Food and Trophic Relationships of Four Mullet Fish (Mugilidae) in the Shatt Al-Arab River, Iraq

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ABSTRACT---- *Food composition and feeding relationships of four mullet species, Planliza abu, P. subviridis, P. klunzingeri and Osteomugil speigleri from the Shatt Al-Arab River, Iraq, were assessed during 2016-2017.Fish were captured by gill nets, cast net and electro-fishing. The index of relative importance (IRI%) of food item was determined by combined the frequency of occurrence and points methods. Monthly variations in feeding activity and intensity of all species were observed. All species were herbivorous and P. abu and P. klunzingeri were considered non-specialized feeders, while P. subviridis and O. speigleri were low specialist feeders. P. abu fed mainly on diatoms (38.6%), high plants (21.7%), algae (15.9%), detritus (15.3%), fish eggs (6.9%) and zooplankton (1.6%).The diet of P. subviridis constituted from diatoms (42.2%), high plants (20.9%), detritus (17.7%), algae (15.9%), zooplankton (2.0%) and fish eggs (1.8%). P. klunzingeri fed mainly on diatoms (35.5%), high plants (29.3%), detritus (16.4%), algae (13.4%), fish eggs (4.1%) and zooplankton (2.4%). O. speigleri were consumed mainly diatoms (52.0%), detritus (17.8%), algae (16.6%), high plants (10.7%), zooplankton (2.5%) and fish eggs (2.4%).Similarity dendrogram among fish species based on their diet showed high significant overlaps among the mullet species. It means that these species might be in direct competition for food in the Shatt Al-Arab River.*

Keywords-- Mullet fish, food habit, herbivorous, Shatt Al-Arab River, Iraq

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1. INTRODUCTION

Mugilidae is a widely distributed family and its member species are generally known as mullets inhabit coastal waters and estuaries of the tropical and subtropical zones of world seas, but also depending on the species, spend part or even their whole life cycle in coastal lagoons, lakes and rivers [1].This family represented of 303 available species and only 77 valid species [2]. Mullets constituted a very significant contribution (30%) to the production of pelagic fish in the northwest Arabian Gulf [3]. Five species of mullets inhabit the Iraq waters, four in marine waters (*Planliza subviridis, P. carinata, P. klunzingeri* and *Osteomugil speigleri*), locally known as Beyah and one species, *P. abu* locally known as Khishni lives in fresh and brackish waters [4-5]. The contribution of mullet's species in the Iraqi marine waters increased from 12.3% (2239.6 tons) during 1990-1994 [6] to 22.1% (6651.0 tons) from the total landings during 2008-2018 [7].

Information on the food habits and trophic interrelationships of fish is essential to understand the life history of fish including growth, behavior, reproduction, migration and other vital activities of fish, and also help to understand the predicted changes on ecosystem due to natural or anthropogenic interventions [8-9].

Many researchers have published their reports on food habits of mullet fish at different water bodies of Iraq; about *P. abu* [10-21] and about *Planliza subviridis* and *P. klunzingeri* [14, 22-24, 21, 25], but up until now, the food habit of *O. speigleri* in the waters of Iraq have not been studied.

Studies on the trophic relationships between some mullet species and other fish species have been made by many workers at different Iraqi waters [26-28, 21, 29-32].

During the last years, the Shatt Al-Arab River has been suffered from the deterioration of the water quality due to series of anthropogenic activities such as agricultural runoff wastes and untreated wastewater, invasion of fish species and seawater intrusion as a result of drastically reduced in water quantity and quality related to the decline in rates of the flow from the Tigris, Euphrates and Karun Rivers [33-35]. Therefore, the present work is designed to described the food and trophic relationships of *P. abu, P. subviridis, P. klunzingeri* and *O. speigleri* in the Shatt Al-Arab River under this circumstance.

2. MATERIALS AND METHOD

The Shatt Al-Arab River forms from the confluence of the Tigris and Euphrates rivers at Al-Qurna town, in the southern of Iraq, and flows to southeastern direction towards the Arabian Gulf (Fig. 1). It is about 204 km, and varies in width from 250to 1,500 m at the estuary. The river is affected by the tidal current of the Gulf. Fish were sampled monthly between November 2015 and October 2016 from the three sites on the river. 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 (Fig. 1).
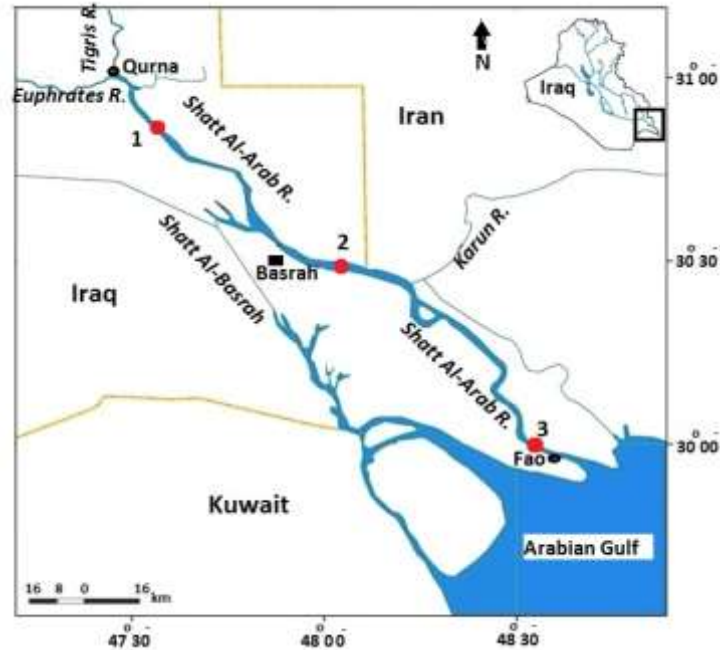

Figure 1: Map of Shatt Al-Arab River with locations of study sites.

The fish were caught from each site using various devices including gill nets, cast net and electro-fishing. After capture, the fish were preserved in ice in a cooler box prior to dissection in the laboratory. Some relevant ecological factors were determined in situ namely, water temperatures and salinity.

During laboratory analysis, the total length (TL, cm) of each fish was measured. The gut of the fish was removed by making a longitudinal incision along the mid ventral line. The stomach was cut off from the gut and gives the degree of fullness, and then opened in Petri dish to examine different food items. The stomachs were scored 0, 5, 10, 15 and 20 points according to its fullness as described by [36] Hynes (1950). Each stomach was split open and the contents emptied into a Petri-dish. The contents were then observed under a stereoscopic microscope. The food items were identified with the aid of keys provided by [37], [38] and [39].The food items were grouped into diatoms, high plants, algae, detritus, fish eggs and zooplankton.

The stomach content was analyzed on the basis of the percentage of points (P%) and frequency of occurrence (O%) methods following [40]. The importance of food item was determined by combined the two methods to calculate the index of relative importance (IRI%) of [41] as follows:

$$IRI = O\% \times P\% \text{ and } IRI\% = IRI / \Sigma IRI * 100$$

Feeding intensity and feeding activity for each monthly sample were calculated after [42] and [43], respectively. The feeding index was determined after [45]. The vacuity index was calculated as the number of empty stomachs divided by the number of stomachs analyzed [46].

The trophic niche breadth for each species was calculated according to the formula proposed by [47]:

$$B = 1/\Sigma P_i{}^2$$

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 [48] 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 feeder's species

fall within the range of 0.0-0.25, while the low specialized feeders between 0.26-0.49 and non-specialized (generalized) feeders are within the range of 0.50-1.0.

The dietary overlap among diets of mullet species was evaluated using cluster analyses for food items that represented more than 10% relative importance were considered major items in the diet of each species and according to the method described by [49].

3. RESULTS

Food habits of 1,762mullet's fish were assessed, including 555 of *P. abu* (TL= 65-195 mm), 456 of *P. subviridis*(TL= 98-265 mm), 564 of *P. klunzingeri*(TL= 96-227 mm) and 187 of *O. speigleri* (TL= 115-181 mm).

The monthly changes in the feeding activity and intensity of the four species are given in Figure 2. The feeding activity of *P. abu* fluctuated from 56.1% in January to 98.2% in July, and the feeding intensity ranged from 5.2 point/fish in July to 11.2 point/fish in September. The feeding activity of *P. subviridis* varied from 39.1% in January to 97.6% in September, whereas, the feeding intensity fluctuated from 5.0 point/fish in July to 12.7 point/fish in September. The feeding activity of *P. Klunzingeri* changed from 45% in January to 100% in April, while, the feeding intensity ranged from 7.0 point/fish in December to 10.2 point/fish in April. *O. speigleri* individuals were not caught during November, February and May. The feeding activity of this species changed from 55% in January to 100% in April, and the feeding intensity varied from 5.5 point/fish in January to 10.8 point/fish in April.
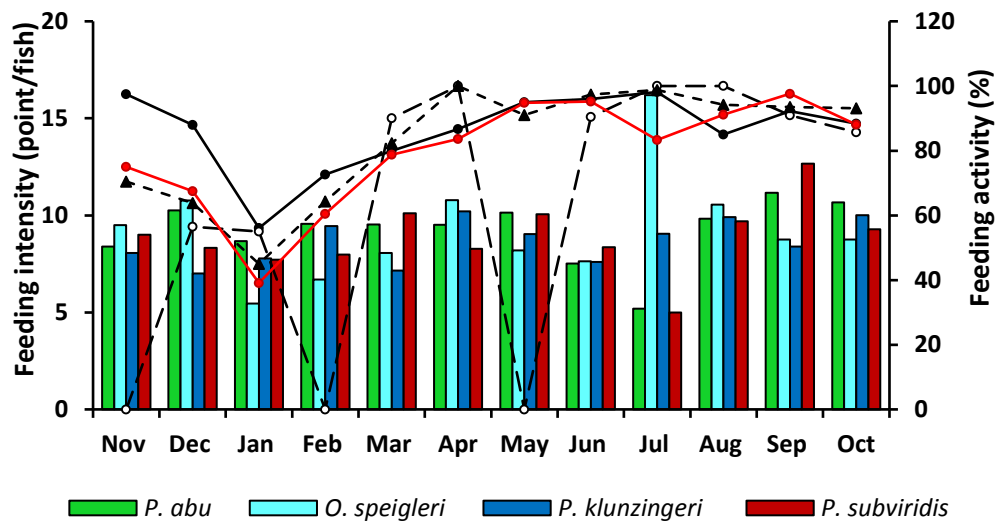

Figure 2: Monthly changes in feeding activity and intensity of four species

The monthly fluctuations in the feeding and vacuity indices of *P. abu*, *P. subviridis*, *P. Klunzinger* and *O. speigleri* in the Shatt Al-Arab River are illustrated in Figure (3).The feeding index of *P. abu* ranged from 26.0% in July to 55.8% in September, *P. subviridis* varied from 25.0% in July to 63.3% in September, *P. klunzingeri* fluctuated from 30.8% in December to 50.9% in April and *O. speigleri* differenced from 27.3% in January to 81.0% in July. The overall values were 45.8, 44.4, 43.2 and 36.2% for the four species, respectively. The vacuity index of *P. abu* fluctuated from 1.9% in July to 43.9% in January, *P. subviridis* varied from 2.4% in September to 60.9% in January, *P. klunzingeri* varied from 0.0% in April to 55.0% in January and *O. speigleri* changed from 0.0% in November, February, April, May, July and August to 45.0% in January. The overall values of vacuity index for the four species were 13.7, 20.7, 17.2and 11.0%, respectively.
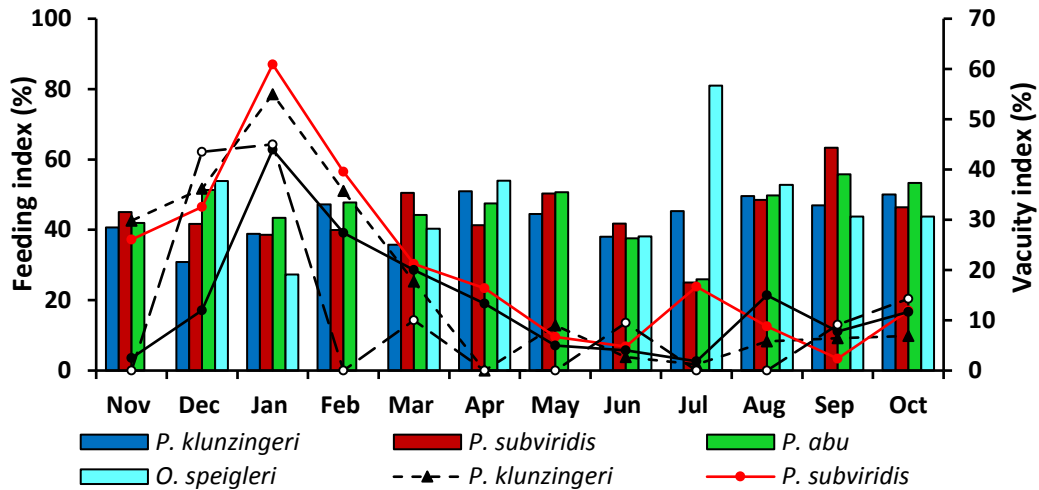
Figure 3: Monthly variations in the feeding and vacuity indices of the four species

The monthly data of various food items of *P. abu*, *P. subviridis*, *P. klunzingeri* and *O. speigleri* were pooled to describe the seasonal variations in the food habits of the species (Fig. 4). It appeared that all species depend on four major food items. Diatoms were the dominant item in the gut of *P. abu* during the study period and the percentage contribution according to the index of relative importance (IRI) ranged from 25.0% in summer to 55.1% in winter. The second most important food item was high plants constituting 7.5% in winter and 20.9% in summer. Algae occupied the third position and ranged from 9.8% in winter to 21.6% in autumn. The contribution of detritus in the diet of the species fluctuated from 11.7% in summer to 19.2% in autumn. The additional food composed of fish eggs and zooplankton were mainly consumed in autumn and spring, respectively. Generally, this species is classified as herbivorous and fed mainly on diatoms (38.6%), high plants (21.7%), algae (15.9%), detritus (15.3%), fish eggs (6.9%) and zooplankton (1.6%).

P. subviridis consumed mostly diatoms and their percentage varied from 34.5% in summer to 48.4% in spring. High plants occupied the second position and ranged from 14.4% in spring to 30.3% in summer. Detritus came in the third place and fluctuated from 12.3% in spring to 22.8% in summer. The lowest value of algae in the diet of *P. subviridis* was 10.4% in summer and the highest value was 22.2% in spring. The other food items were zooplankton and fish eggs fluctuated over season, but their highest values were observed in winter. However, the overall food items of *P. subviridis* were constituted from diatoms (42.2%), high plants (20.9%), detritus (17.7%), algae (15.9%), zooplankton (2.0%) and fish eggs (1.8%).
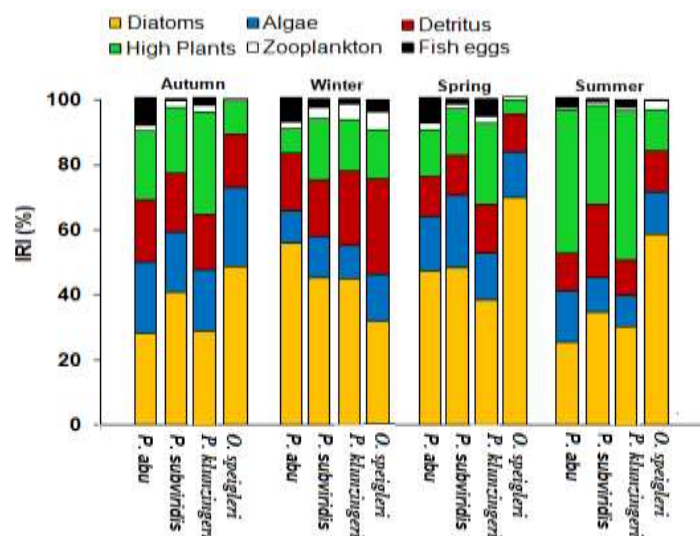

Figure 4: Seasonal changes in the IRI% of food items in the diet of the three species

The major food item of *P. klunzingeri* was diatoms, their percentage contribution ranged from 28.9% during autumn and 44.6% during winter, while the contribution of high plants varied from 15.5% in winter to 45.4% in summer. Detritus occupied the third position and fluctuated from 10.9% in summer to 23.1% in winter. The lowest value of algae in the diet of *P. Klunzingeri* was 9.7% in summer and the highest value was 18.7% in autumn. The highest values of fish eggs and zooplankton in the diet of the specieswere 5.6% and 4.8% in spring and winter, respectively. Generally, this species fed mainly on diatoms (35.5%), high plants (29.3%), detritus (16.4%), algae (13.4%), fish eggs (4.1%) and zooplankton (2.4%).

The diet of *O. speigleri* was mainly dominated by diatoms, which ranged between 32.2% in winter and 68.9% in spring. Detritus occupied the second position and ranged from 11.6% in spring to 30.3% in winter. Algae came third and varied from 12.9% in summer to 24.5% in autumn. The contribution of high plants fluctuated from4.4% in spring to 15.4% in winter. The highest values of zooplankton and fish eggs in the diet of the specieswere 5.3% and 4.2% in winter, respectively. The overall food items of *O. speigleri* were formed from diatoms (52.0%), detritus (17.8%), algae (16.6%), high plants (10.7%), zooplankton (2.5%) and fish eggs (2.4%).

The feeding selectivity index for the various diet items of *P. abu*, *P. subviridis*, *P. klunzingeri* and *O. speigleri* in the Shatt Al-Arab is illustrated in Figure6. The highest mean value of the index (38.5%) was for diatoms with the maximum value (29.9%) for *P. abu*, followed by high plants(23.3%) with the highest value(43.4%) for *P. klunzingeri*. Algae ranked third with 14.2% and the maximum value(34.4%) for *P. abu*. Detritus came fourth with 14.1% and the highest value (33.4%)for *P. abu*. Fish eggs ranked fifth by 3.3% and the maximum value (69.0%) for *P. abu*. Zooplankton placed sixth with 1.6% and the highest value (34.2%) for *P*.

The results of feeding specialization for the four species showed that the index of Levins standardized niche breadth for *P. subviridis* and *O. speigleri* were low specialist feeders (B_i= 0.492 and 0.365, respectively), while *P. abu*and *P. klunzingeri* were considerednon-specializedfeeders(B_i= 0.575 and 0.551, respectively).
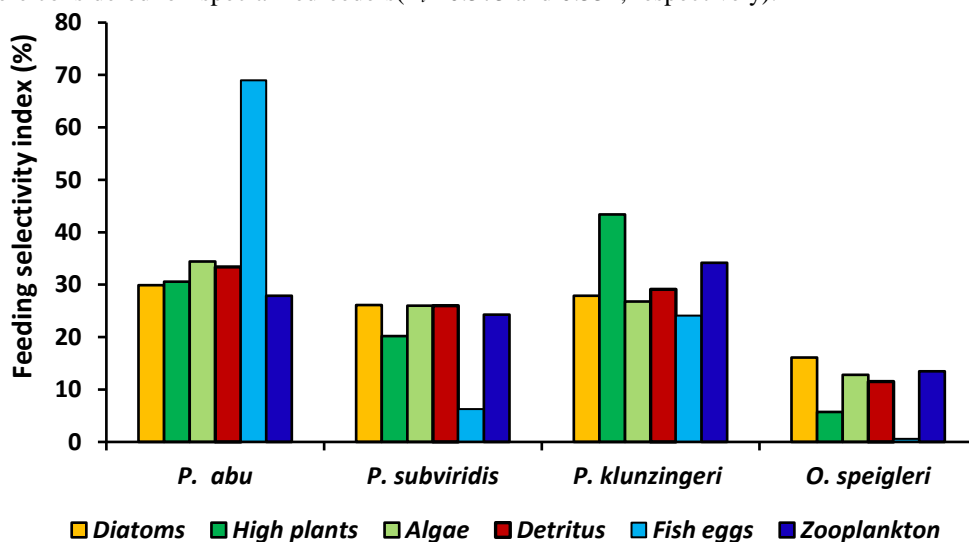

Figure 5: Feeding selectivity index for the different food items of the four species

Similarity dendrogram among fish species based on their diet showed high significant overlaps (Cλ = 1.000) among the mullet species, the overall feeding patterns of the four species characterized by high intake of food items of diatoms, high plants and algae.

4. DISCUSSION

The study revealed that all studied species are continuous feeders and never cease feeding all the year round, despite notable monthly fluctuations in their feeding activities and intensities. The higher values of feeding intensity and activity which recorded in warm periods of the year were coincided with rise in ambient water temperature. [50] stated that the water temperature is the principal environmental factor affecting the gut fullness of fish. This finding agreed with the previous dietary studies on these species, such as [27] on *P. subviridis* in Garmat Ali River; [20] on *P. abu* in Tigris River and [51] on *P. abu* in Eastern Drainage River, Tikrit, Iraq.

The results exhibited that the *P. abu* in the present study was herbivorous, non-specialized feeder and fed mainly on plant components (diatoms, 38.6%, high plants, 21.7% and algae, 15.9%). The dominant of diatoms in the diet of the species is in agreement with the findings of several studies. [27] Lasim (2009) found that diatoms formed 58.6% of *P. abu* diet in Garmat Ali River. [52] stated that *P. abu* consumed diatoms (79.4%) and algae (119.0%) in southern marshes, Iraq. [31] Mohamed *et al.* (2015) stated that diatoms (42.1%3), algae (26.6%) and detritus (15.6%) were apparent in the gut of *P. abu* in East Hammar marsh. However, [14] mentioned that *P. abu* consumed detritus (19.9%), high plants (17.2%), algae (17.2%) and diatoms 16.0%) in Shatt Al-Basrah. [20] found detritus (31.6%), algae (18.2%), zooplankton (12.3%), aquatic plants (8.9%) and diatoms (5.7%) in the gut of *P. abu* in Tigris River.

During the present work, *P. klunzingeri* was found to be herbivores, non-specialized feeder and consumed mainly diatoms (35.5%), high plants (29.3%),detritus (16.4%) and algae (15.9%). Some previous studies have the same results, such as [27] mentioned that *P. klunzingeri* in Karmat Ali River fed on diatoms (42.0%), alge (21.7%), detritus (15.1%) and high plants (8.4%) and [24] stated that the species consumed diatoms (37.0%), detritus (34.0%), high plants (9.0%) and alge (9.0%).Whereas, other studies reported that detritus constituted the bulk of the food of the species [52, 32].

P. subviridis was found to be herbivorous, low specialist feeder and fed more on diatoms (35.5%), high plants (29.3%), detritus (16.4%) and algae (13.4%) in the present study. Several authors considered the diatoms were the most important food items for this species [52, 27, 24, 21]. However, [14] stated that this species consumed algae (30.1%), high plants (16.4%), diatoms (15.0%) and detritus (13.9%) in Shatt Al-Basrah canal. [22] found detritus (35.1%), diatoms (20.0%), crustacean (6.3%) and high plants (6.2%) were the food items for *P. subviridis* in Khor Al-Zubair. [23] mentioned that *P. subviridis* fed mainly on detritus (19.1%), diatoms (16.7%), high plants (12.7%) and algae (12.5%) in the Iraqi marine waters. [31] stated that algae (34.3%), diatoms (33.2%) and detritus (13.0%) were the common food items found in the gut of *P. subviridis* in East Hammar marsh.

The food analyses of the gut of *O. speigleri* clearly indicated that the fish was herbivores, low specialist feeder and consumed mainly diatoms (52.0%), detritus (17.8%), algae (16.6%), high plants (10.7%) in the present study. [53] mentioned that *O. speigleri* fed mainly on detritus (26.7%), diatoms (13.7%), high plants (10.4%) and algae (10.1%) in Iraqi marine waters.

Analysis of food similarity between the four species showed high significant overlaps among the mullet species, all fed mostly on plant origin than the other. It means that these species might be in direct competition for food in the Shatt Al-Arab River. [54] 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.

[55] stated that the diet of most species of mullet fish in the St. Lucia lake system of South Africa consisted of snail, *Assiminea bifasciata*, foraminifera, the large centric diatom *Aptinoptychus splendens*, small centric and pennate diatoms, and filamentous algae. Moreover, [56] mentioned that the Plant materials were the most abundant food items by numerical and occurrence methods in the gut of two mullet species and diatom formed the most frequently consumed food item by both species in the estuary of Merbok, Malaysia. It is well known that the feeding and trophic relationships of fish change with availability of food, locality and spatial distribution within the habitat [57]. Also, it is a widely accepted generalization that stream fish are mostly opportunistic in their feeding habits because of the highly variable nature of habitat and resources [58].

5. CONCLUSION

The results revealed that the fish assemblage in the river was clearly shifted in the number of species, the percents of exotic and marine species and the dominancy species compared with the previous status.

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