Biological and Applied Environmental Research

Vol. 5(1): 74-85, 2021

https://doi.org/10.51304/baer.2021.5.1.74

ISSN: 2002-6153
Biol. Appl. Environ. Res.
www.baerj.com
editor@baerj.com

Trophic Interactions between Two Cichlid Species in Shatt Al-Arab River, Iraq

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Abstract: The diet composition and trophic relationships of the blue tilapia, *Oreochromis aureus* and redbelly tilapia, *Coptodon zillii* were investigated in the Shatt Al-Arab river from November 2015 to October 2016. Fishes were collected by gill nets, cast net and electro-fishing. The index of relative importance (IRI%) of food items was determined by combining the frequency of occurrence and points methods. There were monthly variations in feeding activity and intensity of both species, which decreased in the colder months. Both species were classified as herbivores. The main food items of *O. aureus* were macrophytes (44.3%), algae (31.4%), diatoms (9.3%), aquatic insects (6.6%) and detritus (6.3%). The diet of *C. zillii* is composed mainly of macrophytes (60.8%), algae (23.0%), detritus (8.6%) and diatoms (6.4). The trophic niche breadth values varied between 0.217 for *C. zillii* and 0.360 for *O. aureus*. The results demonstrated a high degree of dietary overlap between *O. aureus* and *C. zillii*, as both species fed on the same food sources.

Keywords: Cichlid fishes, Diet composition, Feeding overlaps, Shatt Al-Arab river, Iraq

Introduction

Cichlidae is one of the largest fish families in the world and its member species are generally known as tilapia (Cichlid). *Tilapia* is the generic name of a group of cichlids endemic to Africa, inhabits a variety of tropical and subtropical freshwater habitats, however, several species of the family are euryhaline and can disperse along brackish coastlines between rivers (Nelson, 2006). This family is represented of 2275 available species and 1720 valid species (Froese & Pauly, 2019). Tilapia consists of three important genera, namely *Oreochromis*, *Sarotherodon* and *Coptodon* (*Tilapia*), each includes many species, such as Nile tilapia *Oreochromis niloticus*, blue tilapia *O. aureus*, Galilean tilapia (*Sarotherodon galilaeus*) and redbelly tilapia *Coptodon zillii* (McAndrew, 2000). Cichlids have been widely introduced, either deliberately for aquaculture or accidentally through the aquarium trade and become the second most important fishes in aquaculture after carp, the

Received Sep. 2, 2020, accepted Nov. 5, 2020

worldwide production exceeded 5,972,000 metric tons during 2016 and increases annually (FAO, 2018). However, in Iraq, the three tilapian species, *O. aureus*, *C. zillii* and *O. niloticus* are invaded species since 2007 (Al-Sa'adi, 2007; Saleh, 2007; Mutlak & Al-Faisal, 2009; Al-Faisal & Mutlak, 2014) and now well established in the freshwater system of Iraq and inhabit different water bodies (Coad, 2010). Mohamed & Abood (2017) found that the three tilapian species dominated the fish assemblage in the Shatt Al-Arab river, comprising 21.3% of the total catch during 2015-2016. Abdullah et al. (2018) found that tilapia species formed 21.9% of fish structure in the Al-Sweib river, a tributary of the Shatt Al-Arab river during 2013-2015. Moreover, the tilapia species formed 32.3% of fish assemblage in the Shatt Al-Arab river at Abu Al-Khasib district (Mohamed & Hameed, 2019).

Knowledge on the food, feeding habits and trophic interrelationships of fishes is essential to understand the life history of fishes including growth, behaviour, reproduction, migration and other vital activities of fishes, and also help to understand the predicted changes on the ecosystem due to natural or anthropogenic interventions (Priyadharsini et al., 2012; Sajeevan & Kurup, 2013).

Various authors have studied the food and feeding habits of *O. aureus* and *C. zillii* in different water bodies (Fryer & Iles, 1972; Khallaf & Alne-na-ei, 1987; El-Sayed, 2006; Agbabiaka, 2012; Onyeche et al., 2013; Badamasi, 2014; Dadebo et al., 2014; Jihulya, 2014; Abari et al., 2015; Abdulhakim et al., 2015; Adams, 2016; Iyabo, 2016). All of them reported that both species fed on different types of food based on the environment in which they live.

Some studies were conducted on the food and feeding habits of *O. aureus* and *C. zillii* in Iraqi waters. Al-Lamy et al. (2012) found that *C. zillii* consumed mostly macrophytes, algae and fish eggs, and reported a low dietary overlaps between *C. zilli* and both species, *Carasobarbus luteus* and *Carassius auratus* in East Hammar marsh. Wahab (2013) stated that *C. zillii* fed mainly on algae, macrophytes and detritus in Tigris river at Samarra (misspelled as Samaraa). Abdullah (2015) mentioned that *C. zillii* and *O. aureus* fed primarily on macrophytes, algae and detritus in the north part of the Shatt Al-Arab river. Khalifa (2017) studied the food habit of *O. aureus* in Tigris river, south Baghdad, and emphasized the importance of detritus, algae and macrophytes as important food categories. Al-Wan & Mohamed (2019) found that the diet of *O. aureus* comprised of detritus, diatoms, algae, macrophytes and crustaceans in the Garmat Ali river. Mohamed & Al-Wan (2020) stated that *C. zillii* fed mainly on detritus, algae, macrophytes and diatoms in the Garmat Ali river.

Shatt Al-Arab river has been suffering from the deterioration of the water quality during the last years, 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 drastical reduction in water quantity and quality related to the decline in rates of water discharges from the Tigris, Euphrates and Karun rivers (Al-Tawash et al., 2013; Brandimarte et al., 2015; Yaseen et al., 2016). Therefore, the present work is designed to describe the food and trophic relationships of *O. aureus* and *C. zillii* in the Shatt Al-Arab river under this circumstance.

Materials and Methods

The Shatt Al-Arab river forms from the confluence of the Tigris and Euphrates rivers at Al-Qurna town, in the south of Iraq, and flows to a south eastern direction towards the Arabian Gulf (Figure 1). It is about 204 km and varies in width from 250 m in the north to 1,500 m at the estuary. The river is affected by the tidal current of the Gulf. Fishes 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 (Figure 1).

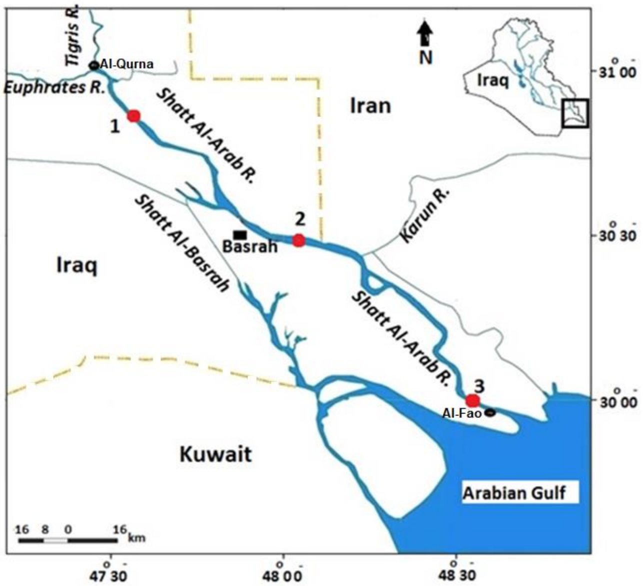

Figure 1: Map of Shatt Al-Arab river with locations of study sites.

The fishes were caught from each site using various devices including gill nets (lengths 200-500 m with 15 to 35 mm mesh size), cast nets (9 m diameter with 15x15 mm mesh size) and electro-fishing (generator with voltage of 300-400V and 10A). After capture, the fishes were preserved in ice in a cool 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 the degree of fullness was scored and then opened in a Petri dish to examine food by a microscope. The stomach fullness scores were 0, 5, 10, 15 and 20 points according to Hynes (1950). The food items were identified with the aid of keys provided by Edmondson (1959), Hadi et al. (1984) and Wehr & Sheath (2003). The food items were grouped into diatoms, macrophytes, algae, detritus, aquatic insects, fish eggs and zooplankton.

The stomach content was analysed based on the percentage of points (P%) and frequency of occurrence (O%) methods following Hyslop (1980). Importance of each food items was determined by combining the two methods to calculate the index of relative importance (IRI%) of Stergion (1988) 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 Dipper et al. (1977) and Gordon (1977), respectively. The feeding index was determined after Sarkar & Deepak (2009). The vacuity index was calculated as the number of empty stomachs divided by the number of stomachs analyzed (Maia et al., 2006).

The trophic niche breadth for each species was calculated according to the formula proposed by Levins (1968):

$$B= 1/\Sigma P_i\wedge^2$$

where B is Levins index of niche breadth and P_i is the proportion of food group (i) in the diet. To standardize niche breadth on a scale from 0 to 1, the modification suggested by Krebs (1989) 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 evaluate the feeding specialization of each species. The highly specialized feeder 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 tilapia species was evaluated using cluster analyses for food items that comprised more than 10% relative importance were considered as major items in the diet of each species, according to the method described by Blackith & Reyment (1971).

Results

Stomachs of 1125 individuals from *O. aureus* and *C. zillii* from Shatt Al-Arab river were examined (*O. aureus*: TL= 54-250 mm, n= 580 and *C. zillii*: TL= 36-240 mm, n= 545).

Feeding Intensity and Feeding Activity

Monthly variations in the feeding activity and intensity of the two species are given in Figure 2. It is clear that these species were active in feeding round the year and never cease feeding, but variations in feeding activity were notable. The feeding activity of *O. aureus* fluctuated from 84.2% in November to 100.0% in April, and the feeding intensity ranged from 8.5 point/fish in January to 13.3 point/fish in May. The feeding activity of *C. zillii* varied from 87.5% in December to 100.0% in June, whereas, the feeding intensity fluctuated from 10.7 point/fish in February to 14.5 point/fish in March.

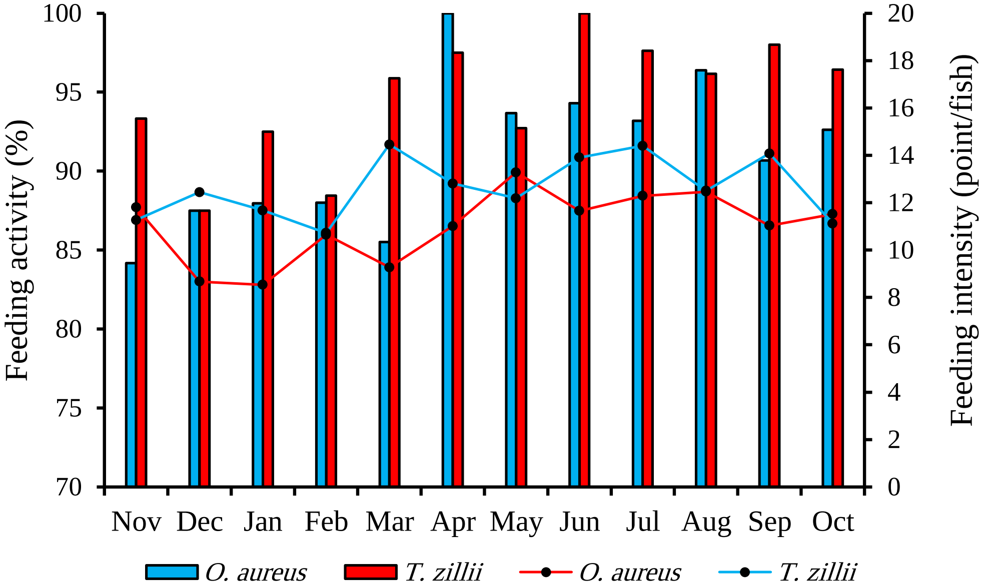

Figure 2: Monthly variations in feeding intensity and activity of *O. aureus* and *C. zillii*.

Feeding and Vacuity Indices

Figure 3 shows monthly fluctuations in the feeding and vacuity indices of *O. aureus* and *C. zillii* in the river. The feeding index of *O. aureus* ranged from 42.7% in January to 66.4% in May and of *C. zillii* varied from 53.6% in February to 72.3% in March. The overall values were 55.1 and 63.2% for the two species, respectively. The vacuity index of *O. aureus* fluctuated from 0.0% in April to 15.8% in November and *C. zillii* varied from 0.0% in June to 12.5% in December. The overall values of vacuity index for the two species were 8.8 and 5.3%, respectively.

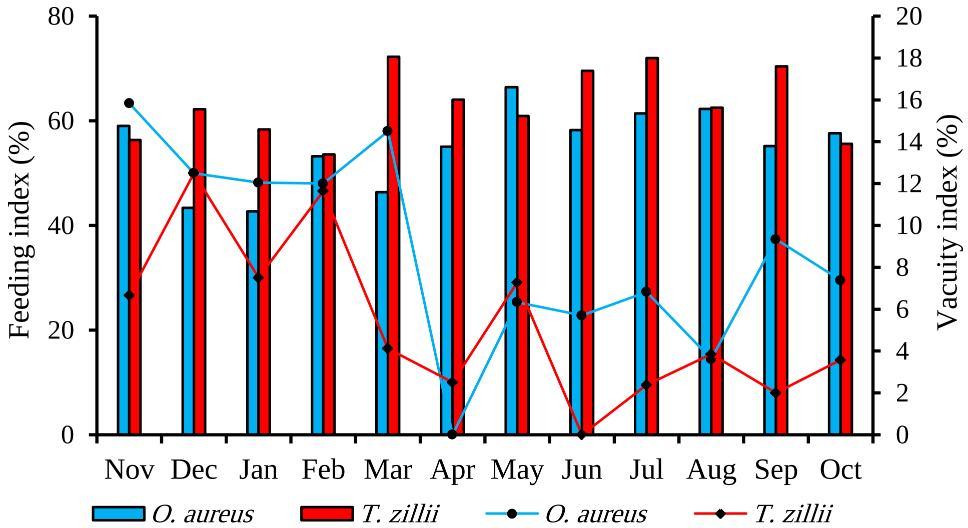

Figure 3: Monthly variations in the feeding and vacuity indices of *O. aureus* and *C. zillii*.

Seasonal Variation in Diet Composition

The monthly data of various food items of *O. aureus* and *C. zillii* were pooled to describe the seasonal variations in the diet of the species (Figure 4). It appeared that all species depend on four major food items. Macrophytes were the dominant item in the diet of *O. aureus* during the study period and the percentage contribution according to the index of relative importance (IRI) ranged from 22.2% in winter to 66.9% in summer. The second most important food item was algae constituting 16.9% in autumn and 48.5% in spring. Diatoms occupied the third position and ranged from 2.6% in summer to 14.6% in winter. The percentage contribution of aquatic insects varied from 4.7% in spring to 9.2% in winter. The contribution of detritus in the diet of the species fluctuated from 4.3% in autumn to 8.4% in winter. The additional food items composed of fish eggs and zooplankton were mainly consumed in winter. Generally, this species is classified as herbivorous and fed mainly on macrophytes (44.3%), algae (31.4%), diatoms (9.3%), aquatic insects (6.6%), detritus (6.3%), fish eggs (1.7%) and zooplankton (0.4%).

C. zillii fed mostly on macrophytes and their percentage varied from 46.6% in summer to 77.7% in summer. Algae occupied the second position and ranged from 13.2% in autumn to 33.0% in spring. Detritus came in the third place and fluctuated from 6.4% in summer to 112.8% in winter. The lowest value of diatoms in the diet of *C. zillii* was 1.79% in summer and the highest value was 8.3% in spring. The other food items were aquatic insects, fish eggs and zooplankton fluctuated over seasons, but their highest values were observed in autumn for aquatic insects and zooplankton, and in winter for fish eggs. However, the overall food items of *C. zillii* indicated that this species is classified as herbivorous, fed on macrophytes (60.8%), algae (23.0%), detritus (8.6%), diatoms (6.4%), aquatic insects (0.7%), fish eggs (0.3%) and zooplankton (0.2%).

Feeding Specialization

The results of feeding specialization for the two species showed that the index of Levins standardized niche breadth for *C. zillii* was a high specialist feeder (B_i= 0.217), while for *O. aureus* was considered as a low specialized feeder (B_i= 0.360).

Similarity dendrogram among fish species based on their diet showed high significant overlaps ($C\lambda$ = 1.000) among *O. aureus* and *C. zillii*, the overall feeding patterns of the two species characterized by high intake of food items of macrophytes, algae, detritus and diatoms.

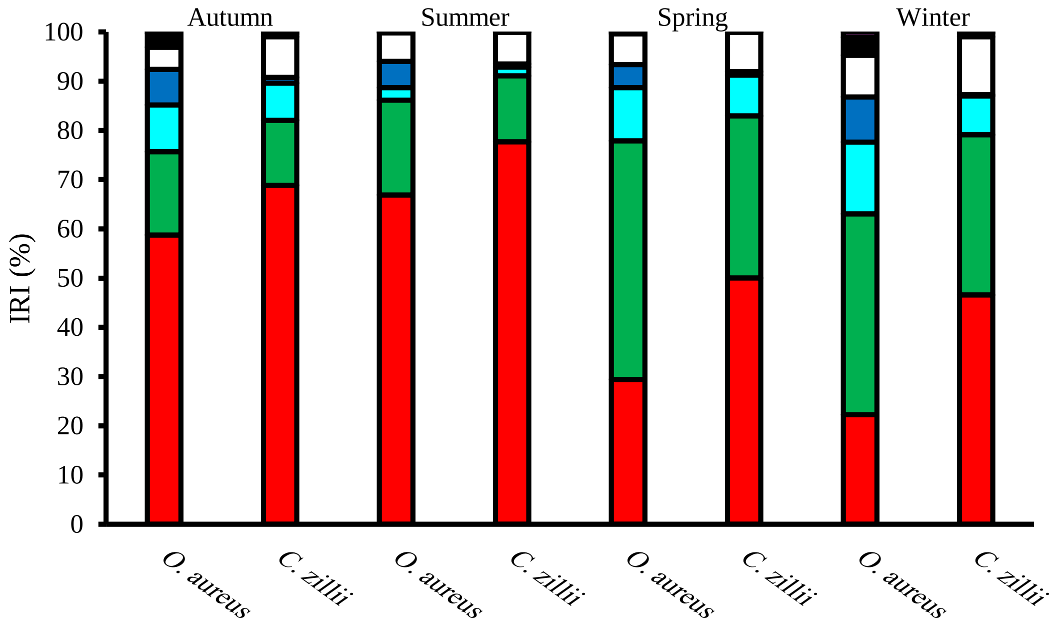

Figure 4: Seasonal changes in the relative importance index (IRI%) of food items in the diet of *O. aureus* and *C. zillii.*

Discussion

Water temperature is one of the most important environmental variables affecting the distribution and abundance of different species of fishes, and the feeding activity and food consumption are affected by temperature due to lower temperature than ideal limits (Chorbley, 2011). The result obtained in this study showed that *O. aureus* and *C. zillii* are continuous feeders and the higher values of feeding intensity and activity were recorded during warm periods of the year. This may be attributed to the effect of low temperature on the ability of fishes to feed in the cold season. Similar results were obtained by Khallaf & Alne-na-ei (1987) about *C. zillii* in a Nile canal, Egypt; Shalloof et al. (2009) about *C. zillii* in the Damietta branch of the river Nile, Egypt; Salah (2015) about *O. aureus* in Chybaish marsh, Iraq; Khalifa (2017) about *O. aureus* in Tigris river, Iraq and Mohamed & Al-Wan (2020) about *C. zillii* in the Garmat Ali river.

In the present study, *O. aureus* was found to be herbivores and low specialist feeder, fed mainly on macrophytes (44.3%) and algae (31.4%). Food of minor importance were diatoms (9.4%), aquatic insects (6.6%), detritus (6.3%), fish eggs (1.7%) and zooplankton (0.4%). Dadebo et al. (2014) stated that *O. aureus* consumed mainly macrophytes (45.2%), detritus (29.4%) and phytoplankton (16.8%) in lake Ziway, Ethiopia. Abdullah (2015) also found that *O. aureus* ingested macrophytes (45.2%), algae (31.3%), detritus (14.4%) and diatoms (4.4%) in the north of Shatt Al-Arab river. Moreover, Salah (2015) mentioned that *O. aureus* individuals were a low specialization feeder, fed on macrophytes (49.6%), algae (25.5%), diatoms (14.5%) and detritus (6.3%) in Chybaish marsh. Khalifa (2017) found that *O. aureus* consumed mainly detritus (46.3%), algae (11.8%) and macrophytes (9.3%) in the Tigris river. Mohamed & Al-Wan (2020) stated that *O. aureus* is an opportunistic feeder, its diet comprised of detritus (43.1%), diatoms (23.9%), algae (22.8%), macrophytes (7.1%) and crustaceans (6.0%) in the Garmat Ali river. El-Jamal (2006) stated that *O. aureus* is a herbivorous, feeding mainly on macrophytes, detritus and microorganisms, and can shift their feeding habits depending on the abundance and composition of food available in different aquatic environments. Mallin (1986) mentioned that the stomachs of *Tilapia aureus* (*O. aureus*) in the North Carolina reservoir contained mainly organic and inorganic detritus, large amounts of phytoplankton, while zooplankton and benthic invertebrates comprised only small percentages of the stomach contents in this reservoir. He concluded that this species is an opportunistic feeder that successfully utilize whatever food source is available.

The results revealed that *C. zillii* was a herbivorous and highly specialized feeder, fed largely on macrophytes (60.8%) and algae (23.0%). The contributions of detritus, diatoms, aquatic insects, fish eggs and zooplankton were relatively low. Al-Lamy et al. (2012) stated that this species was a low specialist feeder and consumed mostly macrophytes (67.3%), followed by algae (18.9%) and fish eggs (12.8%) in East Hammar marsh. Wahab (2013) found that *C. zillii* fed mostly on algae (57.8%), macrophytes (27.1%) and detritus (12.4%) in Tigris river, at Samarra (misspelled as Samaraa), Iraq. Moreover, Abdullah (2015) mentioned that *C. zillii* consumed mainly macrophytes (62.6%) followed by algae (25.5%) and detritus (6.9%) in the north of Shatt Al-Arab river. Plant components constituted 75.6% of the diet of *C. zillii* in the Anwai stream, Niger (Onyeche et al., 2013). Dadebo et al. (2014) also stated that macrophytes, phytoplankton and detritus were the most important components of *C. zillii* food in Ziway lake, Ethiopia. Adams (2016) found that *C. zillii* fed mostly on macrophytes and algae, and considered the species as weed feeding fish species in the Tiga dam, Kano State, Nigeria. The overall food composition of *C. zillii* in the Garmat Ali river is comprised of detritus, algae, macrophytes and diatoms (Mohamed & Al-Wan, 2020). Tilapia preference for algae and vegetative matter may be attributed to its ability to secrete mucus from the gills that trap plankton; however, their ability to digest filamentous algae and aquatic macrophytes is through the mechanism of physical grinding of vegetative matter between the two pharyngeal plates of fine teeth and acidic nature (pH <2) of the stomach which ruptures the cell walls of algae and bacteria (Osho et al., 2006; Iyabo, 2016). However, Shep et al. (2013) considered *C. zillii* as an omnivorous and generalized feeder, fed mainly on macrophytes, insects, molluscs and zooplankton in Ayamé lake, Côte d'Ivoire. Iyabo (2016) mentioned that *C. zillii* in Ebonyi river, Nigeria are opportunistic feeders that are able to consume and digest quite a variety of food items available in the environment, switching from mainly zooplankton diets at the juvenile stage to aquatic macrophytes and invertebrates in adulthood. It is a widely accepted generalization that stream fishes are mostly opportunistic in their feeding habits because of the highly variable nature of habitat and resources (Johnson & Arunachalam, 2012).

The results demonstrated a high degree of dietary overlap between *O. aureus* and *C. zillii*, which both fed on the same food sources. Similar result was obtained by Abdullah (2015) between the same species in the north part of Shatt Al-Arab river. However, da Silva et al. (2012) found that the high values of dietary overlaps between fish species in the Itiz river, 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. Shalloof et al. (2009) stated that cichlid fish species did not consume food at random, but have the ability to select and choose the preferred food stuff even during different seasons. These seasonal variations in preferred food make the intraspecific competition between these species very low.

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