than all studies conducted on these stations in the periods preceding the salinity intrusion, the matter was not limited to that. However, the marine species recorded complete dominance in numerical abundance, reaching 82.8% and 71.1% for the Abu Al-Khaseeb and Sinbad stations, respectively. Complete dominance over fish assemblage, reaching (100%) in the marsh of Al-Hammar [14; 15].

The present study showed that the composition of the fish population is greatly affected in light of variations in the aquatic environment as a result of differences in some environmental factors, such as high and low salinity, including the increase in calcium in the water and high hardness resulting from the increase in carbon dioxide in the water. as a result of the lack in discharges coming to the Shatt al-Arab as a result to the lack of water supplies from the Tigris and Euphrates Rivers, as well as the Karun and Karkheh rivers because of the building of dams in Turkey and Iran, and this is proven by the measurements recorded by the Ministry of Water Resources for the year 2018 as a result of the increase in pollutants dumped into the Shatt al-Arab River, including untreated sewage and other water, [28].

Salinity participates a "significant" role in forming the biological community and its composition [29], and many studies have confirmed this result. Note [30] advanced the salty front in the northern branch of the Changjiang River during the dry season that reaches it from the inner part of the eastern China Sea. An isolated block of salty water is formed at the top of the river within the southern branch. It turns out that the intrusion of salty water is due to major reasons, including fluctuation, the quantities of fresh water from the source of the river, and the advance of the salty front as a result of the high advance of the tide, especially in the dry seasons, as well as the northern winds enhance the intrusion of salt water by reducing the rise in sea level. [31] found that the Pearl River Delta, which flows into the China Sea, was seriously affected by the salinity leakage, which negatively affected drinking water. Surface runoff of fresh water, changes in river topography, differences in sea level, winds and their directions, as well as due to successive dry seasons as a result of the reasons mentioned also, due to the high evaporation of water, especially during the dry seasons in the summer . [32] indicate that salinity mainly affected the land and water in the coastal areas of Bangladesh, which extended its impact to inland waters and soil, and that this gradual increase in salinity in these areas had a severe impact on the primary production

system and biological diversity, and on human health, and one of the reasons for the increase in salinity was due to factors low flow as a result of upstream dams in neighboring countries, as well as mismanagement of coastal flat areas, and sea level rise.

Conclusions

The study concluded that the composition of the fish population in the Shatt Al-Arab and the Al-Hammar Marsh is greatly affected by the salinity heighten during the salt intrusion period, where the marine species recorded complete dominance in numerical abundance, reaching 82.8% in the Abu Al-Khaseeb station, and 71.1% in Sinbad stations, while there was complete dominance over the fish assemblage, reaching 100% in the Al-Hammar marsh station, and concluded that salinity is an influential factor that leads to a change in the composition of the marine fish community through the flow of seawater towards the north of Basrah via the tide.

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