

Trophic relationships among fourteen native and non-native fish species in the Shatt Al-Arab River, Iraq

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Abstract

The present study objectified to evaluate the trophic relationships among 14 fish species (10 natives and 4 non-natives) in the Shatt Al-Arab River, considering the trophic niche breadth and the diet overlaps of the species. The food items in the stomach of each species are determined by adopting the index of relative importance (IRI). The dietary analysis revealed a total of 12 types of major food items consumed (which represent >10% IRI). Two species (*Oreochromis aureus* and *Cptodon zillii*) were herbivores consumed mostly macrophytes, algae and diatoms. Four species (*Planiliza abu*, *P. klunzengeri*, *P. subviridis* and *Osteomugil speigleri*) were herbivores mainly fed on diatoms, macrophytes, detritus and algae. Three species (*Carasobarbus luteus*, *Carassius auratus* and *Cyprinus carpio*) were omnivores mostly consumed macrophytes, detritus, diatoms and algae. Two species (*Tenualosa illisha* and *Nematalosa nasus*) were filter feeders fed largely on zooplankton, algae, detritus and macrophytes. Three species (*Acanthopagrus arabicus*, *Johnius belangerii* and *J. dussumeiri*) were carnivores mainly preyed on shrimps, crabs and fish. Levin's index diet breadth analyses divided the studied fish species into three categories; two species with high specialization, five species with low specialization, and seven species with generalization feeders. The dietary composition of fish species exhibited 62 diet overlaps as indicated by the Jaccard index, eight of them high, 36 moderate and 18 low overlaps. Only *J. dussumeiri* and *J. belangerii* have no diet overlap with other species. Overall, the study demonstrates that most trophic overlaps between species were moderate, but high degree overlap was between the native species (*C. luteus*) and invading species (*C. auratus*) and therefore strengthen earlier conclusions regarding interspecific competition between these two species.

Keywords: Diet composition; Dietary overlap; Trophic niche breadth; Shatt Al-Arab River; Iraq

1. Introduction

Food is a prerequisite for fish growth and development and is important for the survival of living organisms. It also plays a key role in migration, growth, behavior, reproduction and other vital activities of fish [1, 2]. Braga *et al.* [3] stated that the fish feeding ecology is thoroughly linked to population dynamics and has important implications in the subjects of resource partitioning, habitat preferences, prey selection, interspecific competition, and energy transfer within the ecosystem. Niche overlap and partitioning should provide very useful information on how these species rank in the food web to derive implications for fisheries management [4].

Rivers are among the ecosystems with high environmental variables [5]. Shatt Al-Arab River has been subjected to multiple impacts suffered from the drastic reduction in water quantity during the last years caused by the deterioration in rates of the flow as a result of several large dams construction in Turkey, Syria, Iran, and Iraq have diverted water from the Tigris and Euphrates and their tributaries for irrigation, flood control, and hydroelectric power [6], and the diversion of the Karun and Karkha Rivers into Iranian terrene [7]. The reductions of the inflows into the estuary

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promoting the saline arm to extend from the Arabian Gulf up to 100km into Shatt Al-Arab River during dry years and consequently resulting in high salinity levels in the river [8]. The alteration of water discharge in the Shatt Al-Arab River and the saltwater intrusion further upstream have been discussed by several authors [8-10].

Also, during the last two decades, the Shatt Al-Arab River ecosystem has been invaded by several non-native fish species and dramatically expanded their populations. Mohamed and Abood [11] documented 13 non-native species constituted 39.4% of the total catch in the river, and two of them were the most abundant species, *C. auratus* (13.2%) and *O. aureus* (12.6%). Co'rdova-Tapia *et al.* [12] indicated there are several ways in which non-native species can affect native species, but the effects throughout the food web seem to generate several changes in the native fish community structure.

Before the deterioration of the Shatt Al-Arab River, a number of studies on the trophic relationships among fish species in this river have been done by [13-15]. Therefore, this article aimed to investigate the diet composition of the dominant fish species and their dietary breadth in order to study their niche overlaps and partitioning under this deterioration.

2. Material and methods

The study was conducted in the Shatt Al-Arab River, in the southern of Iraq. The river forms from the confluence of the Tigris and Euphrates rivers at Al-Qurna town northern Basra Governorate, and flows to southeastern direction towards the Arabian Gulf [Figure 1]. It is about 204 km, and varies in width from 250 m at Al-Qurna to more than 1,500 m at the estuary. The river is affected by the tidal current of the Gulf. Field samplings were carried out monthly from the three sites on the river during November 2015- October 2016. Site 1 (upstream) is located near Al-Dair Bridge, site 2 (midstream) is sited in Abu Al-Khasib district and site 3 (downstream) is located north Al-Fao town [Figure 1].

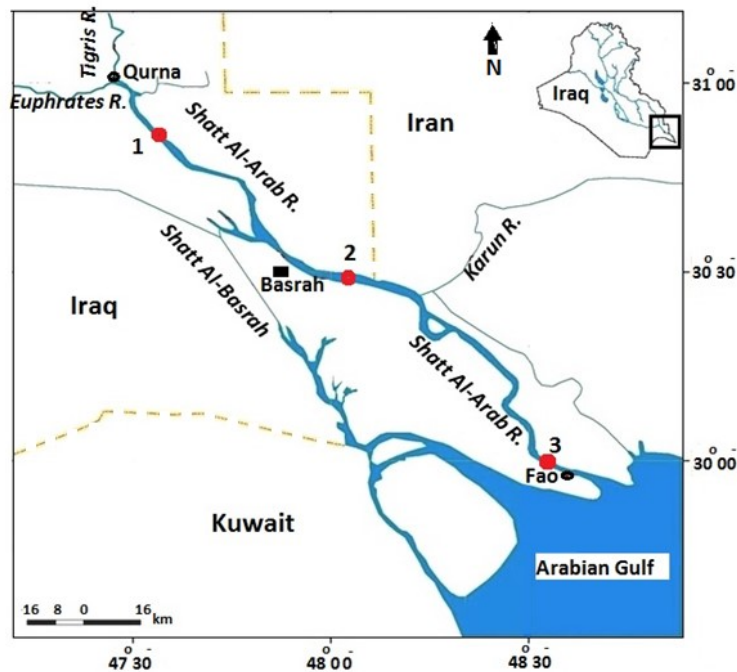


Figure 1 Map of Shatt Al-Arab with locations of study sites

Fish were collected from each site by cast net (9 m diameter with 15x15 mm mesh size) and electro-fishing by generator engine (provides 300-400V and 10A). A total of 5607 individuals of 14 fish species were collected. After capture, the fish were preserved in crushed ice prior to dissection in the laboratory.

Fish were classified to species following Coad [16] and Fricke *et al.*, [17]. Fish were measured for total length (TL, mm) and weight (W, g), then dissected ventrally to extract the digestive tract and adopted the first third of the intestine for those who do not have a distinctive stomach to study their food contents. The contents of the stomach and intestine were examined with the naked eye and under stereoscopic and optical microscopes, and the food items were identified

to the lowest possible taxonomic level. Diet contents were identified according to Hadi *et al.*, [18], and Wehr and Sheath [19].

The diet was analyzed by calculating four methods, i.e., numerical percentage (%N), gravimetric percentage (%W), frequency percentage (%F) and point's percentage (%O) following Hyslop [20]. The importance of food item was determined by combined these methods to calculate the index of relative importance (IRI %) of Pinkas *et al.* [21] for the distinctive stomach species (*A. arabicus*, *J. dussumeiri*, and *J. belangerii*) as follows:

$$\text{IRI} = (\text{N}\% + \text{W}\%) \text{F}\% \text{ and } \text{IRI}\% = \text{IRI} / \sum \text{IRI} * 100$$

For other species, the index of relative importance (IRI) of Stergion [22] was employed to assess the importance of various food items in the dietary as follows:

$$\text{IRI} = \text{O}\% \times \text{F}\% \text{ and } \text{IRI}\% = \text{IRI} / \sum \text{IRI} * 100$$

The trophic niche breadth for each species was calculated according to the formula proposed by Levins [23]:

$$B = 1 / \sum P_i^2$$

Where, B is Levins index of niche breadth and P_i is proportion of food group (i) in the diet. To standardize niche breadth on a scale from 0 to 1, the modification suggested by [24] was adopted as follows:

$$B_A = (B-1) / (n-1)$$

Where, B_A is Levins standardized niche breadth, B is Levins index of niche breadth and n is number of food groups for each species.

This index was used to test the feeding specialization of each species. The highly specialized feeders species fall within the range of 0.0 - 0.25, while the low specialization feeders between 0.26 - 0.49 and generalist feeders are within the range of 0.50 - 1.0.

The similarity and the dietary overlap among diets of fish in Shatt Al-Arab River also were evaluated using cluster analyses for food items that represented more than 10% relative importance were considered major items in the diet of each species. Clustering was performed according to Jaccard similarity index using SPSS software (ver. 22) statistical package. The levels of diet overlap were assessed according to Grossman [25], from 0-39 was considered a low diet overlap, 40-60 a moderate diet overlap and 61-100 a high diet overlap.

3. Results

Data were pooled from all sampling stations as the aim of the study was to describe the overall food habits of the fish species in the Shatt Al-Arab River. A total of 5607 individuals from 14 fish species (10 natives and 4 non-natives) were examined (Table 1).

Figure 2 shows the values of the index of relative importance (IRI) of different food items found in the stomachs of fourteen fish species in the Shatt Al-Arab River. Food items that represented more than 10% relative importance were considered to be major items in the diet of each species. Algae occupied the first position in order of relative importance in diet of *C. luteus* (24.3%), followed by insects (23. %), macrophytes (21.6%), detritus (10.9%), diatoms (10.0%). *C. auratus* fed primarily on insects (28.9%), macrophytes (26.2%), algae (12.8%) and detritus (12.4%). Insects comprised 37.8% of the total food items of *C. carpio*, followed by macrophytes (19.0%), snails (17.2%) and detritus (10.0%). Diatoms formed 39.3% of the food items of *P. abu* followed by macrophytes (22.2%), algae (16.2%) and detritus (15.7%). *P. subviridis* fed on diatoms (44.2%), macrophytes (20.7%), detritus (17.6%) and algae (15.2%). Diatoms formed 35.7%, macrophytes (30.0%), detritus (17.6%) and algae (16.8%) of the food items of *P. klunzingri*. The common food items of *O. speigleri* were diatoms (53.4%), detritus (17.5%), algae (16.3%) and macrophytes (10.8%). *T. ilisha* fed mainly on zooplankton (55.0%), algae (13.9%), detritus (12.6%) and macrophytes (10.0%). *N. nasus* fed on mixed diet of diatoms (22.3%), snails (20.5%), zooplankton (17.4%), macrophytes (15.1%), detritus (15.1%) and algae (10.0%). Macrophytes dominated the food items consumed by *C. zillii* constituting 60.8% following by algae (23.0%). *O. aureus* fed on macrophytes 44.3%, algae (31.4%) and diatoms (10.0%). Shrimps were the most important prey for *A. arabicus*, comprising 38.4% in relative importance, followed by crabs (20.2%), crustacean (12.9%), snails (10.8%) and insects

Table 1 Scientific name, number, total length and original status of studied fish

Family	Scientific name	No. of fish	Total length (mm)	Origin status
Cyprinidae	<i>Carasobarbus luteus</i>	256	95-220	Native
=	<i>Carassius auratus</i>	576	50-223	Non-native
=	<i>Cyprinus carpio</i>	339	38-285	Non-native
Mugilidae	<i>Planiliza abu</i>	555	65-195	Native
=	<i>P. klunzingeri</i>	564	96-227	Native
=	<i>P. subviridis</i>	456	98-265	Native
=	<i>Osteomugil speigleri</i>	187	115-181	Native
Cichlidae	<i>Oreochromis aureus</i>	580	54-250	Non-native
=	<i>Cptodon zillii</i>	545	36-240	Non-native
Clupeidae	<i>Tenuالosa ilisha</i>	560	14-415	Native
=	<i>Nematalosa nasus</i>	177	125-263	Native
Sparidae	<i>Acanthopagrus arabicus</i>	365	19-300	Native
Sciaenidae	<i>Johnius dussumieri</i>	227	92-225	Native
=	<i>J. belangerii</i>	220	122-235	Native

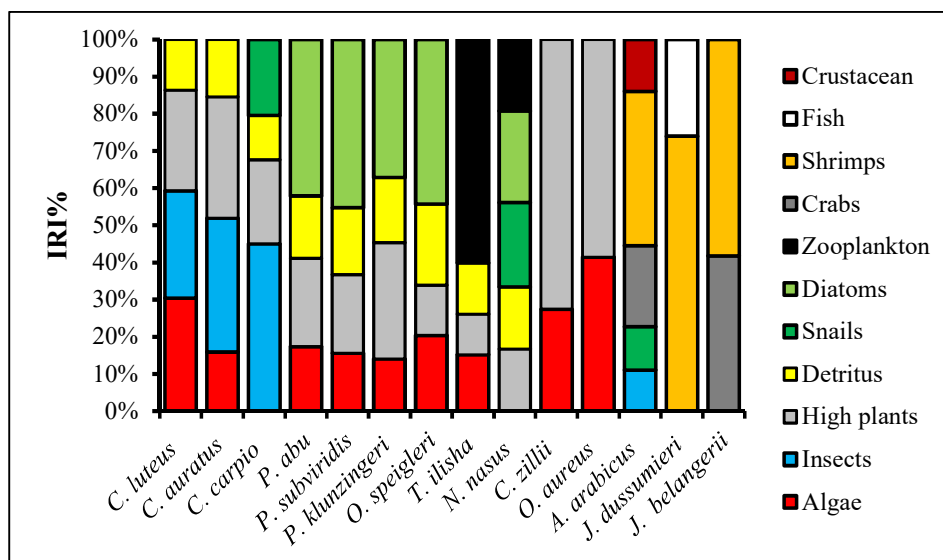


Figure 2 Index of relative importance (IRI %) of the food items in the diets of fish species

(10.2%). *J. dussumieri* preyed mainly on shrimps (77.4%) and fish (27.3%). *J. belangerii* preyed upon shrimps (52.9%), crabs (37.9%) and fish (10.0%).

Table 2 shows Levins index diet breadths analyses (B_A) for 14 fish species from the Shatt Al-Arab River. The results revealed that two species, namely *C. zillii* and *J. dussumieri* with high specialization ($B_A = 0.217$ and 0.219 , respectively), five species, namely *O. aureus*, *T. ilisha*, *P. subviridis*, *C. carpio* and *O. speigleri* with low specialization (ranged from $B_A = 0.360$ for *O. aureus* and $B_A = 0.492$ for *P. subviridis*), and seven species, namely *A. arabicus*, *C. auratus*, *P. klunzingeri*, *P. abu*, *J. belangerii*, *N. nasus* and *C. luteus* with generalization feeders, their B_A values ranged from 0.523 for *O. aureus* to 0.930 for *N. nasus*.

Table 2 Levins index diet breadths analyses for fish species in the Shatt Al-Arab River

Species	Standardized niche breadth		
	High specialization	Low specialization	Generalized
<i>C. luteus</i>	-	-	0.543
<i>C. auratus</i>	-	-	0.523
<i>C. carpio</i>	-	0.380	-
<i>P. abu</i>	-	-	0.575
<i>P. klunzingeri</i>	-	-	0.551
<i>P. subviridis</i>	-	0.492	-
<i>O. speigleri</i>	-	0.365	-
<i>O. aureus</i>	-	0.360	-
<i>C. zillii</i>	0.217	-	-
<i>T. ilisha</i>	-	0.444	-
<i>N. nasus</i>	-	-	0.930
<i>A. arabicus</i>	-	-	0.515
<i>J. dussumeiri</i>	0.196	-	-
<i>J. belangerii</i>	-	-	0.639

Table 3 shows the diet overlaps between the studied species in the Shatt Al-Arab River using a Jaccard index. The results showed 62 diet overlaps between the fish species, eight of them were high, 36 moderate and 18 low diet overlaps. Only *J. dussumeiri* and *J. belangerii* have no diet overlap with other species, while *A. arabicus* exhibited low overlaps with *N. nasus*, *C. carpio*, *C. luteus* and *J. dussumeiri*, and moderate with *J. belangerii* (0.333). The lowest diet overlap (0.111) was observed between *N. nasus* and *A. arabicus*, while the highest diet overlap (1.000) was found between cyprinids species (*C. auratus* and *C. luteus*) also between the mullets species (*P. abu*, *P. klunzingeri*, *P. subviridis*, and *O. speigleri*) and between tilapia species (*O. aureus* and *C. zillii*).

The diet overlap indices of all species were subjected to cluster analysis (Fig. 3). The cluster identified five groups of similar diets. The first group consists of three subgroups, first includes *C. luteus* and *C. auratus*, which fed mostly on insects, macrophytes, algae and detritus, second includes *T. ilisha* fed on zooplankton, algae, detritus and macrophytes, and third includes *P. abu*, *P. subviridis*, *P. klunzingeri* and *O. speigleri*, which fed mostly on diatoms, macrophytes, algae and detritus. The second group consists of *O. aureus* and *C. zillii* which fed primarily on macrophytes and algae. The third group contains *N. nasus* fed on diatoms, snails, zooplankton, detritus and macrophytes. The fourth group contains *C. carpio* fed on insects, macrophytes and snails. The fifth group consists of two subgroups, first includes *A. arabicus* and *J. belangerii*, which preyed primarily on shrimps and crabs, and second includes of *J. dussumeiri*, which preyed mostly on shrimp and fish.

4. Discussion

The study of food and feeding habits of fish has very importance in understanding the biology of fish, since the food is one of the key factors that greatly influence the distribution, growth, reproduction, migration and behavior of fish in the ecosystem [26, 27].

The study suggested that *C. luteus*, *C. auratus* and *C. carpio* are omnivorous species. *C. luteus* fed mainly on algae, insects, macrophytes, detritus and diatoms, while *C. auratus* on insects, macrophytes, algae and detritus, and *C. carpio* on insects, macrophytes, snails and detritus. These findings are in agreement with the findings of several studies on *C. luteus* (Table 4), such as Mohamed *et al.* [28] in East Hamma marsh, Pazira and Vatandost [29] in the Dalaki and Helle Rivers,

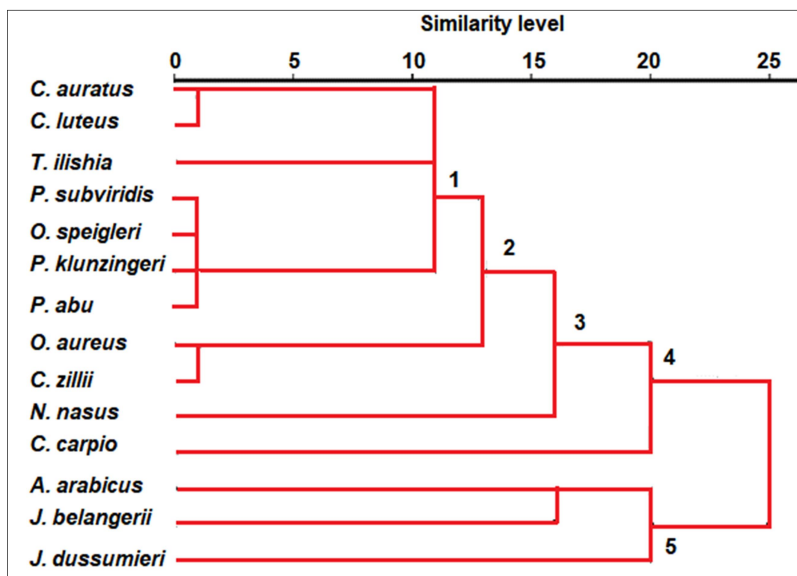


Figure 3 Dendrogram of the clustering of studied species based on their diet overlaps

Table 3 Diet overlaps among the studied fish species using a Jaccard index

Fish species	<i>C. auratus</i>	<i>O. aureus</i>	<i>P. klunzingeri</i>	<i>P. abu</i>	<i>C. zillii</i>	<i>T. ilisha</i>	<i>P. subviridis</i>	<i>A. arabicus</i>	<i>J. dussumeiri</i>	<i>C. carpio</i>	<i>O. speigleri</i>	<i>J. belangerii</i>	<i>N. nasus</i>	<i>C. luteus</i>
<i>C. auratus</i>	1.00	0.50	0.60	0.60	0.50	0.60	0.60	0.13		0.40	0.60		0.29	1.00
<i>O. aureus</i>		1.00	0.50	0.50	1.00	0.50	0.50			0.25	0.50		0.17	0.50
<i>P. klunzingeri</i>			1.00	1.00	0.50	0.60	1.00			0.17	1.00		0.50	0.60
<i>P. abu</i>				1.00	0.50	0.60	1.00			0.17	1.00		0.50	0.60
<i>C. zillii</i>					1.00	0.50	0.50			0.25	0.50		0.17	0.50
<i>T. ilisha</i>						1.00	0.60			0.17	0.60		0.50	0.60
<i>P. subviridis</i>							1.00			0.17	1.00		0.50	0.60
<i>A. arabicus</i>								1.00	0.17	0.33		0.40	0.11	0.13
<i>J. dussumeiri</i>									1.00			0.33		
<i>C. carpio</i>										1.00	0.17		0.33	0.40
<i>O. speigleri</i>											1.00		0.50	0.60
<i>J. belangerii</i>												1.00		
<i>N. nasus</i>													1.00	0.29
<i>C. luteus</i>														1.00

Table 4 Comparison of the food specialization guide for fish in different waters studies.

Waters/ Author	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Species								
<i>C. auratus</i>	-	0.46	0.48	0.63	-	0.51	-	0.52
<i>O. aureus</i>	-	-	-	-	-	-	-	0.36
<i>C. luteus</i>	-	0.50	0.46	0.30	-	0.52	-	0.54
<i>P. klunzingeri</i>	-	0.01	-	-	0.41	-	0.17	0.55
<i>P. abu</i>	-	0.44	0.02	0.31	-	0.37	-	0.58
<i>C. zillii</i>	-	-	-	-	-	-	-	0.22
<i>T. ilisha</i>	-	-	-	-	-	0.69	0.37	0.44
<i>P. subviridis</i>	-	0.02	-	-	0.36	0.37	0.39	0.49
<i>A. arabicus</i>	-	0.00	-	-	0.24	-	0.41	0.49
<i>J. dussumeiri</i>	0.38	-	-	-	0.09	-	0.16	0.22
<i>C. carpio</i>	-	0.67	0.53	0.50	-	-	-	0.38
<i>O. speigleri</i>	-	-	-	-	-	-	-	0.37
<i>J. belangerii</i>	0.51	-	-	-	-	-	0.21	0.64
<i>N. nasus</i>	-	-	-	-	0.35	-	-	0.93

1) Iraqi marine waters [67]; (2) East Hammar marsh [41]; (3) Huwazah marsh [41];
 (4) Chybaish marsh [41]; (5) Shatt Al-Basrah [13]; (6) East Hammar marsh [28];
 (8) Shatt Al-Arab [15]; (8) Shatt Al-Arab (present study).

India and Baboli *et al.* [30] in Karkheh River, Iran. Conversely, several authors reported that *C. luteus* was herbivores species in different Iraqi waters [31-35]. Most previous studies stated that the *C. auratus* was omnivorous, such as Saud [31] in the Qarmat Ali River, Al-Shamma'a *et al.* [36] in Euphrates River, Iraq, Hussain *et al.* [32] in the southern marshes of Iraq, Mohamed *et al.* [28] in East Hammar marsh, Iraq and Wahab [34] in Tigris River, Iraq. Other studies mentioned that *C. auratus* was herbivorous species [33, 37, 38]. The omnivorous feeding habit for *C. carpio* has been observed by several authors, like Saud [31] in the Qarmat Ali River, Al-Shamma'a *et al.* [39] in the Haditha Dam, Saikia and Das [40] in Indian lakes, Hussain *et al.* [41] in southern marshes, Ali *et al.* [42] in Hirfanli Dam, Turkey, Mohamed and Hussain [37] in East Hammar marsh and Dadebo *et al.* [43] in Lake Koka, Ethiopia. Some previous studies indicated that *C. carpio* was carnivorous species [44, 45]. Bagenal [46] stated that the fish feeding and trophic relationships change with availability of food, locality and spatial distribution within the habitat.

The study exhibited that *C. carpio* was a low specialized feeder, while *C. luteus* and *C. auratus* were a dietary generalized feeders. Mohamed *et al.* [28] found that both *C. luteus* and *C. auratus* considered as generalized feeders in the East Hammar marsh, moreover Hussain *et al.* [41] stated that *C. luteus* were low specialized in the Al-Hawizeh and Suq Al-Shuyoukh marshes, and not.

Specialized in the East Al-Hammar marsh (Table 4). Johnson and Arunachalam [47] mentioned that some cyprinids species were generalized feeders because they are opportunistic species in their feeding habits due to their high ability to change the nature and sources of food when the river is poor productivity initially, it depends on the food components incidentally.

The results exhibited that mullets species (*P. abu*, *P. klunzengeri*, *P. subviridis* and *O. speigleri*) were revealed herbivores fed mainly diatoms, macrophytes, detritus and algae. The dominant diatoms in the diet of all species are in agreement with the findings of several studies [41, 33, 36, 28, 37]. Some studies reported that detritus constituted the bulk of the food of the species [41, 19], while other studies found that algae were dominated the diet of *P. subviridis*, such as Wahab [49] in Shatt Al-Basrah canal and Mohamed *et al.* [37] in East Hammar marsh. This difference is explained by the fact

that fish have the ability to shift their diets in response to environmental changes or the abundance of food components, so the change in the temporal and spatial diet may be due to the abundance of food components [50]. Coad [16] mentioned that mullets are herbivorous and/or detritivorous fish, feeding on algae, diatoms and small invertebrates associated with algae, and detritus obtained from bottom muds and sands.

The study showed that *P. abu* and *P. klunzengeri* were generalized feeders, while *P. subviridis* and *O. speigleri* were low specialization feeders. The current study differed from that of Hussain *et al.* [41] who considered *P. klunzengeri* and *P. subviridis* as highly specialized fish in the East Hammar marsh, and also indicated that *P. abu* were highly specialized in Al-Hawizeh marsh, and low specialized in the East Hammar and Suq Al-Shuyoukh marshes (Table 4). Moreover, *P. klunzengeri* was recorded as being low specialized in the Shatt Al-Basra and highly specialized in the Shatt al-Arab, while *P. subviridis* individuals were low specialized in the two regions, respectively [13, 15]. The reason for the different specialization of species is due to fluctuations in the abundance of food items. Offem *et al.* [51] stated that the environmental characteristics of the Cross River in Nigeria made the fish replace one food component with another as a result of fluctuation in the abundance of food items, and this made the fish's ability to use many food items effectively.

The results showed that the Clupeids species (*T. illisha* and *N. nasus*) were filter feeders and omnivores, *T. illisha* fed mainly on zooplankton, algae, detritus and macrophytes, while *N. nasus* on diatoms, snails, zooplankton, macrophytes, detritus and algae. Also, the study indicated that a large number of *T. illisha* entering the Shatt Al-Arab River stopped feeding. Several authors have been reported that *T. illisha* was omnivore's species in different waters [52, 48, 37, 53-55]. Conversely, some authors stated that *T. illisha* were herbivores species [56, 32, 33, 57, 28]. De *et al.* [53] stated that diatoms, algae and crustaceans formed the major constituents of food in the gut of *T. illisha* of all sizes, and copepods were the most important food items consumed in their early stages. Some authors have been stated that *N. nasus* was omnivores species in some waters [13, 58].

The current study showed that *T. ilisha* was low specialized and *N. nasus* was generalized feeders and this was confirmed by Taher *et al.* [15] who considered *T. ilisha* to be low specialized. Also, it was found that *N. nasus* in the Shatt Al-Basra [13] and *T. ilisha* in the East Hammar marsh [28] were generalized feeders. Mukherjee *et al.* [58] stated that *N. nasus* was a generalized feeder on microplankton, with specialization on benthic foraminiferans and Chlorophyceae in Chilika Lagoon, India.

The study revealed that both cichlids species (*O. aureus* and *C. zillii*) are considered herbivores. *O. aureus* fed mainly on macrophytes, algae and diatoms, whereas *C. zillii* consumed mainly macrophytes and algae. These research findings are similar to the previous study on *O. aureus* conducted by Dadebo *et al.* [43] in Lake Koka, Ethiopia, Khalifa [59] in the Tigris river, Iraq and Mohamed and Al-Wan [60] in the Garmat Ali river. Also, the previous studies stated that the *C. zillii* was herbivores, such as Wahab [34] in Tigris river, Iraq, Onyeche *et al.* [61] in the Anwai stream, Niger, Dadebo *et al.* [43] in Lake Koka, Ethiopia, Adams [62] in the Tiga dam, Nigeria and Mohamed and Al-Wan [60] in the Garmat Ali river.

The results revealed that *C. zillii* was a highly specialized feeder, while Shep *et al.* [63] considered *C. zillii* as generalized feeder in Ayamé Lake, Côte d'Ivoire. Shalloof *et al.* [64] stated that Cichlid fish species did not consume food at random but have the ability to select and choose the preferred foodstuff even during different seasons.

The study revealed that *A. arabicus* is considered a carnivore and generalized feeder, preyed mainly on shrimps, crabs, crustaceans, snails and insects. This agreed with the findings of some studies on *A. arabicus*, such as Hussain *et al.* [65] in the Khor-Al-Zubair, Iraq, Hussain *et al.* [41] and Mohamed *et al.* [48] in the southern marshes of Iraq and Mohamed and Hussain [37] in the East Hammar marsh. Conversely, the species was herbivores in the Shatt Al-Basrah [13] and omnivores in the Shatt Al-Arab River [15]. Hussain *et al.* [41] and Taher [13] considered *A. arabicus* as highly specialized feeder in the East Hammar marsh and in the Shatt Al-Basrah, respectively, while Taher *et al.* [15] considered the species as low specialization feeder in the Shatt Al-Arab River.

The study showed that both sciaenid species (*J. belangerii* and *J. dussumeiri*) are considered carnivores. *J. belangerii* preyed upon shrimps, crabs and fish, while *J. dussumeiri* preyed mainly on shrimps and fish. This finding of *J. belangerii* was similar to the previous Iraqi studies [66, 13]. Taher *et al.* [15] observed that *J. belangerii* fed mainly on crabs and shrimps in the Shatt Al-Arab River. However, Al-Dubakel [14] found that *J. belangerii* preyed fish (70%) and fish eggs (30%). Simanjuntak and Rahardjo [67] indicated that *J. Belangerii* in the Mayangan coast in the western Java province of Indonesia fed mainly on shrimps. Also, similar findings in other waters about *J. dussumeiri* [68, 69, 66]. Shrimps were also observed in the most important food item in the diet of *J. dussumeiri* in the Shatt Al-Arab River [15].

The nature of the trophic relationship in fish species is greatly affected by the diversity of food items, as well as by temporal and spatial changes in the river, and the seasonal changes in the diets of species make the fish specialized in

exploiting the sources, and on the other hand, these differences do not exist if the food resources are still available throughout the year and in sufficient quantities [70, 71].

The results exhibited that *J. belangerii* was a generalist feeder, while *J. dussumeiri* was a highly specialized feeder. Ali *et al.* [68] found that *J. sina* (*J. dussumeiri*) was low specialized feeder in Iraqi marine waters. Mohamed *et al.* [66] stated that *J. dussumeiri* was low specialized feeder, while *J. belangerii* was generalized feeder in Iraqi marine waters. Taher [13] and Taher *et al.* [15] found that *J. dussumeiri* individuals were high specialized feeders in both Shatt Al-Basrah canal and the Shatt Al-Arab River.

The results demonstrated eight high degrees of dietary overlaps between the studied species in the Shatt Al-Arab River, between *C. luteus* and *C. auratus*, between *P. abu*, *P. klunzengeri*, *P. subviridis* and *O. speigleri*, and between *C. zillii* and *O. aureus*. Other dietary overlaps exhibited moderate or low diet overlaps, except two species, *J. dussumeiri* and *J. belangerii* showed no diet overlap with other species, excluding with *A. arabicus*. The dietary overlap between *C. luteus* and *C. auratus* was also documented in the previous Iraqi studies [31, 34, 33, 28]. Several studies referred to high diet overlaps between the mullets species in the other Iraqi waters, such as Lazem [34] between *P. abu*, *P. subviridis* and *P. klunzengeri* in Garmat Ali River, Mohamed *et al.* [48] between *P. subviridis* and *P. klunzengeri* in the East Hammar and Mohamed *et al.* [28] between *P. abu* and *P. subviridis* in East Hammar marsh.

Martins *et al.* [72] stated low trophic niche overlapping between two fish species suggests a stable coexistence developed by both species, which allowed them to reach great abundance in the region. However, high overlap values may not indicate competition since species can adopt different strategies to overcome competence. The cluster analysis of the dietary overlap among fish diets in the Shatt Al-Arab River distinguished the following feeding strategies for the fish species: (1) species with herbivorous feeding habits, feeding mainly on macrophytes, algae and diatoms (*O. aureus* and *C. zillii*) or on diatoms, macrophytes, detritus and algae (*P. abu*, *P. klunzengeri*, *P. subviridis* and *O. speigleri*), (2) species with omnivorous feeding habits consuming macrophytes, detritus, diatoms and algae but with aquatic macroinvertebrates as an important complement (*C. luteus*, *C. auratus* and *C. carpio*), (3) species with omnivores and filter feeders, feeding mainly on zooplankton, algae, detritus and macrophytes (*T. illisha* and *N. nasus*), (4) species with carnivorous feeding habits preying mainly on shrimps and crabs (*A. arabicus* and *J. belangerii*) or on shrimps and fish (*J. dussumeiri*).

Silva *et al.* [73] stated that the high values of dietary overlaps between fish species in the Itiz stream, Brazil referred to the food resource partitioning among fish species, and were associated with the abundance of these ingredients through the importance of vegetation, which is a source of conservation of the fish assemblage in the river. The high numbers of significant diet overlap indicated that a theoretical competition existed on food resources in the area, but the high availability of food resources offset such competition [74].

5. Conclusion

The study demonstrates that most trophic overlaps between species were moderate, but high degree overlap was between the native species (*C. luteus*) and invading species (*C. auratus*) and therefore strengthen earlier conclusions regarding interspecific competition between these two species.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors declare no conflict of interest regarding the publication of this paper.

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