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Food habits of two mullets inhabiting Iraqi marine waters, Northwest Arabian Gulf

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Abstract

The food habits of 319 specimens of Klunzinger's mullet *Planiliza klunzingeri* (Day, 1888) and 325 samples of Greenback mullet *P. subviridis* (Valenciennes, 1836) from Iraqi marine waters, northwest Arabian Gulf were investigated from February 2020 to January 2021. The stomach contents were analyzed and quantified with the percentage of points and frequency of occurrence methods, as well as with some complementary indices and measures (vacuity, fullness and relative importance). The annual averages of feeding activity for both species were 80.6 and 82.6%, respectively, while the mean values of feeding intensity were 7.8 and 7.6 points/fish, respectively. The annual averages of the feeding index (%) were 38.9 and 38.1% for the two species, respectively, while the mean values of the vacuity index were 19.1 and 15.4%, respectively. Both species can be classified as gluttonous. Analysis of the stomach contents showed that both species were classified as detritivores. *P. klunzengeri* consumed detritus (62.1%), diatoms (12.7%), algae (10.7%) and high plants (8.4%), zooplankton (3.9%) and fish eggs (2.2%), while *P. subviridis* fed on detritus (60.4%), diatoms (12.8%), algae (12.0%), high plants (9.3%), zooplankton (3.6%) and fish eggs (1.9%). Analysis of food similarity between *P. subviridis* and *P. klunzengeri* showed high similarity for the food items according to the Jaccard similarity index.

Keywords: Mullets; Food habits; Detritivores; Arabian Gulf; Iraq

1. Introduction

Members of the family Mugilidae, generally known as mullets, are coastal marine fish with worldwide distribution including all temperate, subtropical and tropical waters, and some species spend part or even their whole life cycle in coastal lagoons, lakes and rivers [1]. This family constitutes 304 available species and 46 available genera, but only 78 valid species belong to 26 valid genera [2]. Of this total, six species of mullets inhabit the Iraq waters [3], including Klunzinger's mullet *Planiliza klunzingeri* (Day, 1888), Greenback mullet *P. subviridis* (Valenciennes, 1836), Largescale mullet *P. macrolepis* (Smith, 1846), Keeled mullet *P. carinata* (Valenciennes, 1836), Silver mullet *Osteomugil speigleri* (Bleeker, 1858), Longarm mullet *O. cunnesius* (Valenciennes, 1836) and Abu mullet *P. abu* (Heckel, 1843). The landings of these species by the Iraqi marine fisheries were reported as 1439 tons, composed of about 12.7% of the total landings in 2019 [4].

P. klunzingeri, formerly known as *L. carinata* [5] is dispersed within the Indian Ocean, the Arabian Sea and the Arabian Gulf [6], while *P. subviridis* distributes widely in coastal waters and estuaries in the Indian and Pacific Oceans: the Arabian Gulf, the Red Sea and South Africa to the coasts of India, China, north to Japan and northern Australia [7]. Formerly both species were placed in the genus *Liza*, but Durand *et al*. [8] placed both in the genus *Planiliza*. They inhabit coastal marine waters and enter the rivers and marshes of southern Iraq for feeding and are locally known as "Beyah".

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The importance of knowledge on food and feeding habits has been well established since food is one of the critical factors that significantly influence the distribution, growth, reproduction, migration rate and evaluation of the ecological role and position of the species in the food web of ecosystems [9-11].

Studies on the food and feeding habits of *P. subviridis* have been made by many authors in different waters around the world such as Chan and Chua [12] in different coastal locations in Malaysia; Wahab [13] in Shatt Al-Basrah Canal, Iraq; Jabir and Al-Hisnawi [14] in Khor Al-Zubair, Iraq; Mohamed *et al*. [15] in the northwest Arabian Gulf; Lasem [16] in the Garmat Ali River, Iraq; Mohamed *et al*. [17] in East Hammar marsh. Iraq; Mohamed and Hussain [18] in Al-Hammar marsh, Iraq; Fatema *et al.* [19, 20] in Merbok Estuary, Malaysia; Mohamed *et al*. [21] in East Hammar marsh, Iraq; Ashiq Ur Rahman *et al.* [22] in Parangipettai waters, India; Al-Dubakel [23] and Tahar, *et al.* [24] in Shatt Al-Arab River, Iraq; Al Ghiffary *et al*. [25] in Pabean Bay, Indonesia; Mohamed and Abood [26] in the Shatt Al-Arab River, Iraq; Langsa *et al*. [27] in Lampon Estuary, Indonesia. However, few studies have been done on the diets of *P. klunzengeri* including Mohamed and Hussain [18] in Al-Hammar marsh; Al-Dubakel [23], Tahar, *et al.* [24] and Mohamed and Abood [26] in Shatt Al-Arab River, Iraq.

The objective of the present study was intended to examine the food habits of two mullets species, *P. klunzengeri* and *P. subviridis* during different seasons in Iraqi marine waters, northwest Arabian Gulf to provide information that may help in defining the trophic relationship that exists in this estuarine environment and for identification of stable food preferences.

2. Material and methods

The Iraqi marine waters occupy the northwestern tip of the Arabian Gulf representing the estuarine part of the Gulf (Fig. 1). The region is dominated by the large river delta of the rivers Euphrates, Tigris and Karun, merging into the Shatt Al-Arab that represents the main outflow in the Arabian Gulf [28]. The surface water temperature values ranged from 12.4 °C in January to 37.2 °C in June, and salinity varied from 28.1% in November to 47.3 % in July [29]. The main fishing grounds for Iraqi marine fisheries, include the Shatt Al-Arab estuary, Khor Abdulla and Khor Al-Amaya [30]. Fish samples were randomly collected from the Al-Fao port landing site in the northwestern part of the Arabian Gulf from February 2020 to January 2021, except April [31]. The fishermen employed multifilament gears such as drift gillnets, trawl nets, traps and hook and line [3].

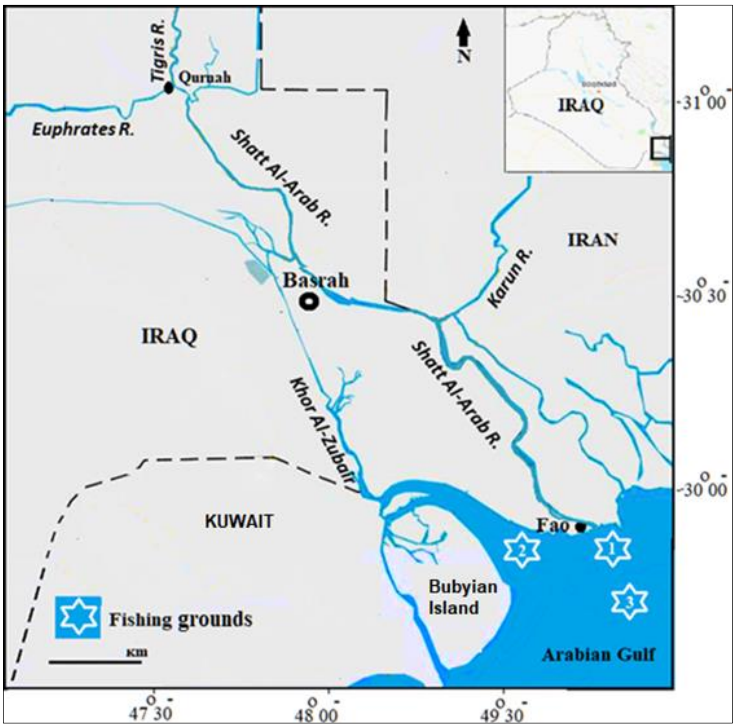

Figure 1 Map of Iraqi marine waters with locations of fishing grounds.

All specimens were preserved with crushed ice in cool fish boxes and brought to the laboratory as soon as possible. In the laboratory, total length and body weight were measured with the help of a measuring scale to the nearest cm 0.01 cm and with the help of an electric balance to the nearest 0.01g, respectively. Then each fish was dissected and the alimentary tract was removed. The degree of fullness of the stomach was assessed by visual estimation and scored 0, 5, 10, 15 and 20 points according to its fullness as empty, ¼ full, ½ full, ¾ full and full, respectively [32].

Each stomach content was emptied into a Petri dish, and diet composition was examined under a stereoscopic microscope to identify the food items with the aid of keys provided by [33, 34]. The food items were grouped into diatoms, high plants, algae, detritus, fish eggs and zooplankton.

Feeding intensity and feeding activity for each monthly sample were calculated after Dipper *et al*. [35] and Gordan [36], respectively:

$$\text{Feeding activity} = \text{Number of fish fed}/\text{Total number of fish examined} \times 100$$

$$\text{Feeding intensity} = \text{Sum of the fullness index scores}/\text{Number of fish fed} \times 100$$

The percentage of empty stomachs to the total number of examined stomachs was expressed as the vacuity index, %VI [37]:

$$VI = \text{Number of empty stomachs}/\text{Total number of stomachs examined} \times 100$$

The interpretation of the obtained VI is determined under the following conditions [38]. If, $0 \leq VI < 20$, the logical conclusion is that the fish is gluttonous, $20 \leq VI < 40$, the fish is comparatively gluttonous, $40 \leq VI < 60$, the fish is middle alimentary, $60 \leq VI < 80$, the fish is comparatively hypo-alimentative, $80 \leq VI < 100$, fish is hypo-alimentative.

The feeding index was calculated after Sarkar and Deepak [9]:

$$\text{Feeding Index} = P/N \times X \times 100,$$

Where;

P= Total points of the stomachs that were examined, N= Number of stomachs examined and X= Total points allotted to the full stomachs.

The stomach content was analyzed basis on the percentage of points (P%) and frequency of occurrence (O%) methods following [39]. The main food items were identified using the index of relative importance (IRI) of Pinkas *et al.* [40], as modified by Stergion [41]:

$$IRI = O\% \times P\%$$

This index has been expressed as: $\%IRI = (IRI/ \sum IRI) \times 100$

The feeding selectivity (PX_i) for different food items was calculated according to the following equation [42]:

$$PX_i = X_i / \Sigma\, i$$

Where X_i = quantity of item i^{th} in the stomach of species (i) and Σ i= sum of the item (i) in all stomachs of all species.

The similarity among diets of the two species in the study region was evaluated according to the Jaccard similarity index using the SPSS software (ver. 16) statistical package.

3. Results

A total of 319 *P. klunzingeri* and 325 *P. subviridis* were collected all year round, having total lengths ranging from 11 to 27 cm and 12.0 to 30.0 cm, respectively. The monthly data on the feeding parameters of both species were gathered to describe the seasonal variations in the feeding intensity and activity, feeding and vacuity indices, percentage of empty stomachs and the food habits of the two species. The seasons were spring (March-May), summer (June-August), autumn (September-November) and winter (December-February).

3.1. Feeding intensity and activity

A comparison of the monthly fluctuations in feeding intensity and activity of the two species is illustrated in figure 2. The feeding activity of *P. klunzingeri* varied from 48.3% in January 2022 to 96.6% in May 2021, and the feeding intensity from 6.3 points/fish in June 2021 to 10.4 points/fish in October 2021, while the feeding activity of *P. subviridis* fluctuated from 68.9% in January 2022 to 100% in June 2021, and the feeding intensity from 6.4 points/fish in March 2021 to 9.3 points/fish in October 2021.

The two species in the present study, *P. klunzingeri* and *P. subviridis* showed similar seasonal patterns in feeding activity and intensity (Table 1). The lowest values of feeding activity for both species occurred in winter, when the values of the index were 75.9 and 78.1%, respectively, while the highest values happened in spring, 91.4 and 89.7%, respectively. Meanwhile, the peak feeding intensity occurred in autumn, when the values were 9.0 and 8.3 points/fish for *P. klunzingeri* and *P. subviridis*, respectively, and the lowest values were recorded in spring, 6.6 and 6.5 points/fish, respectively. The annual averages of feeding activity for both species were 80.6% ± 13.2 and 82.6% ± 10.0, respectively, while the mean values of feeding intensity were 7.8 points/fish ± 1.3 and 7.6 points/fish ± 0.9, respectively.

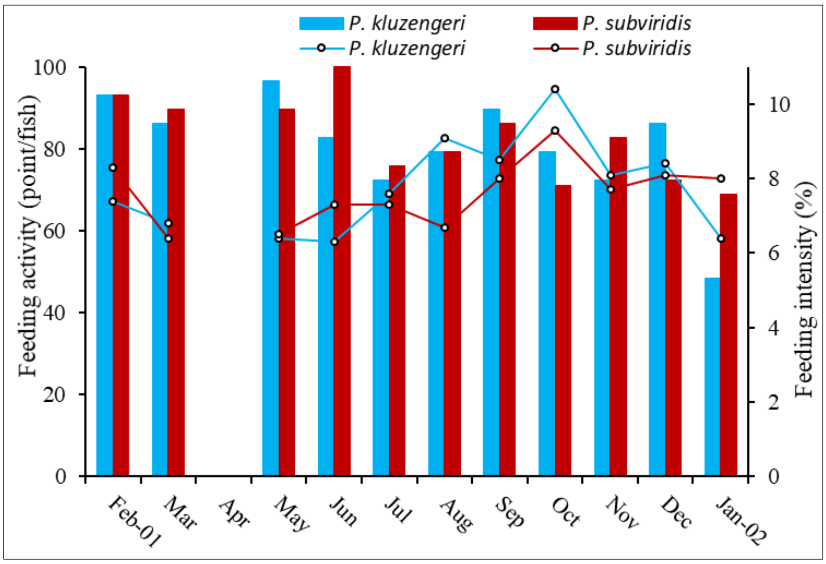

Figure 2 Monthly changes in feeding activity and intensity of *P. klunzingeri* and *P. subviridis*

Table 1 Seasonal variations in the feeding parameters of *P. klunzingeri* and *P. subviridis*

P. klunzingeri	**Winter**	**Spring**	**Summer**	**Autumn**
Feeding activity	75.9	91.4	78.2	80.5
Feeding intensity	7.4	6.6	7.7	9.0
Feeding index	37	33.1	38.4	45
Vacuity index	24.1	8.7	20.7	19.5
P. subviridis				
Feeding activity	78.1	89.7	85.1	80
Feeding intensity	8.1	6.5	7.1	8.3
Feeding index	40.7	32.7	35.7	41.6
Vacuity index	19.7	10.3	14.9	14.9

3.2. Feeding and vacuity indices

The feeding index of *P. Klunzinger* fluctuated from 31.3% in June to 52.2% in October 2021, and *P. subviridis* from 32.6% in March to 46.3% in October (Fig. 3). The vacuity index of *P. Klunzinger* varied from 3.5% in May to 51.7% in January 2022, while *P. subviridis* ranged from 0.0% in June to 31% in January 2022. The two species in the present study showed similar seasonal patterns in feeding and vacuity indices (Table 1). The lowest values of feeding index for both species showed in spring, 33.1 and 32.7%, respectively, while the highest values occurred in autumn, 45.0 and 41.6%, respectively. The lowest values of the vacuity index were recorded in spring, 8.7 and 10.3% for *P. klunzingeri* and *P. subviridis*, respectively, and the highest values were found in winter, 24.1 and 19.7%, respectively. The annual averages of the feeding index were 38.9% ± 4.2 and 38.1% ± 6.52 for the two species, respectively, while the mean values of the vacuity index were 19.1% ± 13.0 and 15.4% ± 8.2%, respectively. It means that both species can be classified as gluttonous.

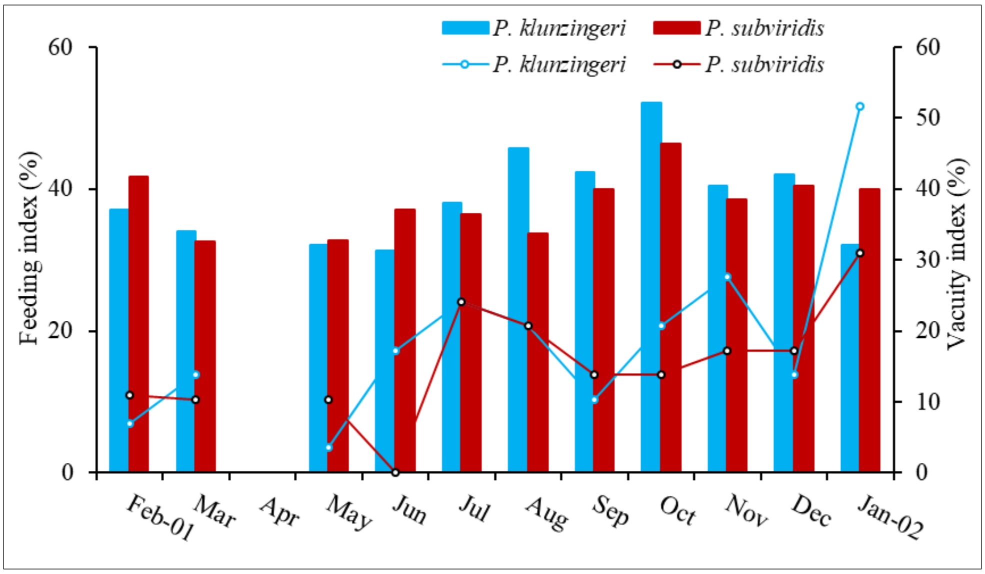

Figure 3 Monthly variations in the feeding and vacuity indices of *P. klunzingeri* and *P. subviridis*

3.3. Diet composition

According to the index of relative importance (IRI) for *P. klunzengeri*, detritus dominated the food items for all seasons (Fig. 4), so they can be regarded as the preferred food. The percentage contribution of detritus varied from 46.6% during spring to 71.3% during autumn, while the contribution of diatoms fluctuated from 6.2% in autumn to 21.6% in spring. Algae engaged in the third position ranging from 6.4% in winter to 13.5% in autumn. Other diets consisted of higher plants, zooplankton and fish eggs. The lowest values of higher plants, zooplankton and fish eggs were 5.1%, 2.6% and 2.2% in autumn, respectively, and the highest values were 11.5%, 5.1% and 3.5% in spring, respectively. Generally, stomach contents of *P. klunzingeri* included food items from six major taxonomical groups, detritus (62.1%), diatoms (12.7%), algae (10.7%), high plants (8.4%), zooplankton (3.9%) and fish eggs (2.2%), and classified as detritivores.

Detritus were the dominant item in the stomach of *P. subviridis* during this study and their percentage contribution according to IRI% varied from 44.4% in spring to 74.7% in autumn (Fig. 4). The second most important food item was diatoms constituting 4.1% in winter and 24.3% in spring. Algae occupied the third rank and varied from 10.2% in summer to 13.1% in winter. The other food items included higher plants, zooplankton and fish eggs. The lowest values of higher plants, zooplankton and fish eggs were 6.6%, 2.2% and 0.5% in autumn, respectively, and the highest values of higher plants and zooplankton were 9.5% and 5.8% and 3.5% in summer, respectively, while of fish eggs 3.8% in winter. Generally, the species fed mainly on six major taxonomical groups, detritus (60.4%), diatoms (12.8%), algae (12.0%), high plants (9.3%), zooplankton (3.6%) and fish eggs (1.9%), and categorized as detritivores.

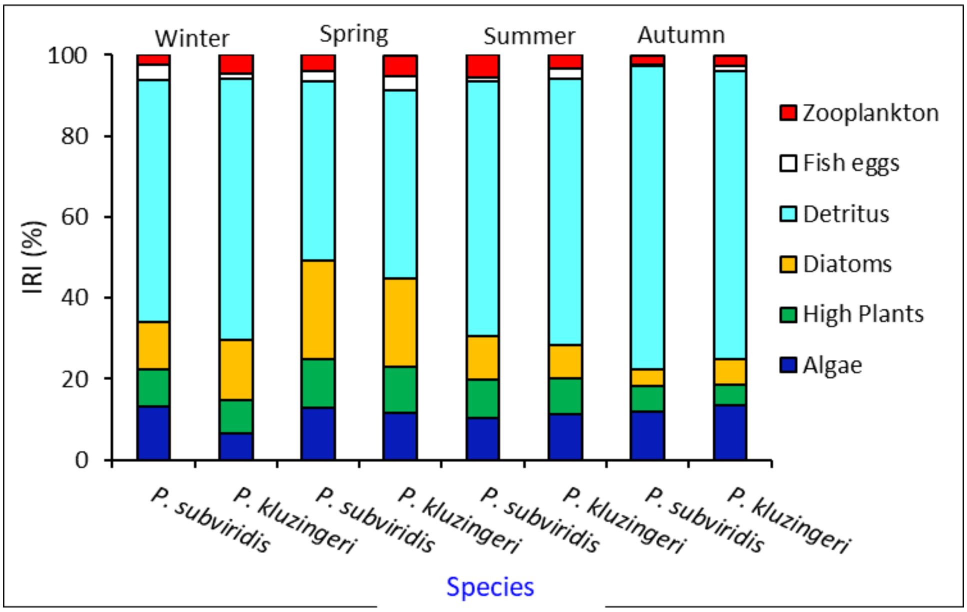

Figure 4 Seasonal changes in % the IRI of food items in the diet of *P. klunzingeri* and *P. subviridis*

3.4. Feeding selectivity index

Figure 5 illustrates the feeding selectivity index for the various diet items for *P. klunzingeri* and *P. subviridis* in this study. Detritus came first as the maximum mean value of the index (54.8%), with the highest value (50.2%) for *P. klunzingeri*, followed by algae (13.2%), with the highest value (51.2%) for *P. subviridis*. The high plants ranked third (12.9%), with the highest value (52.6%) for *P. klunzingeri*. Diatoms graded fourth (9.8%) and the highest value (51.1%) for *P. klunzingeri*. Fish eggs were classified fifth (5.5%) and the highest value (50.8%) for *P. klunzingeri*, and finally, zooplankton came sixth (3.8%) and the highest value (52.7%) for *P. subviridis.*

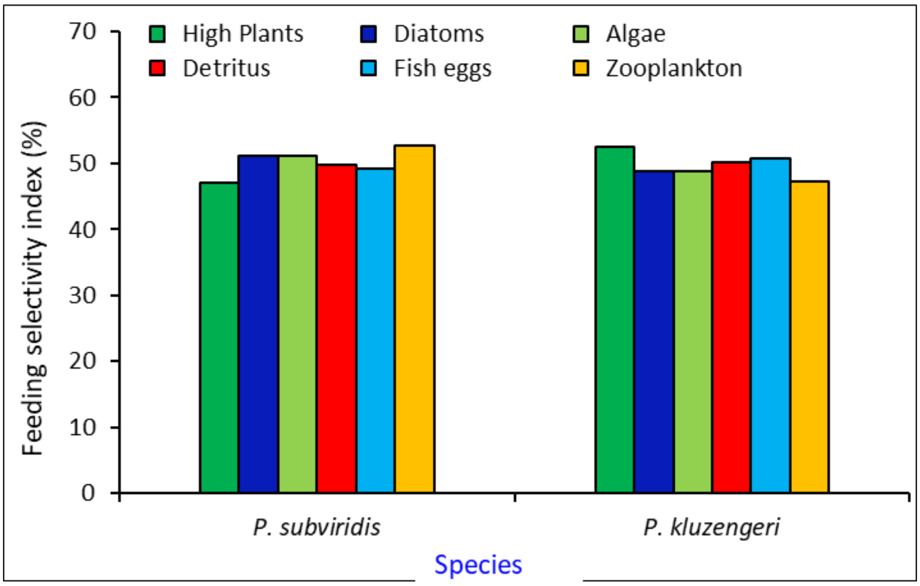

Figure 5 Feeding selectivity index for the different food items of *P. subviridis* and *P. klunzingeri*

The Jaccard similarity coefficient showed very high overlap (Cλ= 1.00) between the two species, and overall the feeding patterns of the species were characterized by a high intake of food items of detritus, diatoms and algae.

4. Discussion

Data on feeding habits in aquatic ecosystems are of great importance in determining the role that a certain fish species plays in its habitat and related ecosystems, as fish like other organisms require energy for proper growth, development, reproduction and their various physiological activities [43]. The estuary ecosystem is rich in organic matter, solutes, and nutrients, representing an important site for material exchange with the atmosphere, associated wetlands, and especially the sea, due to the marine-freshwater interaction [44]. According to the results, *P. klunzengeri* and *P. subviridis* are continuous feeders and never cease feeding all year round despite notable monthly fluctuations in feeding activities and intensities. In general, both species' low rates of feeding and high rates of empty stomachs were found to occur during the winter months when the temperature drops. The highest values of the vacuity index were recorded in winter for both species, and the annual averages of the vacuity index were 19.1% ± 13.0 and 15.4% ± 8.2%, respectively. Also, Mohamed and Abood [26] found that the highest values of the vacuity index of *P. klunzengeri* and *P. subviridis* in the Shatt Al-Arab River were in winter, and the overall values of the vacuity index for both species were 17.2 and 20.7%, respectively. The value of the vacuity index of *P. subviridis* varied from 7.2% (November) to 19.3% (August) in males, while in females ranged from 7.1% (March) to 19.2% (August) in the Parangipettai waters, India [22]. Nikolsky [45] deduced that water temperature plays a substantial role in food intake. As most fish are ectotherms, their physiology is strongly affected by temperature through influences the ability/desire of the fish to obtain food, and how they process food through digestion, absorb nutrients within the gastrointestinal tract, and store excess energy [46]. Our findings are in line with the previous dietary studies on these species, such as Lasem [16] on *P. subviridis* in the Garmat Ali River and Mohamed and Abood [26] on *P. klunzengeri* and *P. subviridis* in the Shatt Al-Arab River, Iraq.

Examination of the stomach contents of *P. klunzengeri* and *P. subviridis* revealed that detritus derived from organic matter dominated the food items during all seasons. About 60% and more of the food constituents were detritus, so they were classified as detritivores. Also, the stomach contents include diatoms, algae and high plants, and occasionally zooplankton and fish eggs were seen. Some previous studies on the food composition of *P. klunzengeri* reported that detritus constituted the bulk of the food of the species. Hussain e*t al.* [47] mentioned that *P. klunzengeri* fed mainly on detritus (78.2%) and diatoms (21.8%) in the recently restored southern Iraqi marshes. Taher *et al.* [24] revealed that detritus formed 75.0% of the diet of the species in the Shatt Al-Arab River. On the other hand, diatoms dominated the stomach content of *P. klunzengeri* in some waters. Lasem [16] found that the species fed on diatoms (42.0%), algae (21.7%), detritus (15.1%) and high plants (8.4%) in Garmat Ali River. Mohamed *et al*. [17] stated that *P. klunzengeri* consumed diatoms (37.0%), detritus (34.0%) and high plants (15.0%) in the East Hammar marsh. Moreover, Mohamed and Abood [26] found that the main food items of the species were diatoms (35.5%), high plants (29.3%), detritus (16.4%) and algae (15.9%).

Also, the high incidences of detritus in the stomach content of *P. subviridis* have been documented by some authors. Jabir and Al-Hisnawi [14] found that *P. subviridis* in Khor Al-Zubair, Iraq fed on detritus (35.1%), diatoms (20.0%), crustacean (6.3%) and high plants (6.2%) and Mohamed *et al.* [15] stated that the species fed mainly on detritus (19.1%), diatoms (16.7%), high plants (12.7%) and algae (12.5%) in the Iraqi marine waters. Ashiq Ur Rahman *et al*. [22] found that *P. subviridis* in the Parangipettai waters, India consumed detritus, diatoms, dinoflagellates, algae, zooplankton, polychaetes, foraminiferans, larval forms and miscellaneous items. Similar results were obtained for the other species of the mullet, *Ellochelon vaigiensis* in the Mekong Delta, Vietnam, where detritus was the essential food in the diet composition of the species and did not vary with sex, body size, season, and sampling site [48]. Several authors considered the diatoms were the most important food items for this species. Chan and Chua [12] stated that the stomach contents of adult *P. subviridis* taken from different coastal locations in Malaysia were consistent, comprising diatoms, detrital material, algae and inorganic sediment. Hussain *et al.* [47] found that the species consume mainly diatoms (77.8%) and algae (22.2%) in the southern Iraqi marshes. Mohamed and Hussain [18] found that diatoms formed 39% of the food items of the species followed by detritus (37.0%) and plant tissues (13.0%) in the East Al-Hammar marsh. Fatema *et al.* [19] mentioned that the diatoms (38.9%) were the most abundant food items of *P. subviridis* in the estuary of Merbok, Malaysia followed by zooplankton (18.2%), plant materials (11.1%), detritus (11.1%) and algae (9.9%), by occurrence method. Mohamed and Abood [26] recognized that *P. subviridis* consumed diatoms (35.5%), high plants (29.3%), detritus (16.4%) and algae (13.4%) in the Shatt Al-Arab River. The most popular food item consumed by *P. subviridis* in Lampon Estuary, Indonesia was diatoms, followed by flagellates, chlorophyceae, bacillariophyta, xanthophyta and dinoflagellates [27].

However, Wahab [13] mentioned that this species fed on algae (30.1%), high plants (16.4%), diatoms (15.0%) and detritus (13.9%) in the Shatt Al-Basrah canal. Mohamed *et al.* [21] stated that *P. subviridis* in East Hammar marsh fed on algae (34.3%), diatoms (33.2%) and detritus (13.0%). Hahn *et al.* [49] explained that fish can 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. Stomach contents reflect the relative density of food items in different seasons and the ability of the fish to utilize the available food according to their needs [50].

Analysis of food similarity between *P. subviridis* and *P. klunzengeri* showed high similarity for the food items according to the Jaccard similarity index, both species fed mostly on detritus, diatoms and high plants. Several studies referred to this finding between *P. subviridis* and *P. klunzengeri* in other Iraqi waters, such as Lazem [16] in Garmat Ali River, Mohamed *et al*. [17] in the East Hammar and Mohamed and Abood [26] in the Shatt Al-Arab River, Iraq. Coad [51] stated 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.

5. Conclusion

The results indicate that *P. klunzengeri* and *P. subviridis* are continuous feeders and never cease feeding around the year. They fed on six major taxonomical groups, detritus, diatoms, algae, high plants, zooplankton and fish eggs, and classified as detritivores.

Compliance with ethical standards

Acknowledgments

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Disclosure of conflict of interest

There is no conflict of interest to be declared.

Statement of ethical approval

The present research work does not contain any studies performed on animals/humans subjects by any of the authors.

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