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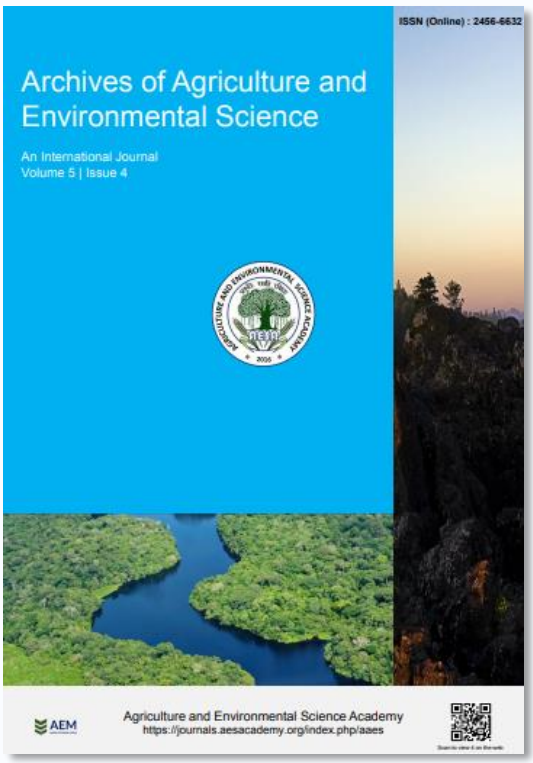

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ORIGINAL RESEARCH ARTICLE

Evaluation of the trophic status of *Sillago sihama* and *Sillago arabica* at the south of Shatt Al-Arab River, Iraq

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ABSTRACT

The present study is investigated the diet composition, feeding activity and intensity, and trophic niche breadth of two Sillaginid fish, *Sillago sihama* and *Sillago arabica* at the south of the Shatt Al-Arab River, Iraq from May 2019 to April 2020. A total of 511 specimens of fish comprised of 239 *S. sihama* and 272 *S. arabica* were used for the study. Fish length ranged from 11.7-23.7 and 13.0- 31.2 cm of the previous species, respectively. The results showed that the feeding activity and intensity influenced by months since the lowest stomach fullness occurred during the winter months. The analysis of diet for both species using the index of relative importance (IRI %) of prey items showed that the species were carnivores. The prey items of *S. sihama* were crabs (80.8%), shrimp (14.6%) and fish (4.6%), while the diet of *S. arabica* composed mainly on crabs (54.3%), shrimp (32.7%) and fish (13.0%). The overall values of feeding and vacuity indices were 40.4% and 9.5%, respectively for *S. sihama*, whereas 52.0% and 18.2%, respectively for *S. arabica*. Based on the results of trophic niche breadth indicate that *S. schema* is a high specialist feeder (B_i= 0.23), while *S. arabica* was considered a non-specialized feeder (B_i= 0.71). The study concludes that both species were carnivorous feeders, feeding mainly on crabs, shrimp and fish. *S. sihama* was a low specialized feeder, while *S. arabica* was not specialized.

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INTRODUCTION

Sillaginidae is a widely distributed family and its member species are commonly known as sand whitings inhabit benthic coastal waters and estuaries of the tropical and subtropical zones from Arabian Gulf to Japan and south to Australia (Nelson, 2006). The family comprises only five genera and 48 available species and 36 valid species (Fricke *et al*., 2020). Three species of this family have been reported from the Shatt Al-Arab river namely Silver sillago (*Sillago sihama* Forsskål, 1775), Arabian sillago (*Sillago arabica* McKay and McCarthy, 1989) and Slender sillago (*Sillago attenuate* McKay. 1985), contributing 1.15, 0.70 and 0.008% of the fish assemblage in this river, respectively (Mohamed and Abood, 2017). Studies on food and feeding habits will help in understanding various aspects of fish biology such as growth, maturation, spawning, migration, understanding its nutritional requirements, its food specialization and interaction with other organisms, and forms the basis for the development of a successful of fisheries management (Nikolsky, 1963; Wootton, 1998; Hajisamae *et al*., 2004; Blaber, 2000; Baghel *et al*., 2020; Jaiswal, 2020). Various authors have studied the food and feeding habits of *S. sihama* in different geographical habitats such as Annappaswamy *et al*. (2002) in Mulki estuary, India; Shamsan (2008) in Dona Paula Bay, India; Taghavi *et al*. (2012) in Hormuzgan Province waters in the northern Arabian Gulf; Khan *et al*. (2014) in Karachi coast, Pakistan; Yeragi and Yeragi (2015) in Mithbav estuary, India; Sawant *et al*. (2017) in Ratnagiri coast, India and Ramarn and Panritdam (2018) in Palian mangrove estuary, Thailand. But no study related to the food habit of *Sillago arabica* has been carried out.

Some studies have been done on the food habits of *S. sihama* and *Sillago arabica* in Iraqi waters. Hussain and Naama (1992) described the morphology of the alimentary tract and food habitat of *S. sihama* in Khor Al-Zubair, northwest Arabian Gulf. The diet composition of *S. sihama* and the dietary overlap with other species in Khor Al-Zubair were studied by Hussain *et al.* (1993). The feeding activity and intensity, and the food habit of *S. sihama* in Iraqi marine waters, northwest of Arabian Gulf was provided by Mohamed *et al.* (2003). The diet components of small individuals of *S. sihama* and the dietary overlap with other species in Shatt Al-Basrah Canal, Iraq were studied by Taher (2010). On the other hand, only one study has been published about the food habit of *Sillago arabica* in Shatt Al-Basrah Canal, Iraq (Taher, 2010). The present study evaluates the trophic status of *S. sihama* and *S. arabica* at the south of the Shatt Al-Arab River through describing the diet composition, feeding activity and intensity, and trophic niche breadth. This paper complements the studies of Mohamed and Abood (2018, 2019a, b) about the trophic status of cyprinid, mullet and sciaenid fish species in Shatt Al-Arab River.

MATERIALS AND METHODS

The Shatt Al-Arab river forms from the confluence of the Tigris and Euphrates rivers at Qurna town and flowing for about 204 km through large date palm plantations towards the Arabian Gulf. The study was conducted in the south of Shatt Al-Arab River, north of Fao city between latitudes 30° 01ˉ to 30° 75ˉ N and longitudes 48°26ˉ to 47° 28ˉ E (Figure 1) from May 2019 to April 2020. Fish were caught by gill nets (lengths 200-500 m with 15-35 mm mesh size), cast net (9 m diameter with 15 ×15 mm mesh size) and electro-fishing (generator with a voltage of 300-400V and 10A). Fish were classified according to Carpenter *et al.* (1997) and McKay (1992). Then, fish samples were immediately preserved in the ice box and transported to the laboratory. The total length (TL, cm) of each fish was measured in the laboratory, then the body cavity of fish was opened. The fish stomach was extracted and gives the degree of fullness, then opened in Petri dish to examine different food items by the naked eye and anatomical microscope. Fullness degree of fish stomachs was categorized to empty, ¼ full, ½ full, ¾ full, full and points were allocated as 0, 5, 10, 15 and 20, respectively (Hynes, 1950).

Food items from the stomach contents of each specimen were identified to the lowest taxa possible. The stomach contents were quantified using three indices (Windell and Bown, 1978; Hyslop, 1980; Hansson, 1998), the percentage by number %N), the percentage by weight (%W) and the percentage by frequency of occurrence (%F). The most important food item was determined by using the Index of Relative Importance (IRI) of Pinkas *et al.* (1971).

$$IRI = (\%N + \%W) * \%F$$

where, %N is per cent of the total number, %W is per cent of total weight and %F is the frequency of occurrence.

The feeding intensity was calculated by taking the average value of points allocated to the fullness of the stomachs for each month's sample (Dipper *et al.* (1977). The feeding activity was calculated as the per cent for feeding fish number to examined fish number (Gordon, 1977). The feeding index was determined after Sarkar and Deepak (2009).

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

where P= total point of the gut that were examined, N= No. of guts examined, X= total points allotted to the full gut. The vacuity index was calculated (Maia *et al.*, 2006) as:

Vacuity index = (No. of empty stomach/No. of stomach examined) * 100

The index of trophic niche breadth was calculated using Levins Index (Levins, 1968), which is based on the sum of the frequencies of each food item that was found for a given species.

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

Where, B = Levins niche breadth index, and P_i = proportion of the food item (i) in the diet. To restrict the breath to a known interval from 0 to 1, the following formula was used (Krebs, 1989).

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

where B_A= standardized Levins index and n= number of food items for each species. This index varies from 0 to 1, with a value of 1 indicating complete overlap among individuals, i.e., a value close to 1 indicates a less specialized individual, while close to 0 indicates a more specialized individual (Bolnick *et al.*, 2002).

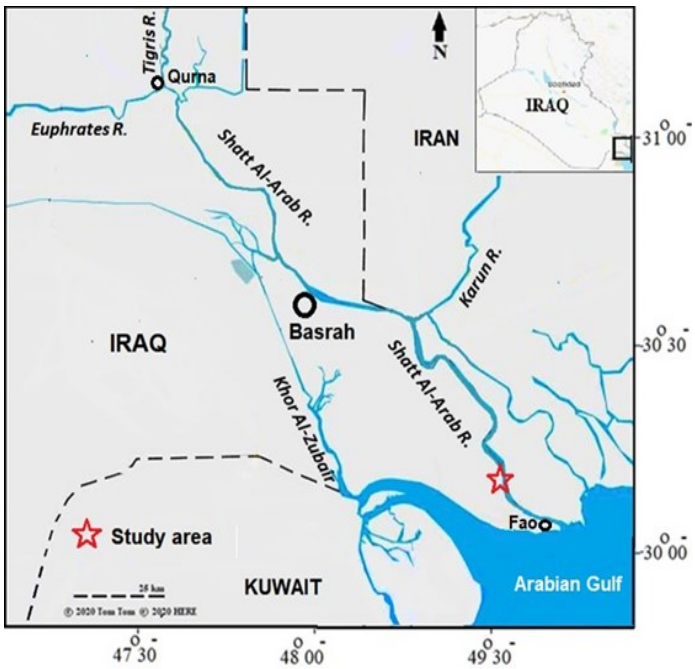

Figure 1. *Map of Shatt Al-Arab with locations of study area.*

RESULTS AND DISCUSSION

Feeding intensity and feeding activity

Five hundred and eleven (511) specimens of fish comprised of 239 *S. sihama* and 272 *S. arabica* were used for the study. The total length of *S. sihama* ranged from 11.7 cm to 23.7 cm and of *S. arabica* from 13.0 cm to 31.2 cm. Figure 2 shows the monthly variations in the feeding intensity and feeding activity of both species in this study. The lowest level of feeding activity for *S. sihama* was 68.8% in January and for *S. arabica* was 56.3% in February, whereas the highest level for *S. sihama* occurred in April (100%) and for *S. arabica* in July (95.8%). The lowest values of feeding intensity varied from 3.6 points/fish for *S. sihama* to 5.8 points/fish for *S. arabica* observed in January for both species, and the highest values ranged from 13.5 points/fish for *S. sihama* to 14.4 points/fish for *S. arabica* recorded in April for both species.

In general, the analysis of the fullness of the stomachs indicated a tendency of both species to continuous feeding around the year with somewhat monthly fluctuations in their feeding activities, where the feeding activity and intensity for both species were reduced during January (winter). This may be attributed to the effect of the decrease in temperature on the ability of fish to feed in cold months. This finding is in agreement with that of Mohamed *et al.* (2003) and Al-Dubakel (2016) whereby the feeding activity of *S. sihama* was lower in the winter. However, Taghavi *et al.* (2012) stated that the feeding activity of the *S. sihama* in the northern Arabian Gulf was strongly reduced during the summer months. Lagler *et al.* (1977) indicated that water temperature is one of the most important environmental variables affecting the distribution and abundance of different species of fish, and the feeding activity and food consumption. Also, this could be due to greater crustacean abundances in the study area during this period and coincided with a rise in ambient water temperature.

Feeding and vacuity indices

Monthly fluctuations in the feeding and vacuity indices of *S. sihama* and *S. arabica* in the river are presented in Figure 3. The minimum levels of feeding index ranged from 18.2% for *S. sihama* to 29.2% for *S. arabica* noticed in January for both species, and the maximum varied from 67.5% for *S. sihama* in May to 71.9% for *S. arabica* in April. The overall values of the feeding index were 40.4% and 52.0% for both species, respectively. The lowest values of vacuity index fluctuated from 0.0% for *S. sihama* in April to 4.0% for *S. arabica* in November, whereas the highest values varied from 31.3% for *S. sihama* in January to 43.8% for *S. arabica* in February. The overall values of the vacuity index were 9.5% and 18.2% for both species, respectively.

The results of the feeding index for both species are in agreement with the results of feeding intensity and feeding activity, in which most of the individuals were in the poor feeding during winter, and the vacuity index for both species was high during this season. The reproduction season of *S. sihama* in Bandar Abbas, south of the Arabian Gulf was extended from March to May (Hossienzadeh *et al.*, 2001; Mirzaei *et al.*, 2013). Kiran and Puttaiah (2004) indicated that the feeding intensity of fish was dependent on gonadal development, stage of maturity and availability of food concerning the environment. The feeding activity of *S. sihama* was significantly decreased due to the reproductive activity due to the filling of the abdominal cavity with mature gonads, and thus their stomachs were empty (Shamsan, 2008). The feeding activity and food consumption are affected by temperature due to lower temperatures than ideal limits (Chorbley, 2011). Okgerman *et al.* (2013) mentioned that the water temperature is the principal environmental factor affecting the gut fullness of fish.

Food composition

The index of relative importance (IRI) of various food items preyed by *S. sihama* show monthly fluctuations (Figure 4). Crabs were the bulk of the species diet, with the highest percentage (97.4%) recorded in March and the lowest one (39.8%) recorded in November. The second most abundant prey item was shrimp. The highest percentage of this prey was noted in November (57.6%) and the lowest in March (0.4). The third most important prey item was fish. It was varying from 0.0% in December to 21.7% in May. The overall gut contents of *S. sihama* were crabs (80.8%), shrimp (14.6%) and fish (4.6%).

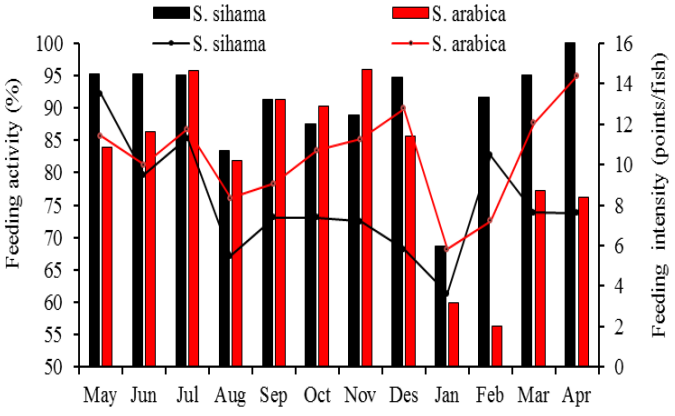

Figure 2. *Monthly variations in feeding activity and intensity of S. sihama and S. arabica.*

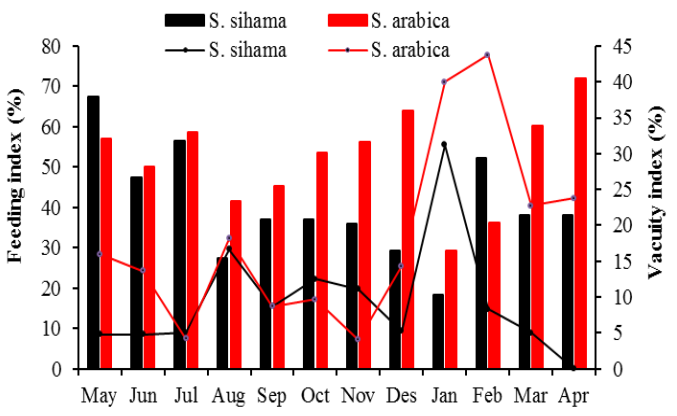

Figure 3. *Monthly fluctuations in the feeding and vacuity indices of S. sihama and S. arabica.*

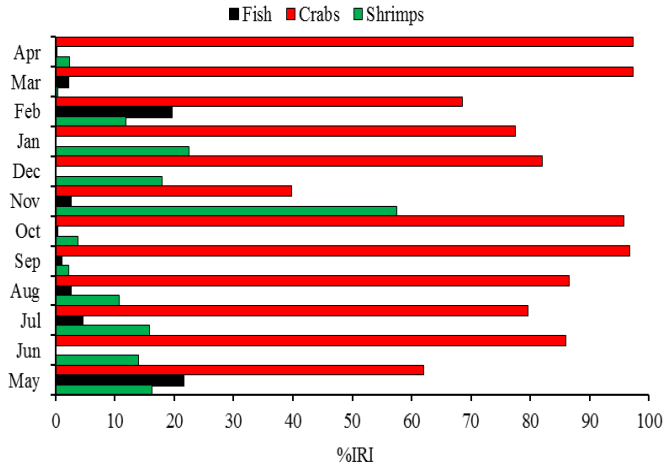

Figure 4. *Monthly variations in the relative importance index (IRI%) of prey items in the diet of S. sihama.*

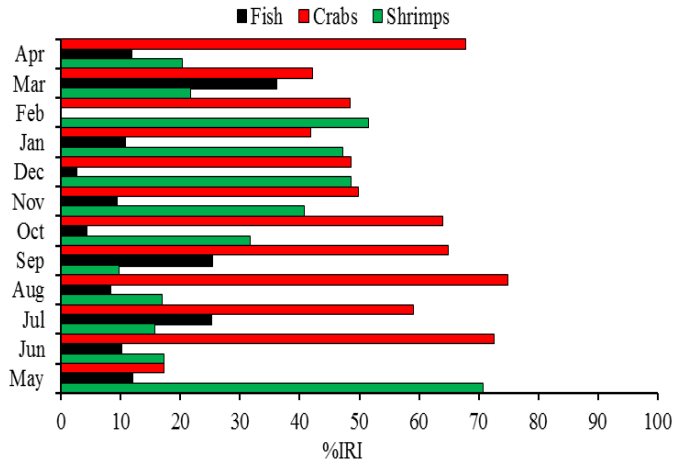

Figure 5. *Monthly variations in the relative importance index (IRI%) of prey items in the diet of S. arabica.*

Result of the monthly variations in the relative importance index (IRI) of various prey items taken by *S. arabica* is presented in Figure 5. Crabs were more important prey for the species constituted 17.3% in May and 74.8% in August. The second most abundant prey item was shrimp comprised of 9.7% in September and 70.7% in May followed by fish constituted 0.0% in February and 36.1% in March. The overall diet composition of *S. arabica* was involved in crabs (54.3%), shrimp (32.7%) and fish (13.0%). The importance of shrimps in diet composition may be due to their abundance (Lagler *et al*., 1977) and nutritional profitability. Salman *et al.* (1990) stated that shrimps (*Metapenaeus affinis)* migrate from the Arabian Gulf to nursery grounds in the inland waters of Iraq through the Shatt Al-Arab river extends from May/June to January/February each year, their sizes ranging from 3–125 mm total length were found in inland waters.

Analysis of stomachs indicated that *S. sihama* and *S. arabica* were carnivores, showing strong preference toward crabs, shrimp and fish. This is in agreement with findings of other studies on *S. sihama* from different regions (Hussain and Naama, 1992; Hussain *et al*., 1993; Shamsan, 2008; Khan *et al*., 2014; Ramarn and Panritdam, 2018). However, *S. sihama* was found to be omnivorous in its diet elsewhere for which data are available (Annappaswamy *et al*., 2002; Taher, 2010; Taghavi *et al*., 2012; Yeragi and Yeragi, 2015; Sawant *et al*., 2017). Also, Taher (2010) reported that the food habit of *S. arabica* was omnivorous in its diet in Shatt Al-Basrah Canal, Iraq.

The present study indicates that *S. sihama* fed predominantly on crabs (80.8%). This finding is in agreement with the findings of some authors. Hussain *et al.* (1993) stated that the most frequently consumed prey by the species in Khor Al-Zubair, Iraq was crabs (64.4%). Mohamed *et al*. (2003) pointed out that crabs constituted 45.3% of the species diet in Iraqi marine waters, northwest Arabian Gulf. The present findings are different from the results of some other studies around the most important animal prey in the *S. sihama* diet. Hussain and Naama (1992) stated that shrimp was the most abundant prey item (70.4%) for *S. sihama* in Khor Al-Zubair. Also, Taher (2010) found that shrimp was the most prey item (47.0%) in the diet of *S. sihama* in Shatt Al-Basrah Canal. While crustaceans formed the main animal prey eaten by the species in Dona Paula Bay, India (Shamsan, 2008) and in the Ratnagiri coast, India (Sawant *et al*., 2017). Moreover, Yeragi and Yeragi (2015) and Taghavi *et al.* (2017) stated that diatoms were the most preferable food for *S. sihama* in Mithbav estuary, India and in the northern Arabian Gulf, respectively. In the other hand, *S. arabica* consumed crabs (54.3%), shrimp (32.7%) and fish (13.0%) in the present study, whereas Taher (2010) mentioned that this species fed mainly on shrimp (36%), eggs (25%) and crustacean (22%) in Shatt Al-Basrah Canal, Iraq.

Trophic niche breadth

The trophic niche breadth index calculated for both species revealed that the index value for *S. sihama* was generally low (B_i= 0.23), which indicates that this species is a high specialist feeder, whereas for *S. arabic* was high (B_i= 0.71) and considered a non-specialized feeder.

Analyses of trophic niche breadth in this study suggest that *S. sihama* is highly specialized in its feeding habit, thus confirming the species mainly consume crabs, whereas *S. arabic* is not so specialized feeder and capable of widening the prefer animal preys depending on the availability in the aquatic ecosystem. The result of *S. sihama* is disagreement with the study of Taher (2010) who considered the species as a low specialized feeder (0.36) and agrees with him as *S. arabica* was not specialized (0.52) in Shatt Al-Basrah Canal. Ramarn and Panritdam (2018) stated that *S. sihama* was selective feeder instead of opportunistic feeder in the Palian mangrove estuary, Thailand. The variation in the basic food components of fish through temporal and spatial changes may be due to the environmental influences, the food resources availability in those environments and the interspecific competition for food which are reflected in the percentage of their contribution to the food (Vitule *et al*., 2013; Specziár and Erős, 2014; Ramarn and Panritdam, 2018).

Conclusion

The study showed that the feeding index for *S. sihama* and *S. arabica* are in agreement with the results of feeding intensity and feeding activity, in which most of the individuals were in the poor feeding during winter, and the vacuity index for both species was high during this season. Both species were carnivorous feeders, showing strong preference toward crabs, shrimp and fish. *S. sihama* was a low specialized feeder, while *S. arabica* was not specialized.

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