A study on age, growth, reproduction, and diet of *Leuciscus vorax* (Heckel, 1843) in Al-Diwaniya River, middle of Iraq

Mohamed Abdul-Razak Mahmood 1,* and Al-Jubouri Mohanad Obas 2

1 Department of Fisheries and Marine Resources, College of Agriculture, Basrah University, Iraq
2 Department of Pathology, College of Veterinary Medicine Al-Qasim Green University, Iraq.

Publication history: Received on 21 February 2020; revised on 29 February 2020; accepted on 02 March 2020

Article DOI: https://doi.org/10.30574/wjarr.2020.5.3.0049

Abstract

In this study, age, growth, sex ratio, size at first sexual maturity, gonad development (GSI) and food habit of *Leuciscus vorax* (Heckel, 1843) in Al-Diwaniya River, middle of Iraq were described between November 2016 and October 2017. *L. vorax* constituted about 6.4% of the fish assemblage. The total length of all individuals ranged from 10.2 to 55.5 cm, the length-weight relationship was calculated as W= 0.007L 3.035 and isometric growth was observed. The mean value of the relative condition factor was 0.8. von Bertalanffy growth parameters were L∞= 61.0 cm, K= 0.227 and t0= -0.196 years. The growth performance index (Φ) was found to be 2.93. The overall male to female ratio was 1:1.51. Length at maturity was 29 cm for males and 31 cm for females. The maximum gonado-somatic index was in January then dropped dramatically for both sex, suggest that the species may spawn in February. The feeding intensity and feeding activity were low during winter and high during summer. The species is a carnivore fed mainly on fish, shrimps, aquatic insects, and crustacean. In conclusion, it is found that the population of *L. vorax* reflects the expected and previously observed features of the species in natural waters, but it is necessary to activate the national law of fishing, exploiting and protecting aquatic resources to continuation the fish populations in the river as an economic resource.

Keywords: *Leuciscus vorax*; Growth; Reproduction; Diet; Al-Diwaniya River; Iraq

1. Introduction

The Cyprinid, *Leuciscus vorax* (Heckel, 1843) belongs to the Cyprinidae family which is regarded as one of the most widespread fish families in the world with 2963 available species and 1722 valid species [1]. *L. vorax* formerly placed in the genus *Aspius* and recently became within the genus *Leuciscus* [2]. The genus *Aspius* includes two species, one *L. aspius*, which lives in Europe, and *L. vorax*, whose geographical distribution is limited to the rivers and lakes of the Mesopotamian basin in Turkey, Syria, Iraq, and Iran[3, 4, 5, 6]. *L. vorax* is locally known as “Shillig” and widely distributed along the Mesopotamian basin in Turkey, Syria, Iraq, and Iran [6]. These fish are one of the most important species for artisanal fisheries, which are consumed locally as fresh fish. Mohamed et al. [7] stated that *L. vorax* was one of the dominated species in the artisanal fishery of Al-Swab marsh, constituted by 10.4% of the total fish landings during 2005.

The distribution of *L. vorax* have been reported in different freshwaters of Iraq including Habbaniyah lake [8], Shatt Al-Basrah canal [9], Razazah lake [10], middle Euphrates river in Iraq [11-14], south marshes [15-17], Derbendikan reservoir [18], Tigris river, Mosul [19], Dukan dam lake [20], Tharthar lake [21], Tigris river at Al-Kut Barrier [22] and Shatt Al-Arab river [23]. Moreover, the species was found in Euphrates river Syria [24, 25], Ataturk lake, Turkey [26], Karakaya reservoir, Turkey [27] and south Iran [28].

*Corresponding author: Mohamed Abdul-Razak Mahmood

Copyright © 2020 Author(s) retain the copyright of this article. This article is published under the terms of the Creative Commons Attribution License 4.0.
Several biological studies conducted on *L. vorax* in different natural waters of Iraq, Turkey and Syria. Some authors have described the growth of the species [29, 8, 9, 30, 31, 26, 25, 32, 27, 33, 13, 34]. Other studies concentrated on the reproduction [8, 10, 35, 24, 26, 32, 36, 34]. Finally, some studies on the food habit of the species [8, 36, 37, 38, 15, 16, 13, 39].

However, there is no available information regarding the biological characteristics of the *L. vorax* in the Al-Diwaniya river, the middle of Iraq. Therefore, this study investigates some biological parameters, such as length frequency distribution, length-weight relationship, relative condition factors, age, growth rate, sex ratio, gonado-somatic index and food habit of *L. vorax* population in Al-Diwaniya river and compare the results with those of the species in other waters.

2. Material and methods

Fish species were collected monthly from the AL-Diwaniya river, middle of Euphrates River, Iraq [Figure 1] between October 2016 to September 2017. Specimens were caught using electrofishing equipment (provides 150-300V) and three types of nets. The 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 an icebox for subsequent analysis.

![Figure 1 Map of Al-Qadisiyah Province showing the sampling sites in Al-Diwaniya River](image)

In the laboratory, total length (*TL*) was recorded to the nearest mm by using a measuring board and whole weight (*W*) was measured with an electronic balance and recorded to the nearest g. After the measurement, scales were extracted, cleaned, dried and mounted between two slides for binocular microscopic study [40]. The gut of each fish was removed and preserved in a specimen bottle containing 4% formaldehyde. The gonads were excised from the body cavity and weighed. Sex was determined by macroscopic observation of the gonads.

Parameters of the length-weight relationship were obtained by fitting the power function *W* = *a* *L*^*b* [41] to length and weight data, 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. The relative condition factor (*K_n*) was estimated from the equation: *K_n* = *W'/W* [41], where *W'* = body weight and *W* = calculated weight from the length-weight relationship.

Total scale radius and the distance between the focus and their respective annuli were measured and the regression between fish length (*L*) and the radius of scale (*S*) was plotted. Back-calculated fish lengths were determined by the following formula: *L_a* = *a* + *S_n*/(*L_a* - *a*), where *L_a* 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* the scale radius and *L* is the length at the time of capture [42].
Growth was investigated by fitting the von Bertalanffy growth function to back-calculated fish lengths using Beverton and Holt method [43]. The von Bertalanffy growth function is defined as follows: 

\[ L_t = L_\infty (1 - e^{-K(t-t_0)}) \]

where \( L_t \) is the total length of the fish at age \( t \), \( L_\infty \) is the ultimate length an average fish could achieve, \( K \) is the growth constant which determines how fast the fish approach \( L_\infty \) and \( t_0 \) is the hypothetical time at which the length of the fish is zero [43]. The growth performance index \( \Phi \) [44] was calculated to provide a basis for the comparison of growth characteristics in terms of length: 

\[ \Phi = \log K + 2 \log L_\infty \]

The population sex ratio was examined by using \( \chi^2 \) goodness-of-fit tests. The mean size at first maturity was taken as that at which 50% of individuals were mature. Gonado-somatic indices (GSI), calculated by expressing gonad weight as a proportion of total body weight [45], were plotted against the sample period by month to establish the timing and seasonality of spawning.

The food items were identified as the least taxon possible and counted. The frequency of occurrence (O) and the points (P) methods were used for analyzing the food items, and then using the index of relative importance (IRI) of Stergion [46]. The index combines the occurrence (O) and points (P):

\[ IRI = O\% \times P\% \text{ and } IRI\% = \frac{IRI}{\Sigma IRI} \times 100 \]

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

3. Results

The monthly fluctuations in the percentage of \( L. \ vorax \) in the river are shown in Figure 2. The abundance of the species was fluctuated from 2.0% in October to 10.2% in January. Generally, \( L. \ vorax \) constituted 6.4% of the fish assemblage in the study river.

![Figure 2](image)

**Figure 2** Monthly variation in the relative abundance of \( L. \ vorax \)

The total length-frequency distribution of all individuals for \( L. \ vorax \) caught by all fishing gears in this study is given in Figure 3. The length of the species ranged from 11 to 48 cm. Several modes can be recognized, but the highest one was 16 cm which constituted 8.9% from the catch, followed by 29 cm comprised 7.7%. Other modes were at different lengths. However, the lengths range of the species were mostly between 13-18 cm and 24-31, which constituted 35.6 and 34.8% of the catch, respectively.
The length-weight relationship of *L. vorax* for 501 specimens ranging from 10.2 to 55.5 cm in total length was represented with the following equation [Figure 4]: \( W = 0.007L^{3.035}, \) \((r^2 = 0.976)\). The exponent of the length-weight relationship was not significantly different from the value 3 \((t\text{-test} = 3.424, \ P > 0.05)\), which means an isometric growth pattern.

Monthly fluctuation in the relative condition factor \((K_n)\) of *L. vorax* for fish length groups 10.2-55.5 cm are presented in Figure 5. \( K_n \) was high in December and January and gradually declined until March followed by a rise in April. The range of \( K_n \) was 0.85 in March to 1.10 in December. The mean value of the relative condition factor in the overall sample was 0.98.
The scale radius (S) and total length (TL) relationship of *L. vorax* were fitted to a linear model, $L = 4.577 + 8.740S$ [Figure 6], which reflects the high degree of correlation between these two parameters ($r^2 = 0.880$). The estimated age ranged from 1 to 8 years. Back-calculated lengths for *L. vorax* at different ages are given in Table 1. The mean calculated lengths of these eight ages were found to be 14.3, 23.4, 31.0, 38.2, 42.9, 45.9, 48.7 and 51.5 cm, respectively. The length annual increment gradually decreased with increasing age. Occurrence of rapid growth in length was found during the first two years of life after which growth increment decreased gradually. The length annual increment varied from 27.7% during the first year of life to 5.3% during the 8th year of life. The growth model parameters of the species were $L_\infty = 61.0$, $K = 0.227$, $t_0 = -0.196$ and the index of growth performance ($\Phi$) was 2.926.

Monthly changes in the gonado-somatic index (GSI) were determined for males and females [Figure 7], and clear seasonal patterns were found. GSI values were high in January and gradually declined until May for males and June for females followed by a rise in July for females and October for males. The mean values of GSI for males varied from 0.12 in May to 4.30 in January, while for females ranged from 0.10 in June to 9.37 in January. There is a significant difference in the values of GSI between males and females among the study months ($t$-test = 2.14, $P < 0.05$).
Table 1 Mean observed and back-calculated total lengths of *L. vorax*

| Age | No. of fish | Length at age (cm) | Observed length (cm) |
|-----|-------------|--------------------|----------------------|
| 1   | 34          | 13.9               | 15.0                 |
| 2   | 31          | 14.1 23.6          | 23.5                 |
| 3   | 41          | 14.1 23.2 30.5     | 31.1                 |
| 4   | 12          | 16.0 23.3 32.3 38.3| 38.4                 |
| 5   | 8           | 14.9 23.9 31.5 37.4| 42.8                 |
| 6   | 8           | 14.4 23.1 31.1 38.1| 43.3 45.9            |
| 7   | 7           | 14.1 23.7 34.8 39.5| 43.0 45.9 48.9       |
| 8   | 8           | 14.3 24.1 34.0 38.0| 42.5 45.7 48.5 51.5  |
| Mean length (cm) | 14.3 23.4 31.0 38.2 42.9 45.9 48.7 51.5 | 52.5 |
| Annual increment (cm) | 14.3 9.2 7.6 7.2 4.7 2.9 2.8 2.7 | 51.45 |
| % Growth increment | 27.7 17.8 14.7 14.0 9.1 5.7 5.5 5.3 |

Figure 7 Monthly variations in the GSI of *L. vorax*

The feeding intensity varied from 5.0 points/fish in December to 12.8 points/fish in September, while the feeding activity of the species ranged from 33.4% in December to 88.5% in May [Figure 8]. 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, $r= 0.853$ and 0.823, $P < 0.05$, respectively.
Fish were divided into two size groups, small fish (<20 cm) and large fish (>20 cm). Small individuals of *L. vorax* in the river fed on fish, shrimps, aquatic insects, algae and crustaceans [Figure 9]. The peak contribution of fish was 59.9% (IRI%) in February, shrimps 38.5% in March, algae 18.1% in October, crustaceans 17.8% and aquatic insects 14.4% in July. The overall diet composition of small individuals was comprised of fish (49.5%), shrimps (24.9%), aquatic insects (9.5%), algae (8.1) and crustacean (8.0%).

Figure 10 also illustrates monthly variations in the relative importance index (IRI%) of food items of large individuals of *L. vorax* in the river. Fish were the most important food items, their contribution varied from 35.2% in January to 78.2% in November. Shrimps ranked second were consumed in October and March at 2.2% and 40.9% respectively. Aquatic insects ranked third and more were eaten in January (38.2%). Finally, crustacean varied from 1.3% in September to 18.4% in October. The overall diet composition of large individuals of *L. vorax* was comprised of fish (58.1%), shrimps (24.3%), aquatic insects (11.0%) and crustacean (6.6%).
4. Discussion

The study revealed that *L. vorax* comprised 6.4% of the fish assemblage in Al-Diwaniya river which was higher than the values reported for the species from some other Iraqi waters, 4.3% of fish in Euphrates River at Al-Mussaib Power Station [11], 4.2% of fish population in Al-Huwaizah marsh [15], 1.8% of fish population in East Hammar marsh [17], 1.6% of fish in Euphrates River between Al-Hindyah Barrier and Kufa [47], 0.7% of fish in Al-Hilla river [12], 3.1% of fish population in Al-Chybayish marsh [48], 1.0% of fish population in Dukan dam lake [20], 5.1% of fish population in south part of Tharthar lake [21] and 0.3% of fish population in Shatt Al-Arab river [23]. However, this percentage was lower than that documented from other Iraqi waters, 15.3% of fish population in Euphrates river at Al-Hindyah Barrier [13], 7.3% of fish population in Tigris river at Al-Kut Barrier [22] and 11.7% of fish population in Euphrates river near Al-Hindyah Barrier [14].

The length sizes of *L. vorax* in the present study, 11.0 to 55.5 cm were within the range of the total length of the species recorded from other waters such as in Al-Habbania lake, 11.4-55.1 cm [8], in Al-Hammar marsh, 18.3-40.3 cm [29], in East Hammar marsh, 3.7-55.6 cm [48] and in Shadegan Wetland, Iran, 11.5-40.5 cm [33]. Conversely, this length size was lower than those recognized from other waters, 4.0-62.0 cm in Garmat Ali river [35], 16.7-62.2 cm in the artificial lake, west of Baghdad [49], 19-70 cm in Euphrates river, Syria [25]. The length of fish ranges may be different between habitats due to the different fishing methods used or to different environmental conditions, food supply, population density or competition with exotic species [50].

The growth of *L. vorax* in the present study was isometric pattern since the regression coefficient (b) in the length-weight relationship equal 3.035, namely, there is no change of body shape as an organism grows and that weight increases as the third power of length [51]. Similar isometric growth for *L. vorax* populations were reported in different locations, like in Al-Habbania lake, 3.060 [8], in the Shatt Al Basrah Canal, 3.077 [9], in Euphrates river, Syria, 3.130 [25], 2.9706 in Karakaya reservoir, Turkey [27], 3.03 for males and 3.02 for females in Shadegan Wetland, Iran [33], 3.085 in East Hammar marsh [34]. Karnal et al. [52] and Cuadrado et al. [53] stated that the value of (b) in the length-weight relationship can be affected by major environmental factors, the size range of fish, food supply, stomach fullness and disease and parasite loads.

The relative condition factor is regarded as a measure of a condition deviation, health, or fullness of the fish from the height-to-weight ratio within a group [42]. *Kc* was high in December and January and gradually declined until March followed by a rise in April. The general pattern of relative condition factor of *L. vorax* was high in December and January coincided with the growth of the gonads, then gradually declined until March which corresponded with the spawning time of the species, after which improved steadily during summer months may be related with the highest period of feeding and the recovery of gonads. The correlation coefficient between gonads somatic index for males and females *L. vorax* and condition factor of the species were positively (r= 0.61 and 0.56, p< 0.01), respectively. Other studies reported variety values of condition factor for the species, 1.01-1.51 in Hammar marsh [29], 0.74-1.18 in Al-Habbaniyah lake [8], 0.76 in Tharthar lake [10], 1.8 in Diyala river [53], 0.7 in Euphrates River, Syria [25] and 0.74 in

![Figure 10 Monthly changes in IRI% of food items of large individuals of *L. vorax*](image)

**Figure 10** Monthly changes in IRI% of food items of large individuals of *L. vorax*
Tigris river, Tikrit [32]. The variations in the condition factor of fish primarily reflect its nourishment status and state of sexual maturity [54].

The growth information of *L. vorax* in the present study and those documented from other waters are given in Table 2. It can be seen that the number of ages of the species in Al-Diwaniyah river is consistent with that of most other environments. The growth rates of the species in the present study were within the range of the growth of the species reported by other authors. Asymptotic length (*L*∞) of *L. vorax* in Al-Diwaniya river was higher than that recorded for the species in the other waters, Al-Hammar marsh [29], Euphrates river, Al-Mussaib [31], Diyala river [53] and East Hammar marsh [34]. However, it was lower than the values that can be reached by the species in Al-Habania Lake [8] and Karakaya reservoir, Turkey [27]. The growth performance index (ϕ) of the species in the present study (2.612) was intermediate with other values for the species in other waters (Table 2). The highest value of (ϕ) was recorded in the Karakaya reservoir, Turkey by Duman and Gül [27]. Some differences between the growth characteristics among populations in different regions involving the same species may be attributed to variation in environmental conditions such as water temperature, diversity, availability of food items and over-exploitation of natural stocks [55, 56].

Table 2 Growth characteristics comparison of *L. vorax* in different environments

| References | *L*∞ (cm) | Mane total length at each age (cm) | ϕ | Environments       |
|------------|----------|----------------------------------|----|-------------------|
| [8]        | 91.0     | 12.9 21.8 29.8 36.8 43.0 48.5 53.4 | 3.0 | Al-Habania Lake   |
| [29]       | 52.3     | 8.2   18.1 25.7 31.5 36.1 - - - | 2.8 | Hammar marsh      |
| [31]       | 52.5     | 16.0  24.8 30.7 35.4 40.2 42.0 44.6 | 2.9 | Euphrates river, Al-Mussaib |
| [53]       | 45.7     | 12.0  17.4 22.0 26.9 31.0 - - - | -   | Diyala river      |
| [27]       | 92.7     | -     - - - - - - -              | 3.11| Karakaya reservoir|
| [13]       | -        | 15.0  21.0 29.2 33.5 38.0 55.0 62.0 | -   | Euphrates river, Al-Hindia dam |
| [34]       | 57.0     | 16.4  24.5 31.2 37.4 42.5 47.2 50.8 53.5 | 2.97| East Hammar marsh |
| Present study | 61.0     | 14.3  23.4 31.0 38.2 42.9 45.9 48.7 51.5 | 2.92| Al-Diwaniya river |

The overall sex ratio of *L. vorax* in the present study was (1:1.51) which biased in favour of females. Similar deviations in the sex ratio have been observed in populations of *L. vorax*. Mutlak [57] stated that the species in East Hammar marsh was composed mostly of females (sex ratio: 1:1.62). Also, the ratio between the sexes of *L. vorax* in Atatürk dam lake, Turkey was poised mostly of females, the sex ratio was 1:1.75 [26]. However, Al-Selah *et al.* [25] and Wahab and Al-Ani [58] stated no significant differences between sexes of the species in Euphrates River, Syria and Eastern drainage/Balad, Iraq, respectively. 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 [50, 55]. Lengths at first maturity (*L*m50) for males and females of *L. vorax* in the present study were 29 and 31 cm, respectively. Al-Selah *et al.* [24] observed that females of the species attained the first maturity at 40 cm and males at 38 cm in the Euphrates river, Syria. Wahab and Al-Ani [58] found that lengths at first maturity (*L*m50) for males and females of *L. vorax* were 29 and 31 cm, respectively in Eastern drainage/Balad, Iraq.

Gonado-somatic index (GSI) is a good indicator to determine the spawning time in fishes, and common parameter widely used by the biologists to predict of spawning season of fish. GSI values of *L. vorax* present study were high in January for both sexes and gradually declined in February suggest the possible spawning period of *L. vorax*. Shafi and Jasim [8] pointed that *L. vorax* spawning started in January at Al-Habania lake, whereas Epler *et al.* [10] reported that spawning of the species started in February in Al-Habania and Tharthar lakes. Oymak *et al.* [26] stated that the higher GSI values of *L. vorax* population were observed in the samples of March, April, and May for females and males, and concluded that the spawning took place in April and extended to May in Atatürk dam lake, Turkey. Al-Selah *et al.* [24] mentioned that the spawning of the species lasted from the end of February to the middle of March in the Euphrates river, Syria. Abdullah *et al.* [36] found that the maximum values of GSI for females and males occurred in February in Al-Huwaizah marsh. Several authors refer to the effects of water temperature on the developing gonad and assign it to
the spawning time of L. vorax in different waters [26, 25, 36]. Nikolsky [50] pointed out that the spawning characteristic of a fish varies concerning species and ecological characteristics of the water system in which they live.

Monthly trends in the feeding activity and intensity of L. vorax were related positively with a water temperature of the river ($r < 0.820$), the highest values of the criterion were recorded in summer and the lowest in winter. During this study, the water temperature of the river ranged between 10.2 and 32.8 ºC. It was about 10.2-13.3 ºC in winter and increased up to 32.0-32.8 ºC in summer. Similar observations were reported by Hussein and Al-Kanaani [38] and Khaddara [13] who found the feeding rates of L. vorax were low during winter and high during summer in Al-Hammam marsh and Euphrates river, respectively. 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 [50]. It is generally known that feeding activity of Cyprinids decreases with decreasing in the water temperature [59].

Diet of small and large individuals for L. vorax in the present study consisted of fish, shrimps, aquatic insects, and crustaceans, this means that the species is carnivorous food habit depends chiefly on animal food sources making up 92%. Various authors studied the food habit of L. vorax is different in different parts of Iraqi waters have reported similar finding [8, 29, 38, 17, 15, 32, 13, 39]. Fish dominated the food items consumed by L. vorax in all studies. Fish accounted for 66.7% in the diet of the species in south marshes [17], 47.4% in Al-Huwaizah marsh [15], 52.3% in Garma river [60] and 92.2% in East Hammar marsh [39].

5. Conclusion
It is found that the population of L. vorax reflects the expected and previously observed features of the species in natural waters, but it is necessary to activate the national law of fishing, exploiting and protecting aquatic resources to continuation the fish populations in the river as an economic resource.

Compliance with ethical standards

Acknowledgments
The authors express their thanks to the staff of the Department of Fisheries and Marine Resources, College of Agriculture, University of Basrah for their supports.

Disclosure of conflict of interest
The authors declare that they have no conflicts of interest.

References

[1] Frickle R, Eschmeyer W and Fong JD. (2019). "Species by family/subfamily in Eschmeyer’s Catalog of Fishes. California Academy of Science.
[2] Froese R and Pauly D. (2018) World Wide Web electronic publication.
[3] Beckman CW. (1962). The freshwater fishes of Syria and their general biology and management (FAO fisheries biology branch technical paper). Fisheries Division, Biology Branch, Food and Agriculture Organization of the United Nations, 297.
[4] Al Daham NK. (1977). Fishes of Iraq and the Arabian Gulf. Vol. 1, Arabian Gulf Studies Centre. Publ, 9, University of Basrah. 546.
[5] Coad BW. (1996). Zoogeography of the fishes of the Tigris-Euphrates basin. Zoology in the Middle East, 13, 71-83.
[6] Coad BW. (2010). Freshwater Fishes of Iraq. Pensoft Publishers, Sofia, Bulgaria, 274.
[7] Mohamed ARM, Al-Noor SS and Faris RAK. (2008). The status of artisanal fisheries in the lower reaches of Mesopotamian rivers, north Basrah, Iraq. Proc. 5th Int. Con. Biol. Sci. (Zool), 5, 126-132.
[8] Shafi M and Jasim BM. (1982). Some aspects of the biology of a cyprinid Aspius vorax Heckel. Journal of Fish Biology, 20, 271-278.
[9] Al-Daham NK and Al-Dubical Ay. (1995). The growth of *Aspius vorax* Heckel in the first year of age at Shatt Al-Basrah Canal. *Marina Mesopotamia*, 8, 344-354.

[10] Epler P, Bartel R, Chyp J and Szczurowskii JA. (2001). Diet of selected fish species from the Iraqi Lakes Tharthar, Habaniya and Razazah. *Archives of Polish Fisheries*, 9, 211-223.

[11] Al-Rudainy AJ, Mohamed ARM and Abbas LM. (2006). Ecology, biology and assessment of fish community in Euphrates River near Al-Mussaib Power Station. *Euro Arab Environment Conference and Exhibition*, 11, 27-29.

[12] Al-Amari MJY. (2011). Study of some biological and ecological aspects of fish community in Al-Hilla River/Iraq. Ph.D. thesis, College of Science, University of Babylon, Iraq.

[13] Khaddara MM. (2014). Ecological and biological study of fish community in Euphrates River/Middle of Iraq. M.Sc. thesis, College of Science, University Babylon, Iraq.

[14] Abbas LM, Abu Alhana AJ, Radhy AG and Hassan AH. (2017). Evaluating the fish structure community at Euphrates River near Al-Hindyah Barrier, Babylon Province/Iraq. *Journal Tikrit University For Agriculture Sciences*, 17, 28-29.

[15] Mohamed ARM, Hussain NA, Al-Noor SS, Coad BW, Mutlak FM, Al-Sudani IM, Mojer AM and Toman AJ. (2008). Species composition, ecological indices and trophic pyramid of fish assemblage of the restored Al-Hawizeh Marsh, Southern Iraq. *Ecohydrology & Hydrobiology*, 8(2-4), 375-384.

[16] Mohamed ARM and Hussain NA. (2012). Trophic strains and diet shift of the fish assemblage in the recently restored Al-Hammam marsh, southern Iraq. *Journal of University of Duhok*, 15(1), 119-127.

[17] Hussain NA, Mohamed ARM, Al-Noor SS, Mutlak FM, Abed IM, Mojer AM and Coad BW. (2009). Structure and ecological indices of fish assemblages in the recently restored Al-Hammam Marsh, Southern Iraq. *Bio Risk*, 3, 173-186.

[18] Rasheed RO. (2012). Length-weight relationships of (9) fish species from Derbendikhan Reservoir- Kurdistan region, Iraq. *Journal of Babylon University/Pure and Applied Sciences*, 5(20), 1434-1440.

[19] Jasim AA and Mohamed MA. (2013). Fish structural community in Tigris River, Mosul City, Iraq. *Basrah Journal of Agricultural Sciences*, 26(2), 275-288.

[20] Sedig SO and Abbas LM. (2013). Fish community structural in Dukan Dam Lake, Northern Iraq. *Iraqi Veterinary Medical Journal*, 37(1), 1-16.

[21] Shakir HF and Wahab NK. (2015). Structure of fish community for South East Al-Tharthar Lake in Salah Alddin Province/Iraq. *Journal College of Agriculture-University of Tikrit-Iraq*, 15(2), 111-124.

[22] Abbas LM, Abu Alhana AJ and Radhy AG. (2015). Fish community of Tigris River before Al-Kut Barrier, Southern Baghdad, Iraq. *Journal of Chemical, Biological and Physical Sciences (JCBPS); Section B, 5(2)*, 1639-1645.

[23] Mohamed ARM and Abood AN. (2017). Compositional change in fish assemblage structure in the Shatt Al-Arab River, Iraq. *Asian Journal of Applied Sciences*, 5(5), 944-958.

[24] Al-Saleh F, Hammoud V and Al-Hussein A. (2010). Reproduction biology of *Aspius vorax* (Heckle, 1843) within the middle Euphrates River, Damascus University. *Journal for Basic Sciences*, 26(1), 159-170.

[25] Al-Saleh F, Hammoud V, Hussein AR and Alhazzaa R. (2012). On the growth and reproductive biology of *Aspius vorax*, population from the Middle Reaches of Euphrates River. *Turkish Journal of Fisheries and Aquatic Sciences*, 12, 149-156.

[26] Oymak S, Ahmed UE, Parmaksiz A and Dogan N. (2011). A study on the age, growth and reproduction of *Aspius vorax* (Heckel, 1843) (Cyprinidae) in Ataturk Dam lake (Euphrates River), Turkey. *Turkish Journal Fish Aquatic Sciences*, 11, 217-225.

[27] Duman E and Gül MR. (2013). Age, growth, fecundity and mortality of *Aspius vorax* (Heckel, 1843) in Karakaya Reservoir (in Euphrates River), Turkey. *Ege Journal of Fisheries and Aquatic Sciences*, 30(4), 155-159.

[28] Hashemi S, Eskandary G, Ansary A and Yooneszadeh M. (2011). Stock Assessment and production of fish species in the Shadegan Wetland, Iran. *World Journal of Fish and Marine Sciences*, 3(6), 502-508.

[29] Al-Mukhtar MA. (1982). Biological studies on two fresh water species *Barbus luteus* (Heckel) and *Aspius vorax* (Heckel) in Al-Hammam marsh. Basrah. M.Sc. thesis, Basrah University, Iraq, 203.
[30] Szympa J, Epler P, Bartel R and Szezerbowski JA. (2001). Age and growth of fish in the lakes Tharhar, Razazzah and Habbaniya. Archives of Polish Fisheries, 9, 185-197.

[31] Abbas LM and Al-Rudainy AJ. (2006). Ecology and biology of two freshwater fish species in Euphrates River, middle of Iraq. Proceedings of the International Conference on Underwater System Technology: Theory and Applications July 18-20, Penang, Malaysia.

[32] Wahab NK. (2013). Food habits and diet overlaps for some freshwater fish in Tharhar Arm, Tigris, Iraq. Basrah Journal of Agricultural Sciences, 26(2), 182-197.

[33] Hashemi SA, Eskandari G and Sedaghat S. (2013). Length-weight relationships of Leuciscus vorax (Heckel, 1843) (Cyprinidae) in the Shadegan Wetland, Iran. World Journal of Fish and Marine Sciences, 5(1), 100-103.

[34] Mohamed ARM, Hussein SA and Mutlak FM. (2017). Some biological aspects of four fish species in East Hammar marsh, Iraq. Journal of Scientific and Engineering Research, 4(8), 278-287.

[35] Al-Mudaffar RAA. (1999). Reproductive biology of Aspius vorax Heckel, 1843. In Garmat Ali River, Basrah. M.Sc. College of Agriculture, University of Basrah, Iraq.

[36] Abdullah Hj, Al-Zaidy FM and Habbeb FS. (2017). Reproductive characteristics of Leuciscus vorax (Heckel, 1843) from Al-Huwaiza marshes, Southern Iraq. International Journal of Marine Science, 47, 447-454.

[37] Hussein SA and Al-Knaanini SM. (1989). Feeding of shilig, Aspius vorax (Heckel) in Al-Harmmar Marsh, Southern Iraq. I- Diet of small individuals. Basrah Journal of Agricultural Sciences, 2(1-2), 81-92.

[38] Hussein SA and Al-Kananni SM. (1993). Feeding ecology of the shilig Aspius vorax Heckel from Al-Hammar marsh, southern Iraq. III. Seasonal pattern of feeding. Marina Mesopotamia, 8(1), 91-103.

[39] Mohamed ARM, Hussein SA and Mutlak FM. (2015). The feeding relationships of six fish species in East Hammar marsh, Iraq. Thi-Qar University Journal for Agricultural Research, 4(1), 460-477.

[40] Schneider JC, Laarman PW and Gowing H. (2000). Age and growth methods and state averages. Chapter 9 in Schneider, James C. (ed.) 2000. Manual of fisheries survey methods II: with periodic updates. Michigan Department of Natural Resources. Fisheries Special Report 25, Ann Arbor.

[41] Le Cren ED. (1951). The Length-weight relationship and seasonal cycle in gonad weight and condition in the perch (Perca fluviatilis). Journal of Animal Ecology, 20, 201-219.

[42] Bagenal TB and Tesch FW. (1978). Age and growth. In: B. Bagenal TB (Ed.) Methods for assessment of fish production in fresh waters, 3rd ed., Blackwell. Sci. Publ. Oxford, 101-130.

[43] Ricker WE. (1975). Computation a

[44] Pauly D and Munro JL. (1984). Once more on the comparison of growth in fish and invertebrates. ICLARM Fish byte, 2, 21.

[45] De Silva SS. (1973). Aspects of the reproductive biology of the sprats Sprattus sprattus L. in inshore waters of the west coast of Scotland. Journal of Fish Biology, 5, 689-705.

[46] Stergion KI. (1988). Feeding habits of the lessepsian migrant Siganus luridus in the Eastern Mediterranean, its new environment. Journal of Fish Biology, 33, 531-543.

[47] Salman JM. (2006). Ecological study of possible pollution in the Euphrates River between Al-Hindyah barrier and Kufa, Iraq. Ph.D. thesis. College of Science, University of Babylon, Iraq.

[48] Mohamed ARM, Hussein NA, Al-Noor SS and Mutlak FM. (2012). Ecological and biological aspects of fish assemblage in the Chaybayish marsh, Southern Iraq. Ecophysiology & Hydrobiology, 12(1), 65-74.

[49] Abu Alhana AJ and Al-Nasri SK. (2004). Some biological aspects of Aspius vorax (Heckel) in an artificial lake, Baghdad. Proceedings of the 3rd Regional Scientific Conference on Livestock Sciences, April 5-4, 2005, 66-58.

[50] Nikolsky GV. (1963). The ecology of fishes. Academic Press, London and New York, 352.

[51] Riedel R, Caskey LM and Hurlbert SH. (2007). Length-weight relations and growth rates of dominant fishes of the Salton Sea: implications for predation by fish-eating birds. Lake and Reservoir Management 23, 528-535.

[52] Karma SK, Sahool D and Panda S. (2012). Length weight relationship (LWR), growth estimation and length at maturity of Etroplus suratensis in Chilika Lagoon, Orissa, India. International Journal of Environmental Sciences, 2, 1257-1267.
Al-Rudainy AJ. (2008). Growth and mortality rates of *Cyprinus carpio* and *Aspius vorax* in Dyala River, south of Baghdad. Iraqi journal of Agriculture, 13(2), 195-192.

Cuadrad JT, Lim DS, Alcontin RMS, Calang JL and Jumawan JC. (2019). Species composition and length-weight relationship of twelve fish species in the two lakes of Esperanza, Agusan del Sur, Philippines. FishTaxa, 4(1), 1-8.

Sharma NK, Singh R, Gupta M, Pandey VN, Tiwari VK and Akhtar MS. (2016). Length–weight relationships of four freshwater cyprinid species from a tributary of Ganga River Basin in North India. Journal of Applied Ichthyology, 32(3), 497-498.

Bartulovic V, Glamuzina B, Conides A, Dulcic J, Lucic D, Njire J and Kozul V. (2004). Age, growth, mortality and sex ratio of sand smelt, *Atherina boyeri*, Risso, 1810 (Pisces: Atherinidae) in the estuary of the Mala Neretva River (Middle-Eastern Adriatic, Croatia). Journal of Applied Ichthyology, 20, 427-430.

Wootton RJ. (2011). Growth: environmental effects. In: Farrell AP (Ed.). Encyclopedia of fish physiology: from genome to environment (Elsevier Science Publishing Co. Inc, United States, 1629-1635.

Mutlak FM. (2012). Stock assessment of some fish species from East Hammar marsh, Southern Iraq. Ph.D. thesis. College of Agriculture, University of Basrah, Iraq.

Wahab NK and Al-Ani SMH. (2013). Some biological aspects of some fishes Eastern drainage/Balad, Iraq. Diyala Journal of Agriculture Sciences, 1(1), 1-15.

Penttinen OP and Holopainen IJ. (1992). Seasonal feeding activity and ontogenetic dietary shifts in crucian carp, *Carassius carassius*. Environmental Biology of Fishes, 33, 215-221.

Lazem LF. (2009). Composition structural of the fish community assemblage and their connection to the prevailing abiotic conditions in Garmat Ali River, southern Iraq. M.Sc. Thesis College of Agriculture, University of Basra, Iraq.

How to cite this article

Mohamed ARM and Al-Jubouri MO. (2020). A study on age, growth, reproduction, and diet of *Leuciscus vorax* (Heckel, 1843) in Al-Diwaniya River, middle of Iraq. World Journal of Advanced Research and Reviews, 5(3), 25-37.