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Reproductive Biology of the Bunni *Mesopotamichthys sharpeyi* (Günther, 1874) from Southern Missan Province Marshes, Southern Iraq

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ABSTRACT

Due to the lack of the Bunni Mesopotamichthys sharpeyi stock, some biological aspects of highly exploitable species were investigated to highlight fecundity, gonads developments, relationships between morphometric and reproductive features, in addition to relative condition factors. The study was conducted from June 2020 to May 2021 in the southern Missan Province marshes, southern Iraq to investigate the reasons that resulted in the decline of the current species stock. Hence, 496 specimens (312 females and 184 males) were caught each month from the study area. The total length of fish ranged from 18 cm to 46cm, collected in June and January, respectively, while the weight fluctuated from 143 to 1400g. The values of the gonadosomatic index varied from 0.02 for females in June 2020 and 0.01 for males in May, to the highest of 17.55 and 8.39 in March for females and males, respectively. Absolute fecundity ranged from 34371 eggs at a total length of 40.8cm and an 889.60 g weight to 224495 eggs at a total length of 44.1cm and a 1171.30g of weight. Strong relationships were noticed between morphometric and reproductive characteristics, except that between absolute fecundity and egg diameter, which was weak. The relative condition factors ranged from 0.93 in March to 1.13 in May, with a mean of 1.01±0.06. The present study confirmed that the spawning season for *M. sharpeyi* prolonging from March to April in the southern Missan Province Marshes occurs in two batches, but all individuals have a spent stage during May. An increase was recorded in fecundity aligned with the increase in length, weight, gonad weight, suitable condition factors and food availability.

The current study concluded no changes in species fecundity, but the shrinking of the reproductive ground area, the overfishing, the absence of stock support for the current species and fishing during the spawning season caused the lack of population stock of the species under study.

INTRODUCTION

The Bunni, *Mesopotamichthys sharpeyi* (Family: Cyprinidae) is a very highly exploitable species, which suits the consumer’s desires in the central and southern Iraq **(Mohamed & Al-Jubouri, 2019)**. The genus of this species was shifted to *Mesopotamichthys* after it was inserted under the *Barbus* genus **(Borkenhagen, 2014)**. The species is native to the Tigris-Euphrates basin. After being inserted under the *Barbus* genus, the genus of this species was changed to *Mesopotamichthys* **(Abdullah, 2020)**.

It was necessary to re-evaluate the species' reproductive strategy and compare it with previous studies carried out in the region and its vicinity. There is a crucial need to study the reproductive biology of fish in order to develop appropriate strategic plans for the management and maintenance of fishery resources associated with the collected information about the species life history. The assessment of the effects of environmental changes on current fish population dynamics and knowledge of the reproductive pattern require a development in the commercial aquatic aquaculture sector **(Muchlisin *et al*., 2010; Muchlisin, 2014)**.

The reproduction is an important process that indicates the continuity of life. It enhances recruitment maintenance and offspring survival, and assesses the effects of habitats shafting on fish assemblages, the success of the commercial aquaculture, and on stocks potential as well **(Muchlisin, 2014; Kant *et al*., 2016)**. The reproductive strategies in fish are mainly responses to the anatomical differences between males and females. The targeted reproductive strategy depends on the magnitude of passing the genes to subsequent offspring, forming new generations capable of reproducing and recruiting new individuals **(Abdullah & Al-Noor, 2015)**.

Fecundity in fishes includes the total number of matured oocytes released from females at the spawning season and is species-specific **(Abdullah *et al*., 2017)**. Fecundity can be split into several types, viz. potential annual fecundity, total fecundity, annual realized fecundity, relative fecundity, annual population fecundity and batch fecundity **(Muchlisin, 2014)**.

The reproductive biology of *M. sharpeyi* was recorded in the study of **Marammazei *et al*. (2000)** who stated that Bunni spawns in Shadighan marsh (Khuzestan Province) in March. **Al-Mukhtar *et al*. (2006)** discussed the reproductive biology of *M. sharpeyi* in Al-Huwaizah Marsh in southern Iraq. They recorded the spawning time of this species in March and it prolonged to April. **Hashemi *et al*. (2014)** investigated some biological aspects of *M. sharpeyi* in Shadegan wetland, Iran and they mentioned that the spawning occurred from April to July. **Mohamed and Al-Jubouri (2020)** conducted a comparative study on the growth, reproductive, and food habits of *M. sharpeyi* in the Al-Diwaniya River, in the middle of Iraq.

Due to the continued stock reduction in southern Iraq, there was no available data on the reproductive biology of *M. sharpeyi* from the southern Missan Province Marshes. Thus, the present study aimed to highlight the gonado-somatic index (GSI), absolute fecundity, relative fecundity, and condition factor, evaluating some relationships between reproduction and morphometric characters. The current data was implemented to be compared to the results of previous studies.

MATERIALS AND METHODS

A total of 496 specimens (312 females and 184 males) of *Mesopotamichthys sharpeyi* were monthly caught during the period from June 2020 to May 2021 in southern Missan Province Marshes (N 31º 15′ 57.6", E 47º 07′ 39.36"). Various fishing methods were used to obtain the fish samples, gill nets (22×22, 27×27, 30×30 and 57×57mm mesh size, 30m long), cast nets and electro-fishing. Samples were deposited in the ice-box and brought to the laboratory for further work. Several measurements were implemented for mature fishes. The total length was measured to the nearest 0.1cm; body weight and gonad weight were recorded to nearest 0.1g; gonad length to nearest 0.1cm; egg diameters in microns (µ). Fishes were identified following the description of **Fricke *et al*. (2021)**. The gonadosomatic index (GSI) is examined two to three times in a month and calculated according to the following equation:

$$\mathbf{GSI = gonad\ weight\ /\ Body\ weight *100}$$

Absolute fecundity was determined using gravimetric methods application **(Bagenal, 1978)**. Gonads of ripe females were exacted; an average of three subsamples of gonad eggs were counted taken from various locations to obtain the absolute fecundity. Relative fecundity was determined by the successive equation:

Relative fecundity = Absolute fecundity/body weight (g)

The objective micrometer (μ) was used to measure the egg diameter. The morphometric and reproductive variables were determined using the relationship between weight (g) and length (cm). Then the equation was converted to a linear regression by using the consequential log equation: $\mathbf{W = a\,L^{b}}$ **(Le Cren, 1951)**

$$\mathbf{Log\ W = log\ a + b\ log\ x}$$

Where, (a) and (b) are constants. Furthermore, the calculated weight (Wc) was estimated using the above weight-length relationship, referring to the observed weight as (WO). The relative condition factor (Kn) was determined according to the consequent relationship:

$$K_n = W_O / W_c$$

Statistical analysis

The data were analyzed using the SPSS program, version 20, and the statistical application of ANOVA was used to determine the significance of differences in GSI between males and females. The same program was implemented to estimate the correlations among morphometric and reproductive parameters. A student t-test was done due to the negative allometric growth (less than 3) value of coefficient (b).

RESULTS

Fish length and weight frequency distribution

A total of 496 individuals of bunni *M. sharpeyi* were sampled from the southern marshes of Missan Province during the study periods, with 23 fish in August to 56 fish in March (Table 1). The specimens' length varied from 18 cm in June to 46cm in September and January. The length means fluctuated between 31.28±4.77cm in December to 43.46±1.36cm in January. The weight ranges of fishes differed from 143g in June to 1400g in January 2021, while the weight mean values ranged from 513.08±191.90g in December to 1080.43±153.41g in January.

Gonadosomatic index (GSI)

Mature individuals (males and females) witnessed gradual variations in the gonadosomatic index (GSI) from June 2020 to May 2021. In females, the GSI mean values revealed a slow monthly increase from June (0.02), reaching a high value (16.93) in January and peaking (17.55) in March, then a decline was recorded with 8.81 in April and 0.09 in May. The mean values of the males slowly rose from June (0.05), attaining the peak of 8.39 in March, then started to decline to record 4.15 and 0.01 in April and March, respectively (Fig. 1).

The results showed that all individuals have a single spawning season that begins in two batches in March and lasts until April, but most specimens sampled in April were partial spawners. Whereas in May, all females and males were in the spent stage and the ovaries sacs were empty and strikingly red. No significant differences (P > 0.05) were detected in GSI values between females and meals (Sig. = 0.060, F= 3.941).

Table 1. The total length and weight frequency distribution (ranges & means) of *Mesopotamichthys sharpeyi* from southern Missan Province Marshes

Month	No. of Fish	Total length (cm)		Weight (g)	
		Range	Mean ± SD	Range	Mean ± SD
June 2020	39	18 - 42.20	32.12 ±7.97	143 – 1017	588.77 ±316.54
July	28	26.9 - 40	34.40 ±4.19	307 – 856	649.42 ±194.97
August	23	25.60 - 42	35.81 ±5.99	250 - 1064.2	704.72 ±274.60
September	53	24 - 46	34.52 ±6.50	198 – 1363	632.30 ± 343.91
October	46	23 - 45	32.75 ±6.87	189 – 45	578.73 ±371.63
November	42	21.60 - 41	32.07 ±6.56	166 – 957	560.9 ±292.19
December	37	21.40 - 36.50	31.28 ±4.77	167- 701	513.08 ±191.90
January 2021	41	41.50 - 46	43.46 ±1.36	929 – 1400	1080.43 ±153.41
February	54	26 - 41.4	38.35 ±5.26	276- 920.90	811.28 ± 243.14
March	56	24.3 - 45	39.67 ±7.10	206 – 1299	883.76 ±375.87
April	44	25.2 - 41	38.11 ±5.04	253 - 1074.20	769.84 ±216.69
May	33	29 - 37.20	34.73 ±2.88	504 -770	689.40 ±85.99

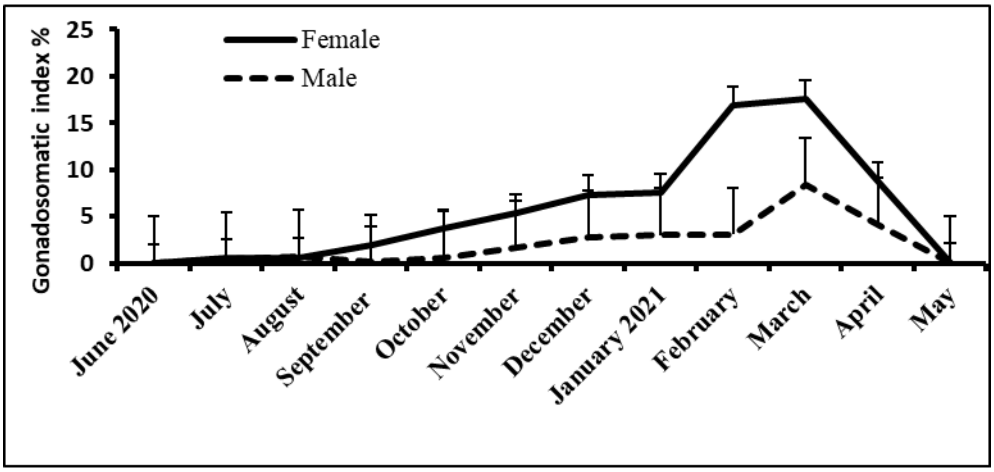

Fig. 1. Monthly variations in gonadosomatic index (GSI) of *M. sharpeyi* sampled from southern marshes of Missan Province

Error bars are referring to standard deviation

Absolute fecundity and relative fecundities

The total length of spawned females of the Bunni brooder ranged from 37.4 to 46cm. Body weight varied from 755.50 to 1299.50g. The lowest absolute fecundity was recorded at 34371 eggs at a total length of 40.8 cm and a total body weight of 889.60g. The highest absolute fecundity was recorded at 224495 eggs at a total length of 44.1 cm and a total weight of 1171.30g. The relative fecundity varied between 38.64 (40.8 cm total length and 889.60 g weight) and 208.74 (44.1 total length with 1171.30g weight). Gonad weight ranged between 50.3g at 40.8cm total length to 351.1g at 45 cm total length, while gonad length varied from 13cm at 37.4cm total length to 19 cm at a total length, ranging from 44.1cm to 46cm. Eggs' diameters oscillated from 1352µ at a total length of 40.8cm to 1888µ at a total length of 40.5cm (Table 2).

The relationships between absolute fecundity and morphometric parameters of female *M. sharpeyi* from the southern marshes of Missan province are presented in Table (3) and

Fig. (2). A strong correlation coefficient (r= 0. 81) appeared between absolute fecundity and fish total length; the equation inserted was as follows:

$$\text{Log F}=-8.9939+8.5554 \log L.$$

The relationship between absolute fecundity and fish body weight was forceful with correlation coefficient (r= 0.81), and the equation can be expressed as follows:

$$\text{Log F}=-4.0223+2.9664 \log W.$$

A powerful relationship was found between absolute fecundity and fish gonads weight, with a correlation coefficient (r= 0.85), and it can be addressed as:

$$\text{Log F}=3.0102+0.8974 \log W_g.$$

A Strong positive relationship was detected between absolute fecundity and gonad length, the correlation coefficient was r= 0.82, and it can be expressed in the consequent equation:

$$\text{Log F}=-0.2899+4.2512 \log L_g.$$

A weak positive correlation was recorded between absolute fecundity and egg diameter, the coefficient of correlation (r= 0.32), and it can be recorded using the equation as follows:

$$\text{Log F}=4.2757+0.2079 \log D_{egg}.$$

A strong positive relationship was showed between fish body weight and total length, the correlation coefficient (r= 0.85), and we can express it in the equation as **Log BW= -0.9681+2.4481 log TL**.

Table. 2. Monthly changes in gonadosomatic index (GSI) values of Bunni, *M. sharpeyi* from southern Missan Province Marshes

Total length, L (cm)	Body weight, W (g)	Gonad weight, W_g (g)	GSI	Gonad length, L_g (cm)	Absolute fecundity, F	Relative fecundity F/W*100	Eggs diameter, D_{egg} (μ)
37.4	903.90	76.5	8.46	13	45692	50.55	1430.00
39	755.50	80	10.59	15	51600	68.30	1340.00
40.5	878.30	71.6	8.15	15	42664	48.58	1456.00
40.5	789.80	125.1	15.84	17	37530	47.52	1888.00
40.8	889.60	50.3	5.65	15	34371	38.64	1352.00
40.8	1027.30	76.7	7.47	14	45766	44.55	1510.60
40.9	1024.00	85.1	8.31	16	48013	46.89	1566. 50
41.4	920.90	145	15.75	16	85256	92.58	1653.60
41.6	973.20	92.4	9.49	17	75738	77.82	1378.00
42.3	1096.40	108	9.85	18	115457	105.31	1534.00
43.3	1036.00	186.1	17.96	17.5	113431	109.49	1560.00
44.1	1171.30	241.2	20.59	19	244495	208.74	1534.00
44.8	1299.50	279.5	21.51	19	158411	121.90	1682.00
45	1273.90	351.1	27.56	19	167523	131.50	1596.40
45.5	1267.20	285.3	22.51	19	114521	90.37	1485.60
46	1172.50	140	11.94	19	130815	111.57	1451.33
Mean 42.12	**1029.96**	**149.6**	**13.9**	**16.7**	**94455**	**87.14**	**1526.13**
S.D 2.45	**171.26**	**92.0**	**6.54**	**1.99**	**59540.99**	**44.76**	**138.53**

$\mathbf{D_{egg}}$= egg diameter; **F**= absolute fecundity; **GSI**= gonadosomatic index; **L**= total length; $\mathbf{L_g}$= gonad length; **W**= body weight; $\mathbf{W_g}$= gonad weight.

Table 3. The relationships between reproductive and morphometric parameters of *M. sharpeyi* female from southern marshes of Missan Province

Relationships				
Y	**X**	**a**	**b**	**r**
Absolute fecundity	**Total length**	- 8.99	8.55	0.81
Absolute fecundity	**Body weight**	- 4.02	2.97	0.81
Absolute fecundity	**Gonad weight**	3.01	0.9	0.85
Absolute fecundity	**Gonad length**	- 0.29	4.25	0.82
Absolute fecundity	**Egg diameter**	4.28	0.21	0.32
Body weight	**Total length**	- 0.97	2.45	0.85

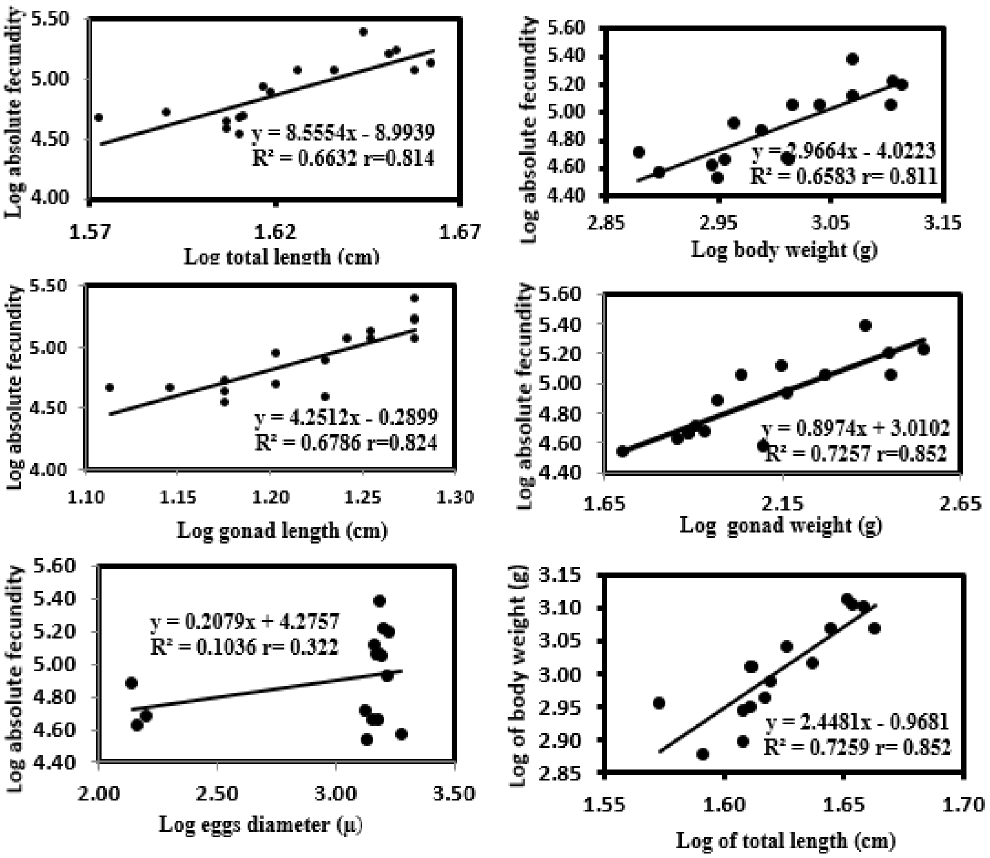

Fig. (2). The correlations between absolute fecundity and the total length, body weight, gonad length, gonad weight, eggs diameter, body weight, and total length of *M. sharpeyi* female from southern Missan province marshes.

Length-weight relationship

The general equation for the relationship of length-weight of *M. sharpeyi* in southern Missan Province Marshes presented in Fig. (3) is as follows:

$$\mathbf{W = 0.0504\ L^{2.6516}}$$

The exponent (b) in the present relationship showed different values during the months for population length groups, which ranged from 18 to 46 cm, and weights fluctuating from 143 to 1404 g (Fig. 3). It was lower than 3 in January at 2.65 and was recorded 2.51 in February. The value rose to 2.95 in March and declined in April to 2.43. Since the (b) value in the present equation is lower than 3.0, then it refers to negative allometric growth (t-test, b < 3, P < 0.05).

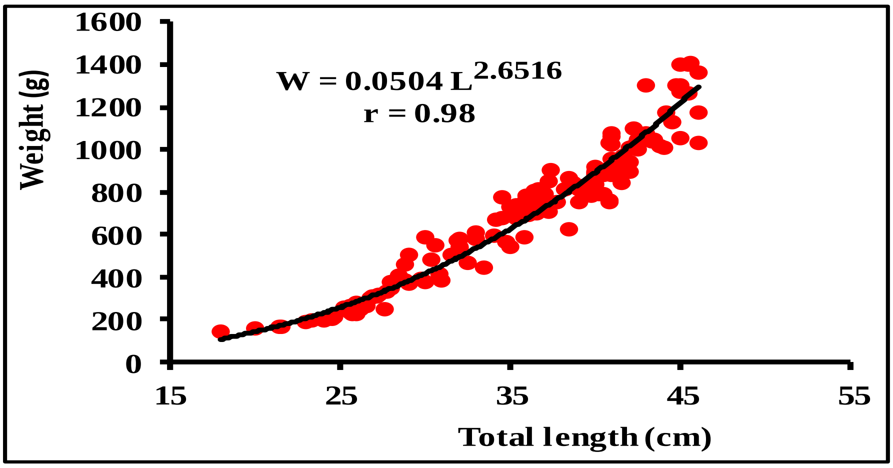

Fig. 3. Length-weight relationship of *Mesopotamichthys sharpeyi* from southern Missan Province Marshes

Relative condition factor

The relative condition factor (K_n) exhibits a fluctuation during the study period for fish length, with ranges from18 to 46 cm. A high value was recorded in June 2020 (1.08), and then it started to decline to record 0.96 in September; whereas, a progressive rise was detected from October to January, then started to mark a steady depression reaching its lowest (0.93) in March to attain the highest 1.13 in May with the mean of 1.01±0.06 (Fig. 4).

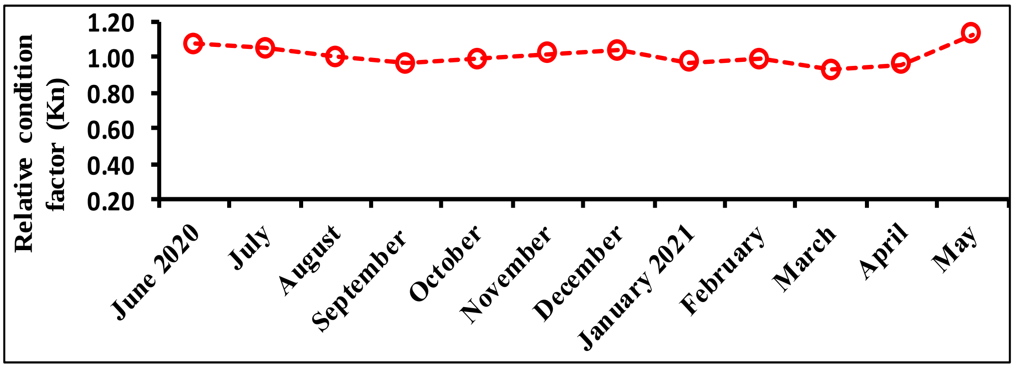

Fig. 4. Monthly changes in the condition factor (K_n) values of *M. sharpeyi* from marshes of southern Missan Province

DISCUSSION

Generally, length and weight frequency distribution are two important variables used in measuring size development in organisms that exhibit growth in both length and weight. They represent basic parameters applied in biological information and fishery management **(Tagarao *et al*., 2020)**. The two parameters are widely used to establish the mathematical equation between these variables, which is used to find one of the variables in terms of the other in the length and weight groups of fish, and there is a close correlation between reproductive and morphometric parameters **(Abdullah *et al*., 2017)**. However, there were some differences in the distribution of length and weight in the monthly catch samples due to the increase in the means of length and weight and the abundance of catgut in February, March, and April, which included a large ratio of males. This is attributed to the spawning migration of Bunni for the purpose of reproduction, which facilitated fishing **(Al- Mukhtar *et al*., 2006**; **Taylor *et al*., 2016)**.

During the analysis of the monthly collected data, it was discovered that the males began their reproductive migration at a similar or slightly smaller size than the females.These findings correspond to those recorded by several authors that have been reported from various aquatic bodies from the middle and south of Iraq, referring to male and female length-frequency distributions. **Al-Hakeim (1976)** in Al-Razaza Lake postulated that males were smaller than females, while **Jasim (1988)** pointed out that most size population range from 21 to 23.4 cm in the South Al-Hammar Marsh, whereas **Al-Muktar *et al*. (2006)** in Al-Huwaizah Marsh found an increase of mean length at the spawning season, starting with small- sized fish, which are mostly males. On the other hand, **Mohamed & Al-Jubouri (2020)** in Al-Diwaniya River, central of Iraq, mentioned that mean values of length group ranged between 11 to 40cm.

The GSI mean values of the *M. sharpeyi* population reached their highest in March and April, then they were found in a spent stage in May for both sexes, suggesting that females lay eggs in batches during the spawning period. **Jasim (1988)** in Al-Hammar Marsh stated that the spent period of *M. shrpeyi* is in April, while **Al-Muktar *et al*. (2006)** reported that the spawning stage in Al-Huwaizah Marsh begins in March and span to April, these results are closely similar to those of the present findings. **Hashemi *et al*. (2014)** mentioned that the spawning occurs from April to July in Shadegan wetland, Iran. In addition, **Mohamed and Al-Jubouri (2020)** reported that the highest level of GSI in the Al-Diwaniya River, in the middle of Iraq, was in April. The differences in the spawning time in poikilothermic organisms could be attributed to geographical differences and other environmental conditions. However, gonad development is related to other several factors, i.e. nutrition, genetics, brood fish, spawning frequencies, fish health, and status, which have a great role in specifying the reproductive time of fishes **(Abdullah *et al*., 2017)**.

Fecundity differs due to differences in species reproductive strategy. Most studies linked the high fecundity value to fishes that live in open water compared to those building nests or Ovovivi-parus or Vivi-parus species, which are distinguished by the low number of eggs, large size, and parental care **(Robart & Sinervo, 2019)**.

Fecundity studies play a significant role in possessing more reproductive biology knowledge which is essential to spawning success and transfering the genes feature to the next new offspring until it attains maturity and recruitment **(Tagarao *et al*., 2020)**. Population fecundity is specific to species. Its common phenomenon differs from one species to another, and among individuals. It fluctuates in terms of time and locality and is affected by many factors, such as total length, weight, age, type of fish species, food availability and season. Fishes with large oocytes and parental care behavior have fewer eggs account than those spawning in open waters or nest building. In general, the current results are consistent with those of **Nandikeswari *et al*. (2014)**, **Abdullah *et al*. (2017)** and **Mohamed and Al-Jubouri (2020)**. Eggs' size and the larvae status are critical factors, mostly related to fish size, condition factors, adult individuals' age, food availability, maximum species size (genetic), and eggs' biochemical composition. **Mandic and Regner (2014)** reported that larger eggs include a large amount of yolk, which results in large larvae hatching, giving the larvae brooder more chance of survival in the worst habitat condition to succeed the reproductive cycle. While, **Abdullah *et al*. (2017)** mentioned the extent of reproductive success depends on the amount of yolk in the eggs, which is crucial in crossing the larva through the difficult conditions that go through after hatching in order for the fast growth to avoid predators.

However, the temperature is the most important parameter that could help to accelerate the process of egg hatching and larvae growth to pass the critical time after hatching **(Imslanda *et al*., 2018)**.

Reproductive effort and morphometric parameters showed strong positive relationships among absolute fecundity, length, body weight and gonad weight. The present results are compatible, in the general direction, with those of **Al-Mukhtar *et al*. (2006)**, **Abdulla and Al-Noor (2015)**, **Abdullah *et al.* (2017)** and **Mohamed and Al- Jubouri (2020)** in different aquatic bodies in Iraq. Nevertheless, there was a weak positive correlation between absolute fecundity and egg diameters. This could be attributed to the type of reproductive strategy according to which fish spawning in open water are characterized by high fecundity with small-size eggs **(Mandic & Regner, 2014**; **Robart & Sinervo, 2019)**.

On the other hand, the length-weight relationship can be calculated from all the samples collected from the study area. The coefficients (b) of *M. sharpeyi* in the present work refer to the negative allometric growth (b = 2.6516), indicating that fish are becoming more streamlined or longer, whereas **Al-Hakeim (1976)** reported a value of b = 3.254 when he studied the morphology and length at first maturity of Bunnei, *M. sharpeyi* and *Barbus grypus* in Al-Razaza Lake. **Jassim (1988)** studied the reproductive biology of *M. sharpeyi* population south Al-Hammar marsh and found that value of b= 2.046. **Mohamed and Barak (1988)** mentioned that the value of b= 3.245 of *M. sharpeyi* population in Al-Hammar Marsh. Additionally, **Al-Mukhtar *et al*. (2006)** calculated the value of b of *M. sharpeyi* in Al-Huwaizah Marsh and obtained b=2.7097;while, **Hashemi *et al*. (2014)** analyzed some biological aspects of *M. sharpeyi* in Shadegan wetlands, Iran and recoded that b= 3.14 in females and 3.11 in males. **Mohamed and Al-Jubouri (2020)** referred to b =2.7017 of *M. sharpeyi* in Al-Diwaniya River in the middle of Iraq. The differences in the values of b can be attributed to the status of fishes being affected by several factors, including condition factors, fish size, gonad growth, sexes, season, fish health and feeding intensity **(Cuadrado *et al*, 2019**; **Robart & Sinervo, 2019)**. Therefore, differences in the values of b are in normal position in overall previous studies conducted on the species population.

The relative condition factor (K_n) is a common parameter widely used to determine the fish status **(Jisr *et al*., 2018)**. K_n values of the evaluated species in the present study oscillated between 0.93 and 1.13. The deviation in the Kn values between this range revealed the variance in the fish life cycle, especially in the availability of food and physicochemical interactions between biotic and abiotic factors with other interactions inside the fish body. High values of Kn were observed during hot periods or months (May, June, July, and August). These increases may be explained by the availability of large amounts of food or increased feeding intensity when the temperature is suitable for increased feeding activity and growth. Kn values were recorded greater than one **(De Giosa *et al*., 2014**; **Jisr *et al*., 2018)**. The result showed a slight rise in k_n values from November to February, and this may be attributed to gonad development **(Sharma *et al*., 2016)**. However, when comparing the range of relative condition factors in the present work with the finding of previous papers it was noticed that the present values are within the range of previous studies. Broadly, **Al- Hakeim (1976)** documented the K_n range from 0.73 to1.02 in Al-Razaza Lake,; **Mohamed and Barak (1988)** in Al-Hammar Marsh mentioned the range between 1.03 to1.33, **Al-Mukhtar *et al*. (2006)** recorded values from 0.91 to 1.25 in Al-Huwaizah Marsh, **Mohamed *et al*. (2012)** in Al-sweb marsh stated K_n range from 0.75 to 1.16 and **Mohamed and Al-Jubouri (2020)** spotted the values from 0.81to1.01 in Al-Diwaniya River. Generally, these slight fluctuations mostly depend on gonad development, feeding intensity and fish size **(Jisr *et al*., 2018**; **Mohamed & Al-Jubouri, 2020)**.

The present consequences showed that the spawning season prolonged from March to April in southern Missan Province Marshes in two batches, but that all individuals were in a spent stage during May. Moreover, fecundity increased with the increase in length, weight, gonad weight, suitable condition factors, and availability of food. The present paper highlighted some reproductive aspects of the most exploitable species due to the decline in population stock to enhance species abundance and support fisheries management, maintenance, and aquaculture with more information about the reasons causing the reduction in the abundance of species in southern Missan Province.

CONCLUSION

The current study recorded no variations in the species's fecundity compared to previous studies. Nevertheless, the shrink in the reproductive ground areas, overfishing, the absence of stock support for the current species and fishing during the breeding season caused the lack of stock of the current species.

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