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A comparison study on growth, reproductive and food habit of *Mesopotamichthys sharpeyi* in the Al-Diwaniya River, middle of Iraq

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Abstract
Biological aspects of *Mesopotamichthys sharpeyi* was studied in terms of length and weight, age, growth, sex ratio, size at first sexual maturity, gonad development (*GSI*) and food habit in the Al-Diwaniya River, Iraq. These biological features were compared with other studies on the species. Fish were collected by different fishing gears. The length–weight relationship was calculated for fish sizes 11 to 39 cm as $W = 0.032L^{2.7017}$, with negative allometric growth. The monthly fluctuation in the relative condition factor of the species was influenced by the spawning cycle and feeding intensity of the fish. Seven ages were identified from scales and the mean lengths of these ages were 11.8, 21.4, 26.2, 30.5, 34.5, 37.8 and 41.1 cm, respectively. von Bertalanffy growth parameters were $L\infty$= 56.0 cm, K= 0.229 and t_0= - 0.103 years. The growth performance index (*Φ*) was found to be 1.99. The overall male to female ratio (1:1.48) was biased in favour of females. Length at maturity was 33 cm for males and 34 cm for females. The *GSI* was at the highest level in April then dropped dramatically for both sex, suggest that the species may spawn in late April to May. *M. sharpeyi* is a herbivore fed on macrophytes, algae, detritus, and diatoms. Some biological properties of the species were among those described for the species in other waters.

Keywords: *Mesopotamichthys sharpeyi*, age and growth, reproduction, food habit, Al-Diwaniya river

1. Introduction

Cyprinidae is one of the largest families of freshwater fish, with 2978 available species and 1738 valid species widely distributed around the world [1]. *Mesopotamichthys sharpeyi* (Gunther, 1874), which is locally known as Bunnei, belongs to this family. This species formerly placed in the genus *Barbus* and recently became within the genus *Mesopotamichthys* [2]. *M. sharpeyi* is endemic to the Tigris-Euphrates River basin in Iraq including the rivers of Tigris, Euphrates, Diyala and Shatt Al-Arab river, the southern marshes, lakes such as Saniyah, Habbaniyah, Tharthar and Razzazah, and reservoirs such as Al-Qadisiyah and Dukan dam. In Iran, it is recorded from the Hoor Al Azim marsh and in rivers in the northern Gulf basin [3]. However, Ali and Jawad [4] stated that the species is scarce in the north of Baghdad on Tigris and Ramadi on the Euphrates. Moreover, Bawazir and Ali [5] assumed that the Tigris-Tharthar canal and northern part of the Tharthar reservoir itself as the northern border of the geographical area of distribution of *M. sharpeyi* at the time of the study.

This species has been identified as endangered species in the Iraqi marshlands and involved in red list of threatened species due to overfishing and the destruction of marshes this species declined massively, by more than 80% since 1977, the species is also susceptible to the large dam projects in the headwaters of the Tigris which will lead to a lack of water for biodiversity in marshes at the lower Tigris [6, 7].

Since the stocks of the commercially fish in Iraqi waters were declined due to several reasons, *M. sharpeyi*, as other *Barbus* spp. becomes a subject of restocking and potential fish species for aquaculture [5]. This species is considered one of the most important species for artisanal fisheries and is widely consumed in the southern region of Iraq. Al Daham [8] mentioned that the species had the highest production in the catch of the Iraqi inland fisheries (about 5,000 tons), which was one-quarter of these fisheries. Mohamed *et al.* [9] stated that the *M. sharpeyi* was dominated by the artisanal fishery of Al-Swab marsh, apart from Al-Huwazah marsh, Iraq and constituted 24.5% of the total fish landings in Al-Qurna district during 2005.

There have been several biological studies conducted on *M. sharpeyi* in different natural waters of Iraq. Some authors have described growth of the species [10-18]. Others have concentrated on some features of reproduction [19, 12, 20-25, 5]. Finally, some have investigated the food habit of the species [26-29]. Hashemi *et al*. [30] studied length-weight relationship, length at maturity and time of spawning of *M. sharpeyi* in Shadegan wetland in Iran.

There was no data available on biological characteristics of *M. sharpeyi* in the Al-Diwaniya river, middle Euphrates until now. Therefore, this study was carried out to determine the length-frequency distribution, length-weight relationship, relative condition factors, age, growth rate, sex ratio, gonado-somatic index and food habit of *M. sharpeyi* population habiting in Al-Diwaniya river and our data are compared with results from other populations.

2. Materials and Methods

2.1 Study area

AL-Diwaniya river is the major water resource for the AL-Diwaniya City/Al-Qadisiyah Province, which flows through the city. It is an extension of the Al-Hilla River which is a branch of Euphrates river at Al-Hindyah barrier, in the middle of Iraq. It is 123 km long, 25-30m wide and 3-5m depth with a drainage capacity of 60 m^3/ sec depth. Two sites of the study were selected within the part that extends from Daghara front to Diwaniya city center (Fig. 1). During the time of this study, water temperatures varied from 10.2 to 32.8 °C, dissolved oxygen 4.5–10.0 mg/L, salinity 0.53-0.81 mg/L and pH was between 6.5–8.9 [31]. The predominant vegetation on both banks of this locality was reed, *Phragmites australis*, and cattail, *Typha domingensis*, whereas hornwort, *Ceratophyllum demersum* was dominant in the deeper areas. The fish fauna comprises 27 species and is dominated by cyprinids, including *Carassiu carassius*, *Carasobarbus luteus*, *Leuciscus vorax*, *A. grypus*, *Luciobarbus xanthopterus* and *Mesopotamichthys sharpeyi*; other common species are *Planiliza abu* (Mugilidae) and *Oreochromis aureus* (Cichlidae) [31].

2.2 Fish sampling

Fish species were collected monthly from October 2016 to September 2017 from two sites (Fig. 1). The sampling was performed using electrofishing equipment (provides 150-300V), seine net (3m long and 2.5m depth with a 20mm mesh size), gill nets (25m long with 20x20, 30x30 and 50x50mm mesh sizes) and cast net (9m diameter with 15x15mm mesh size). Fish were immediately preserved in the icebox for subsequent analysis.

Fig 1: Map showing the study sites in Al-Diwaniya River

2.3 Laboratory analyses

Fishes were measured for total length (L) to the nearest mm and weighed (W) to the nearest 0.1 g. Scales were used for age determination. Scales from the left side of the body between the lateral line and dorsal fin were removed and dry mounted between two slides for binocular microscopic study [32]. Total scale radius and the distance between the focus and their respective annuli were measured under the Projectina microscope, 20X. The gut of each fish was removed and preserved in a specimen bottle containing 4% formaldehyde. The food items were identified as the least taxon possible and counted. The frequency of occurrence (O) and the points (P) methods [38] was used for analyzing the food items. Gonads were removed and weighed. Sex was determined by macroscopic observation of the gonads.

2.4 Data analyses

The relationship between total length (L) and total weight (W) was calculated for all individuals using the model: $W= a L^b$ [33], (Le Cren, 1951), where "a" and "b" are constants. The deviation of the allometric coefficient "b" from the theoretical value of isometric growth (b= 3) was tested by Student's *t*-test. To estimate the condition of individual fish, the relative condition factor (K_n) was computed from the equation; $K_n= W'/W$ [33], where W'= body weight and W= calculated weight from the length-weight relationship.

The relationship between fish length (L) and the radius of scale (S) was calculated from the equation: L= a + bS [34], where "a" is the intercept and "b" is the slope of the regression line. Length at age was back-calculated employing the following formula: L_n= a + S_n /S (L-a) [34], where L_n is the length of the fish at age 'n', "a" is the intercept with the axis of the abscissa of the previous regression, S_n is the radius of the annulus 'n', S is the scale radius and L is the length at the time of capture.

The lengths calculated through back readings were used to determine the parameters of the mathematical growth models of the von Bertalanffy growth equation $L_t = L_\infty (1 - e^{-K(t-t_0)})$, where L_t is the total length of the fish at age t, L_∞ is the ultimate length an average fish could achieve, K is the growth constant which determines how fast the fish approach L_∞ and t_o is the hypothetical time at which the length of the fish is zero [35]. The index of growth performance (Φ) of the species was calculated with the equation of Pauly and Munro [36]: $\Phi = \log k + 2\log L_\infty$, where K and L_∞ are the von Bertalanffy parameters.

The overall sex ratio was determined and the deviations from 1:1 null hypothesis were statistically tested by Chi-square (χ^2) analysis. The spawning period was determined through the monthly changes in the gonado-somatic index (GSI%) calculated by using the following equation [37]:

GSI=Gonad weight / Body weight *100

The diet was determined using the index of relative importance (IRI) of Stergion [39]. The index combines the occurrence (O) and points (P):

IRI= O% × P% and IRI %= IRI / ΣIRI * 100

All the calculations were done by using Microsoft Office Excel 2010.

3. Results

M. sharpeyi found in all monthly samples and constituted 5.1% of the total fish catches in the study area by number. The monthly variations in the percentage of *M. sharpeyi* are illustrated in Figure 2. The abundance fluctuated from 0.6% in October to 8.5% in June.

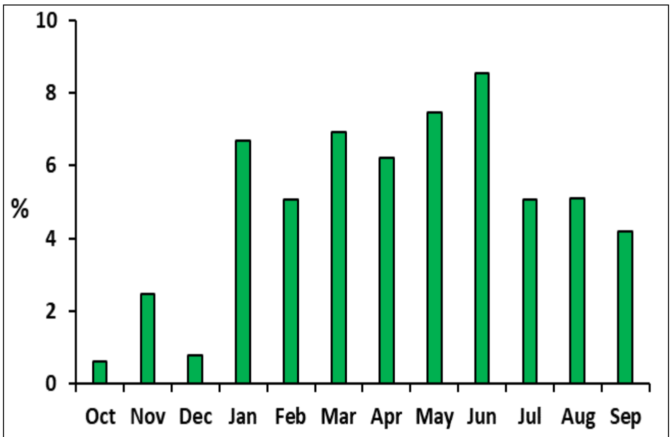

Fig 2: Monthly variation in the relative abundance of *M. sharpeyi*

The total length of all individuals for *M. sharpeyi* (n= 682) collected in this study ranged from 11 to 40 cm (Fig. 3). Several modes can be recognized, but the highest one was 27 cm which constituted 12% from the catch. Other modes were at 25, 30, 19, 13 and 36 cm. However, lengths of the species were mostly between 23-30 cm which constituted 60.3% of the catch.

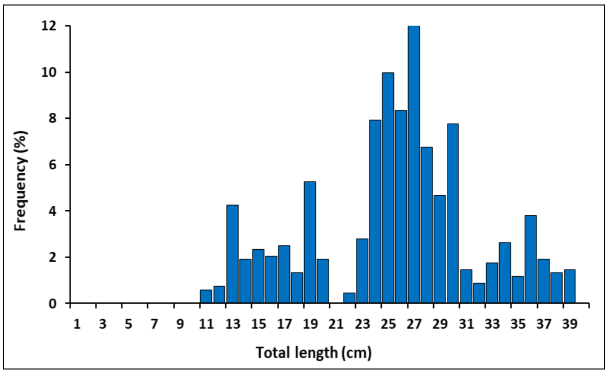

Fig 3: Length frequency distribution of *M. sharpeyi*

The length-weight relationship of *M. sharpeyi* for 396 specimens ranging from 11 to 39 cm in total length and between 25 to 789 g in weight was represented with the following equation (Fig. 4): $W = 0.032L^{2.7017}$, (r= 0.978). The value of 'b' for this species is less than 3.0, therefore the growth was negative allometric (*t*-test= 3.424, P>0.05) for the overall samples.

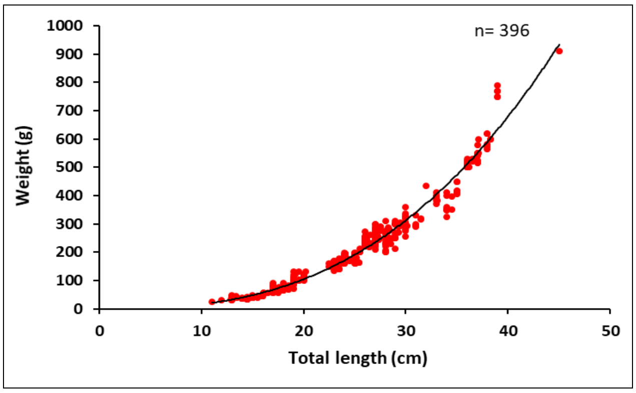

Fig 4: The length-weight relationships of *M. sharpeyi*

The monthly variation in the relative condition factor (K_n) for fish lengths from 11 to 39 cm is illustrated in Figure 5. The lowest mean value of K_n (0.81) was reported in October and the highest value (1.01) was observed in April. Generally, the monthly trend K_n values were high at the beginning of spring (March-April) and low during autumn (October). The mean value of the relative condition factor in the overall sample was 0.94.

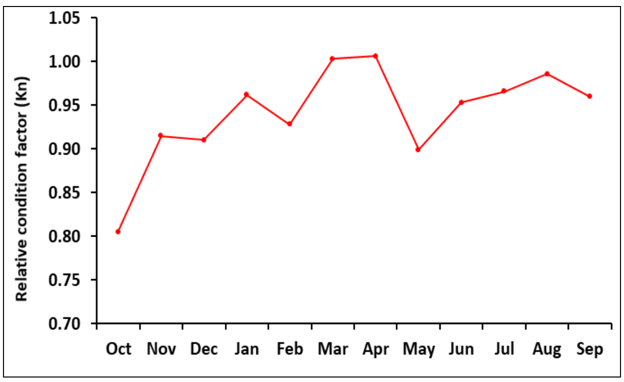

Fig 5: Monthly variation in relative condition factor (K_n) of *M. sharpeyi*

The relationship between fish length (L) and scale radius (S) fitted to a linear model, L =1.580+4.488S (Fig. 6), which reflects the high degree of correlation between these two parameters (r= 0.848). In the present species, seven ages were determined. The average back-calculated lengths of the pooled data at different ages have been calculated as given in Table 1. The mean back-calculated lengths of these seven ages were found to be 11.8, 21.4, 26.2, 30.5, 34.5, 37.8 and 41.1 cm, respectively (Table 1). The occurrence of rapid growth in length was found during the first two years of life after which growth increment decreased gradually. The percentage of annual increments varied from 26.6% during the first year of life to 7.3% during the 7th year of life.
The parameters of the theoretical growth in length of *M. sharpeyi* were $L\infty$ = 56.0, K = 0.229, t_o = - 0.103 and the index of growth performance (Φ) was 2.855.

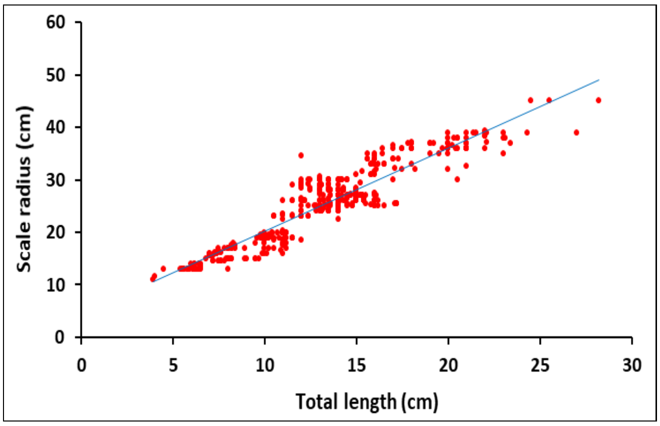

Fig 6: Linear relationship between total length and scale radius of *M. sharpeyi*

Table 1: Mean observed and back-calculated total lengths of *M. sharpeyi*

Age	No. of fish	Length at age (cm)							Observed length (cm)
		1	2	3	4	5	6	7	
1	31	11.0							12.7
2	42	10.9	20.0						21.7
3	64	11.2	22.4	26.4					27.2
4	37	11.1	20.1	26.8	30.1				30.9
5	63	11.2	22.0	25.7	31.0	34.7			34.4
6	11	11.3	22.1	25.4	30.5	34.0	38.0		38.2
7	8	11.1	20.9	26.0	29.2	33.5	37.7	40.9	40.9
Mean length (cm)		11.1	21.5	26.1	29.6	33.6	37.4	41.5	
Annual increment (cm)		11.8	21.4	26.2	30.5	34.5	37.8	41.1	
% Growth increment		26.6	21.7	10.8	9.9	8.9	7.6	7.3	

From a total number of 393 fish sampled, 162 males and 231 females were detected. The chi-squared test shows a significant departure from a 1:1 sex ratio. The overall male: female ratio (1:1.48) was biased in favour of females (χ^2= 8.4, P>0.05). Lengths at first maturity (L_{m50}) for males and females were 33.0 and 34.0cm, respectively.
Gonad development was studied using the gonado-somatic index (GSI) values of samples. Monthly changes in GSI for all individuals are shown in Figure 7. It is observed that the mean values of GSI for males varied from 0.11 in September to 6.32 in April. The lowest mean value for females was 0.47 in August and the highest value was 8.98 in April. However, there is no significant difference in the values of GSI between males and females among the study months (t-test = 1.025, P < 0.05).

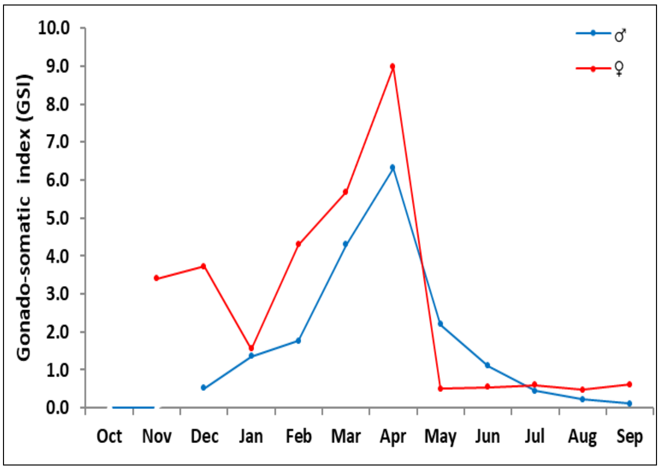

Fig 7: Monthly variations in the GSI of *M. sharpeyi*

Figure (8) illustrates monthly variations in the feeding activity and intensity of *M. sharpeyi* in the river. The feeding intensity varied from 5.0 points/fish in December to 14.2 points/fish in July-September, while the feeding activity of the species ranged from 28.3% in December to 95.0% in September. In general, both feedings were low during winter and high during summer, as there were significant correlations between water temperature and both feeding activity and intensity, r= 0.824 and 0.819, P < 0.05, respectively.

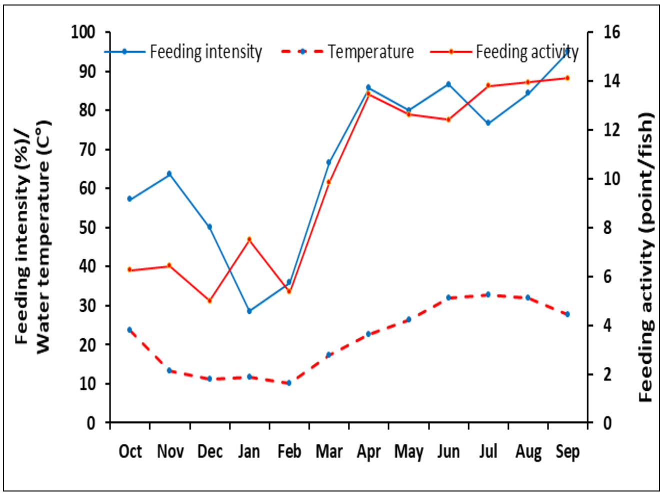

Fig 8: Monthly variations in water temperature (C°) and feeding intensity and activity of *M. sharpeyi*

Monthly variations in the relative importance index (IRI%) of food items of *M. sharpeyi* are illustrated in Figure 9. Macrophytes and algae materials dominated the food spectrum all year round. Macrophytes were dominant food items in six months (October, December, and June to September) and algae in November and January to May. However, macrophytes varied from 14.8% in December to 80.9% in October, and algae from 19.1% in October to 64.6% in February. Detritus found in ten months and varied from 0.4% in February to 27.9% in August. Finally, diatoms recorded the highest value of 20.2% in January. Overall, the most important food items of *M. sharpeyi* were macrophytes (41.0%), followed by algae (39.1%), detritus, (13.3%) and diatoms (6.5%).

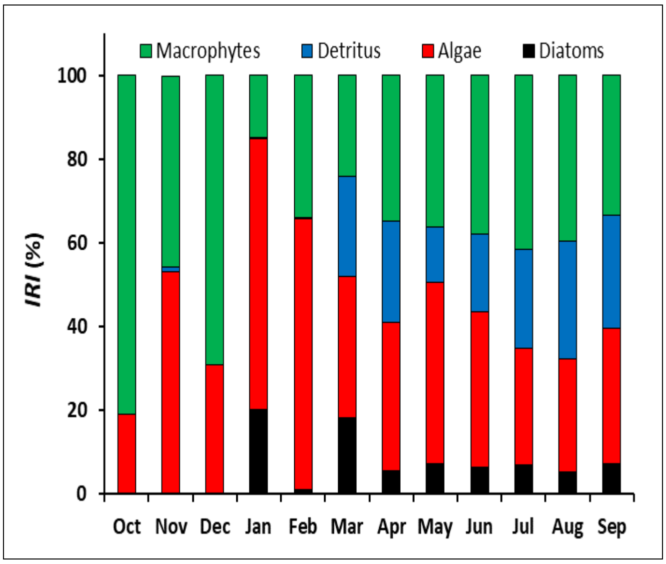

Fig 9: Monthly changes in *IRI*% of food items of *M. sharpeyi*

4. Discussion

As it can be seen from the results, *M. sharpeyi* constituted 5.1% of fish population in Al-Diwaniya river which was higher than the values reported from some other Iraqi waters, 1.4% of fish population in Al-Huwaza marsh [40], 1.04% of fish in Euphrates River at Al-Mussaib Power Station [41], 0.15% of fish in East Hammar marsh [42], 0.77% of fish in Al-Hilla river [43] and 0.014% of fish population in Shatt Al-Arab river [44]. However, *M. sharpeyi* comprised 24.5% of the total fish landings from the artisanal fishery of Al-Swab marsh during 2005 [9]. The size of *M. sharpeyi* in the present study (11-40 cm) was within the range of the total length of the species recorded from other waters, 15.0–57.0 cm in Al-Hammar marsh [21], 21.9-53.9 cm in the same marsh [14], 15.5-42.7 cm in Al-Hammar marsh [27], 10.0-53.3 cm in Al-Swab marsh [18] and 9.5-37.4 cm in Shadegan Wetland, Iran [30]. The difference in the length of fish ranges may be due to the different fishing methods used or to different environmental conditions, food supply, fish density or competition with exotic species [45].

The regression coefficient (b) in the length-weight relationship calculated for the overall sample of *M. sharpeyi* was 2.702 indicating negative allometric growth. Negative allometric growth implies the fish becomes more slender as it becomes longer and is indicated by a b < 3.0 [46]. A similar result was also obtained by Al-Mukhtar *et al.* [25] as the b value obtained for *M. sharpeyi* in Al-Huwaizah marsh was 2.709 indicating negative allometric growth. The available data analysis in the literature shows that the values of b for *M. sharpeyi* in other water bodies exhibited positive allometric growth. Al-Hakeim [12] stated b= 3.254 for *M. sharpeyi* population in Al-Razzaza lake; Mohamed and Barak [14] indicated that b was 3.245 for the species in Al-Hammar marsh. Jasim [21] found that b= 2.046 in Al-Hammar marsh. Mohamed *et al.* [18] indicated that b= 3.202 in Al-Swab marsh. Finally, Hashemi *et al.* [30] stated that b= 3.14 for females and 3.11 for males in a population of *M. sharpeyi* in Shadegan wetland, Iran. The length-weight relationship in fish is influenced by several other factors including size range of fish, sex, gonad maturity, stomach fullness, health, season, and a major change in environment factors [47-49].

Condition factor represents the health status of fish which is the result of the interactions between biotic and abiotic factors and their effect on the physiological condition of the fish [50]. In the present study the relative condition factor was low during October and increased progressively to the maximum during March-April as the growth of the gonads, then declined in May which coincided with the spawning time of the fish, after which improved steadily during summer months corresponded with the highest period of feeding. Thus it may be concluded that the seasonal fluctuation in the relative condition factor of *M. sharpeyi* was influenced by the spawning cycle and feeding intensity of the fish. Sharma *et al.* [51] stated that the variations in the condition factor of fish primarily reflect its nourishment status and state of sexual maturity.

The range values of relative condition factor of *M. sharpeyi* population in the study region was 0.81-1.01 which is within the findings of other studies on the species in some Iraqi waters, such as in Al-Razzaza, K_n= 0.73-1.02 [12], Al-Hammar marsh, K_n= 1.03-1.33 [14] and Al-Swab marsh, K_n= 0.75-1.16 [18]. In general, the seasonal fluctuation in the value of relative condition factor in fish has been mainly assigned to dependency on many factors such as feeding activity, gonad development, fish size and several other factors [52, 53].

It was found that the oldest age of *M. sharpeyi* was 7 years in this study (Table 2). Similar age results were reported for the Shatt Al-Arab river [15] and Al-Swab marsh [18]. On the other hand, specimens up to 8 years old were reported for Al-Razzaza lake [12] and Al-Hammar marsh [15]. An age of 5 was reported in Al-Hammar marsh [14]. This can be because of fishing pressure and sampling method.

As seen in Table 2, the growth rate of *M. sharpeyi* in the present study was within the range of the growth of the species documented from other waters. However, the ultimate growth of length ($L\infty$) in the present study was lower than that of other Iraqi waters. Backiel *et al.* [13] stated that $L\infty$ of *M. sharpeyi* was 72.0 cm in Tharthar lake. Mohamed and Barak [14] indicated that $L\infty$= 75.0 cm for the species in Al-Hammar marsh. Mohamed *et al.* [18] found $L\infty$= 65.0 cm in Al-Swab marsh. Wootton [55] stated that the growth of an individual fish achieves depends on three constraints, the genetic constitution of the individual, the abiotic environment experienced by the fish will set constraints on growth and the biotic environment will determine the extent of the growth potential that the fish can achieve as defined by its genotype and the abiotic environment experienced.

The overall sex ratio was (1:1.48) was biased in favour of females for *M. sharpeyi* in the present study. Al-Mukhtar *et al.* [25] stated there was a fluctuation in the sex ratio of *M. sharpeyi* in Al-Huwaizah marsh during months, and increased rapidly, 1:1.29 in favour of females during February. Moreover, Bawazir and Ali [5] found that the sex ratio for the whole sample of *M. sharpeyi* in the water system of Tigris-Euphrates marshes was 1.29:1 with a certain predominance of females, except in March and April when more adults of specimens were males.

Table 2: Growth comparison of *M. sharpeyi* in different ecosystems

Ecosystem	Mean total length at each age (cm)								$L\infty$	Reference
	1	2	3	4	5	6		7		
Al-Swab marsh	17.8	25.1	30.3	36.8	42.4	35.4	52.1	-	65	[18]
Al-Razzaza lake	14.3	19.8	24.4	28.5	30.4	33.7	35.1	38.3	-	[12]
Al-Hammar marsh	10.3	23.7	30.6	39.6	45.9	49.2	-	-	75	[14]
Shatt Al-Arab river	15.2	21.9	27.6	32.3	36.2	39.4	46.3	-	-	[15]
Al-Hammar marsh	14.9	21.5	26.9	31.9	36.0	39.3	46.3	52.0	-	[15]
Al-Diwaniya river	11.8	21.4	26.2	30.0	33.7	37.3	40.9	4.3	56	Present study

Although, the sex ratio for fish populations depends on different factors like differences in mortality rates between sexes, spawning migration and differences in growth between sexes, the selectivity of fishing gears and differences in sampling and different habitats [55].

The lengths at first maturity (L_{m50}) for males and females of *M. sharpeyi* in the present study were 33.0 and 34.0cm, respectively. Bawazir and Ali [5] observed that females of the species attained the first maturity at 32 cm in standard length, SL (38cm TL) and males at 24.6 cm SL (30 cm TL) in the water system of Tigris-Euphrates marshes. However, Hashemi *et al.* [30] reported that the length at maturity for males and females of *M. sharpeyi* in Shadegan wetland, Iran were 20.8 and 22.0 cm, respectively.

It was noticed that the mean values of GSI of *M. sharpeyi* in the present study were at the highest level in April then dropped dramatically for both sexes, suggesting that the species may spawn in late April to May. Jasim [21] found the spent stage of *M. sharpeyi* in Al-Hammar marsh during late April. Al-Mukhtar *et al.* [25] stated that the GSI and sex ratio of *M. sharpeyi* in Al-Huwaizah marsh indicates that the spawning season of the species started in March and prolonged until April. Hashemi *et al.* [30] reported that the spawning occurred from April to July in a population of *M. sharpeyi* in Shadegan wetland, Iran. Nikolsky [45] pointed out that the spawning characteristic of a fish varies for species and ecological characteristics of the water system in which they live.

In general, the feeding activity and intensity of *M. sharpeyi* in the present study were low during winter and high during summer, this may be related with the seasonal climatic change such as temperature, rather than the reproductive cycle. The monthly trend in the feeding activity and intensity of *M. sharpeyi* are related positively with a water temperature of the river (r < 0.820), the highest value of the criterion was recorded in summer and the lowest one in winter. Temperature is an important factor that regulates the biological and chemical activities in the aquatic environment as well as the metabolism and growth of fish. Our data are consistent with others' suggesting fish feeding rates decrease as water temperature drops [56]. It is generally known that feeding activity of Cyprinids decreases with decreasing of the water temperature [57].

Analysis of diet contents during this study indicated that *M. sharpeyi* is herbivorous food habit, fed chiefly on plant food sources including macrophytes, algae, detritus, and diatoms. This is in agreement with the findings of other authors who studied the food habit of *M. sharpeyi* in southern marshes. Nasir *et al.* [27] stated that the food taken by the species was dominated by filamentous algae and diatoms in Al-Hammar marsh. Mohamed *et al.* [40] mentioned that *M. sharpeyi* consumed algae, diatoms and plant tissues in Al-Huwaizah marsh. Algae dominated the food items consumed by *M. sharpeyi* constituting 50% following by diatoms 27% and plant tissues 12% in Chybayish marsh [58].

The results highlighted basic biological aspects of *M. sharpeyi* which can assist in fisheries management, aquaculture, and conservation of the fish resources in the Al-Diwaniya river. Some biological properties of the species were among those described for the species in other waters.

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