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Comparison of Morphometric Characteristics Between Cultivated and Wild Common Carp *Cyprinus carpio* L. Populations

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ABSTRACT

The current study aimed to conduct a biological evaluation of common carp (*Cyprinus carpio*) by comparing the length-weight relationship and the condition factor. The study also focused on morphological and meristic characteristics for river and cultivated common carp. The samples of the river fish were collected by the fishermen who were working at a beach called Al-Sahel located at the center of Abu Al-Khaseeb district, South of Basra Governorate, Iraq. Cultivated common carp in earthen ponds were brought from ponds farm of Aquaculture Unit-Agricultural Research Station of the College of Agriculture, University of Basra, Al-Hartha district, north of Basra. The common carp cultivated in floating cages were brought from floating cages farm located in Jurf Al Nasar district, north of Al- Mahaweel district, Babylon, Iraq. The results of the current study showed that the morphometric characteristics of the common carp are affected by the environmental factors present in specific areas. The morphometric characteristics (total length, forked length, standard length, head depth, head width, head and snout length) were found to be close within the range at the three environments. Significant differences were noticed between individuals of the three groups, with large differences in morphometric measurements. These results confirm that this method is a useful tool to differentiate between carp groups. There was a difference in the three sites that led to a change in some morphometric characteristics of the three groups. This difference may refer to a change in the environment or a change in the genetic composition or both or adaptation to living according to the abundance and quality and availability of food as in river fish. Based on results, each pair of barbels in fish was found to be close in length and number and was not affected by changes in the aquatic environment.

INTRODUCTION

The Cyprinidae family is the largest among fish families, as it represents about 10% of the fish in the world and 25% of freshwater fish. The most important characteristic of this family is its high rate of production and rapid growth. Due to these advantages, this family has received great attention in farm cultivation, especially the common carp (*Cyprinus carpio*), rohu (*Labeo rohita*), sliver carp (*Hypophthalmmichthys molitrix*) and the bighead carp (*Aristichthys nobilis*) **(Gupta *et al.*, 2005)**. In 2020, the

production of the grass carp (*Ctenopharyngodon Idella*) around the world was 5791.5 tons, followed by the silver carp with a production of 4896.6 tons, then the Nile tilapia (*Oreochromis niloticus*) with a production of 4407.2 tons, while the common carp ranked fourth with a production of 4236.3 tons **(FAO, 2022)**.

Franco *et al.* (2016) explained that the availability of morphological characteristics saves valuable information for species identification, individual differentiation in fish stocks and understanding fish structural characteristics in different fields. Moreover, it is also used to distinguish between groups which were cultivated and groups which were available in natural environments. **Thilan *et al.* (2018)** explained that morphological characteristics can be used as a replacement for environmental traits, providing a sight into habitat use, feeding, and life history strategies. The study of morphological characteristics can help specify classification, conservation efforts, as well as understanding the role of fish in the aquatic environment **(Tripathy, 2020)**. **Maheboob (2021)** mentioned that morphological characteristics are important for understanding growth, estimating production, and studying fish populations. These measurable characteristics can provide valuable information about the size and shape of organisms, allowing for the analysis of variation and shape change over evolutionary time. Morphological characteristics in fish are an important factor in the classification, as scale number and scale shape are reliable characteristics for classification **(Maheboob, 2021)**.

Jafari *et al.* (2022) stated that the study of morphometric characteristics and meristic counts of fish is important for several reasons. These characteristics can be used to address issues in fisheries science and stock management, such as classification and identification of fish in natural and cultured environments, through data mining algorithms to classify common carp populations in the southern Caspian Basin. Moreover, it can be used to determine the head height in the eye area as the best marker to distinguish between natural and cultured carp. Morphological studies are one of the oldest techniques used to identify fish populations **(Ganesh, 2025)**. The morphometric characteristics and meristic counts are an important factor in determining the nature of fish populations and knowing whether these populations are one group or more. **Lamarck (1744-1829)** emphasized the importance of the distinctive morphological characteristics among individuals of the animal group and indicated that these characteristics should be influential and mostly distinctive **(Rochmatika *et al.*, 2023)**. These studies include extracting morphological characteristics such as measurements, areas, angles, proportions, colors, graphs, patterns, shapes and outlines from images of segmented digital samples **(Cui & Jiang, 2021)**.

MATERIALS AND METHODS

Samples were collected from three different environments, with an average of 90 common river carp, 100 fish cultivated common carp in earthen ponds, and 71 common carp cultivated in floating cages. River fish were brought from the coastal area which is located at Abu Al-Khaseeb district (A gathering place for fishermen at the Shatt al-Arab at the coordinate 30°27'43.5"N 48°00'11.6"E). Pond fish were brought from the earthen ponds at the Agricultural Research and Experimental Station at Al-Hartha (College of Agriculture - University of Basra), which is located at Al-Hartha district, and it is approximately 16km north of Basra Governorate's center. Cages fish were brought from floating cages on the Euphrates River in Jurf Al-Nasr district at Babil Governorate, which is found 13km north of Al-Musayyab district.

Fish were transported from the three locations in containers equipped with ice to the Fish Biology Laboratory at the Department of Fisheries and Marine Resources, College of Agriculture, University of Basrah. The measurements studied involved taking morphological measurements according to the method described by **Hubbs and Lagglar (1958)** and mentioned by **Al-Hakim (1976)** and **Lapierre and Coad (2005)**. Total forked length and standard length were measured to the nearest millimeter using a measuring tape. A Chinese-made digital vernier was used to measure other morphological characteristics to the nearest millimeter, which included length, depth and width of the head, snout length, eye diameter and eye orbital, distance between two eyes orbitals and behind the eye, depth and length of the caudal peduncle, length before the dorsal, pre-pectoral length, pelvic and anal fins, as well as the length of the first and second barbles. The straight-line equation was used to represent the relationship between the rest of the studied characteristics as follows:

$$\mathbf{Y = ax + b}$$

The statistical analysis was carried out using a completely randomized design (CRD) with three treatments and was dependent on the least significant differences (LSD) test. All statistical tests were conducted using the Statistical Package for Social Sciences (SPSS) version 26.

RESULTS

Table (1) exhibits twenty morphological characteristics measured in this study and includes the range of these measurements for carp fish cultured in cages and in ground ponds as well as those fished from the Shatt al-Arab River. Table (2) presents the average ratios between the standard length and the other studied morphological characteristics with the standard deviation of these ratios. Statistical analysis of the results showed there were no significant differences (P>0.05) in the ratio between standard

length and eye diameter for the three treatments, as well as in the ratio between standard length and each of the total length, forked length, head length, eye orbital diameter and pre-pectoral length for cage and pond fish. Significant differences were found ($P \leq 0.05$) in the ratios between the standard length and each of the total length, forked length, head length, snout length, first barbel length, orbital diameter, interorbital distance, post-dorsal fin length, pre-pelvic and anal fin length among river fish, cage fish, and pond fish. Table (3) shows the straight-line equations that represent the relationship between the standard length and the rest of the studied morphological characteristics for each of the floating cage fish, earthen pond fish, and river fish, in addition to the coefficient of determination that shows the correlation range of these morphological characteristics with the standard length. It is clear from the previous data in Table (1) that the highest correlation (0.9823) was between the standard length and the spiny length for river fish, while the lowest correlation (0.0006) was between the standard length and the second barbel length for the floating cage fish.

Table 1. The range of morphological characteristics of common carp cultured in cages, ponds and which had been fishing from the river

Ref.	Morphological characteristics	Range of floating cages fish	Range of earthen ponds fish	Range of river fish
1	Total length	623 -320	275-670	253-660
2	Forked length	285-565	245-610	225-610
3	Standard length	235-515	205-515	203-590
4	Head depth	30.28 -116.15	47.76-119.65	42.74-105.65
5	Head width	89.21-44.79	37.05-90.93	32.34-92.06
6	Head length	067.3-131.71	52.73-147.83	63.15-147.33
7	Snout length	23.75-53.71	18.77-49.00	21.72-55.39
8	First barbal	5.95-15.49	7.64-21.93	06.6-17.33
9	Second barbal	1.21-8.41	2.05-11.02	1.83-10.80
10	Eye diameter	8.68-14.99	07.9-15.91	7.91-15.33
11	Eye orbital length	11.07-19.42	11.30-20.21	10.02-022.7
12	Interorbital distance	26.23-53.31	22.31-58.54	21.33-62.77
13	Post orbital	24.29-57.55	29.57-70.62	28.00-96.24
14	Caudal peduncle length	41.17-92.81	42.54-102.52	39.59-109.92
15	Caudal peduncle depth	46.68-89.04	35.15-90.41	31.68-81.46
16	Pre-dorsal length	125.02-226.77	099.00-249.25	103.34-266.58
17	Post-dorsal length	93.18-172.33	87.42-213.93	70.71-202.57

18	Pre-pectoral length	61.18-128.27	61.15-139.36	51.09-135.50
19	Pre-pelvic length	129.32-258.66	107.73-257.41	0103.9-259.47
20	Pre-anal length	215.88-413.47	165.14-432.02	146.27-421.51

Table 2. The rates of the relationship between standard length and other morphological characteristics with the standard deviation

Ref.	Ratio of standard length to morphological characteristics	Floating cage-culture carp	Carp fish cultured in ponds	River carp
1	Total length	0.7846 b ±0.0221	0.7827 b ±0.0323	0.8329 a ±0.0240
2	Forked length	0.8778 b ±0.0800	0.8858 b ±0.0863	0.9046 a ±0.0804
3	Head depth	4.4895 a ±1.1970	4.2593 b ±0.3170	4.5438 a ±0.4319
4	Head width	5.1678 b ±0.6034	5.7735 a ±0.5108	5.8481 a ±0.4087
5	Head length	3.7481 a ±0.2699	3.7916 a ±0.3680	3.5764 b ±0.2762
6	Snout length	10.1466 b ±1.0527	11.0202 a ±1.2681	9.7758 c ±0.9436
7	First barbule length	30.9219 a ±6.4753	22.6370 c ±4.1779	27.6753 b ±6.2337
8	Second barbel length	76.7283 a ±32.9491	57.2224 b ±16.6925	62.6377 b ±21.8982
9	Eye diameter	28.0002 a ±4.1632	27.6966 a ±3.9214	27.5152 a ±3.6035
10	Eye orbital length	22.8374 a ±2.7819	22.7149 a ±2.6429	21.7524 b ±2.5724
11	Interorbital distance	9.6578 a ±1.0754	9.6095 a ±0.8875	9.0002 b ±0.7980
12	Post orbital	8.4792 a ±1.1288	7.7552 b ±0.7342	7.6887 b ±0.7676
13	Caudal peduncle length	5.0363 a ±0.5032	4.8718 b ±0.3863	5.1645 a ±0.4330
14	Caudal peduncle depth	5.4257 b	6.1943 a	6.2681 a

		±0.4355	±0.5010	±0.4461
15	Pre-dorsal length	2.0544 b ±0.1320	2.1535 a ±0.1431	2.0716 b ±0.1220
16	Post-dorsal length	2.4950 b ±0.1949	2.3472 c ±0.2309	2.7037 a ±0.2339
17	Pre-pectoral length	3.8914 ab ±0.2740	3.8443 b ±0.2862	3.9624 a ±0.3241
18	Pre-pelvic length	1.9906 c ±0.1182	2.07434 b ±0.1289	2.1677 a ±0.1203
19	Pre-anal length	1.2201 c ±0.0652	1.2778 b ±0.0922	1.4253 a 0.2449±

Mean values in the same row having the same letters are not differing significantly (P>0.05)

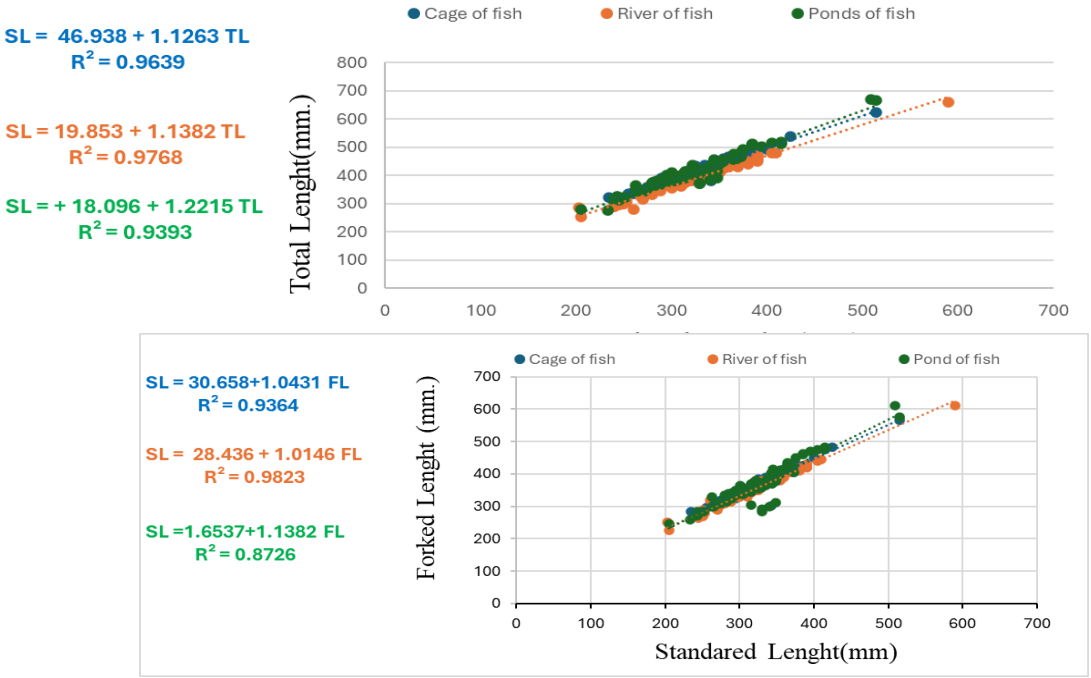

Fig. 2. Relationship between standard length and forked length

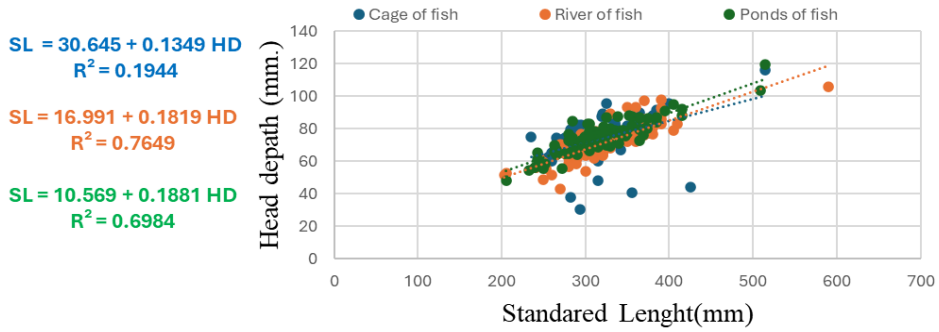

Fig. 3. Relationship between standard length and head depth

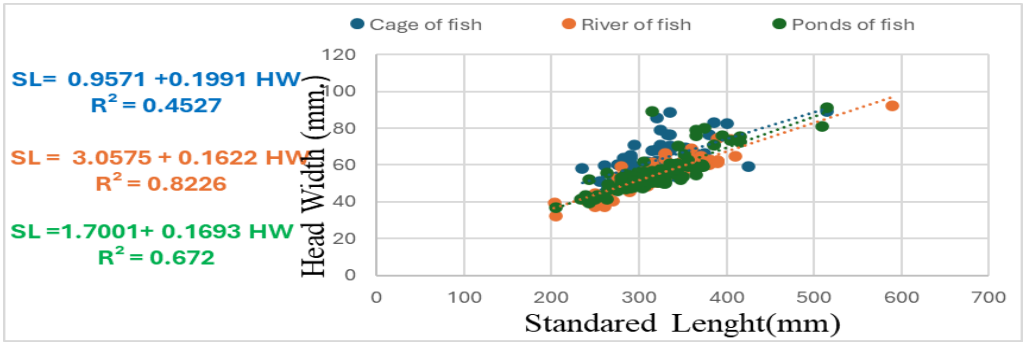

Fig. 4. Relationship between standard length and head width

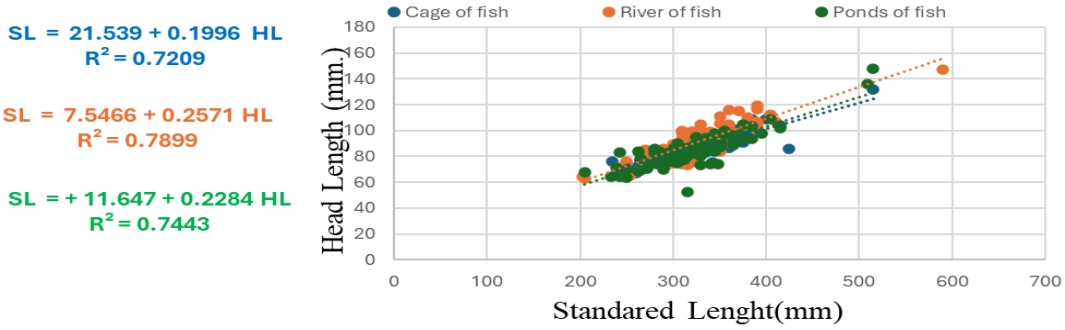

Fig. 5. Relationship between standard length and head length

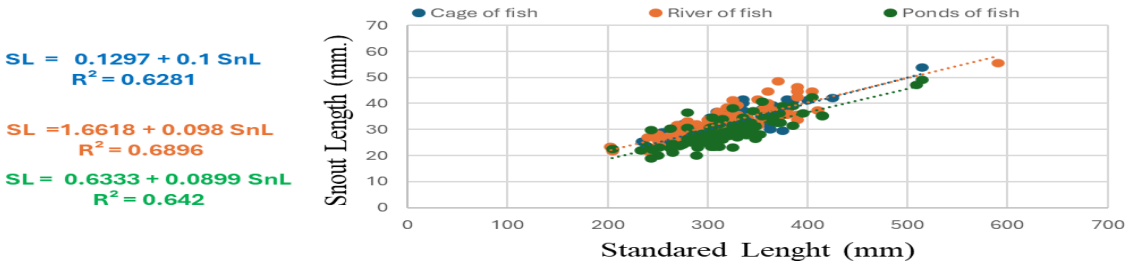

Fig. 6. Relationship between standard length and snout length

Table 3. Straight line equations representing the relationship between standard length and the rest of morphological characteristics for studied fish

Morphometric characteristics	Relationships with Standard Length		
	Floating cages	Earthen ponds	Shatt al-Arab River
Total length	SL=30.6580+1.1263 TL R^2 = 0.9639	SL=18.096+1.2215 TL R^2 = 0.9393	SL=19.853+1.1382 TL R^2 = 0.9768
Forked length	SL=46.938+1.0431 FL R^2 = 0.9664	SL=1.6537+1.1382 FL R^2 = 0.8726	SL=28.4360+1.0146 FL R^2 = 0.9823
Head depth	SL=30.6450+0.1349 HD R^2 = 0.1944	SL=10.5690+0.1881 HD R^2 = 0.6984	SL=16.9910+0.1819 HD R^2 = 0.7649
Head width	SL=0.9571+0.1991 HW R^2 = 0.4527	SL=1.7001+0.1693 HW R^2 = 0.6720	SL=3.0575+0.1622 HW R^2 = 0.8226
Head length	SL=21.539+0.1996 HL R^2 = 0.7209	SL=7.5466+0.2571 HL R^2 = 0.7899	SL=11.647+0.2284 HL R^2 = 0.7443
Snout length	SL=0.1297+0.1000 SnL R^2 = 0.6281	SL=0.6333+0.0899 SnL R^2 = 0.6420	SL=1.6618+0.0980 SnL R^2 = 0.6896
First barbel length	SL=5.4065+0.0165 Bl R^2 = 0.1121	SL=2.7899+0.0367 Bl R^2 = 0.3702	SL=6.309+0.0175 Bl R^2 = 0.1363
Second barbel length	SL=4.3802 + 0.0008 B2 R^2 = 0.0006	SL=1.2284+0.0148 B2 R^2 = 0.1603	SL=0.2735+0.0186 B2 R^2 = 0.2469
Eye diameter	SL=7.7844+0.0118 ED R^2 = 0.1183	SL=5.9024+0.0180 ED R^2 = 0.3218	SL=6.3449+0.0165 ED R^2 = 0.3629
Eye orbital length	SL=7.9396+0.0192 EOL R^2 = 0.2893	SL=7.9091+0.0193 EOL R^2 = 0.4568	SL=5.7649+0.028 EOL R^2 = 0.5092
Interorbital distance	SL=5.5051+0.0871 ID R^2 = 0.5545	SL=3.4073+0.0939 ID R^2 = 0.7241	SL=4.5769+0.0972 ID R^2 = 0.7344
Post orbital	SL=4.9283+0.1042 PO R^2 = 0.4970	SL=7.0539+0.1074 PO R^2 = 0.7052	SL=3.2000+0.1210 PO R^2 = 0.7228
Caudal peduncle length	SL=1.1228+0.2041CpL R^2 = 0.6855	SL=7.3397+0.1831 CpL R^2 = 0.7852	SL=3.5535+0.1836 CpL R^2 = 0.7737
Caudal peduncle depth	SL=10.9670+0.1506 CpD R^2 = 0.6822	SL=1.5205+0.1669 CpD R^2 = 0.7886	SL=6.2412+0.1404 CpD R^2 = 0.7857

DISCUSSION

The morphological and meristic characteristics of the common carp are affected by the environmental factors present in the specific area **(Jafari *et al*., 2022)**. **El-Zaeem *et al*. (2017)** found significant differences ($P \leq 0.05$) in most of the morphological characteristics and meristic counts of three breeds of carp cultured in Barzik fields and Saft-Khaled hatchery in Beheira Governorate in the Arab Republic of Egypt. **Șerban *et al*. (2024)** showed that there is a complex interaction between genetics and growth factors in carp species, which provides new insights for dedicated farming programs and aquaculture practices.

When comparing some morphological characteristics (total length, fork length, standard length, head depth, head width, head length and snout length) among the three studied environments, the measurements were found to be within similar range. However, complete differences were observed between individuals of the three groups, with significant differences in morphological parameters. This result confirms that this method is a useful tool for distinguishing between carp groups. The results of the current study are consistent with the findings of **Barriga-Sosa *et al*. (2004)** in their study on the Nile tilapia morphology. They noted significant differences in morphological characteristics between farmed and tank reared groups.

Through the results of the current study, it was found that there is a variation between the phenotypic characteristics of fish in the three environments, as well as the presence of significant differences ($P \leq 0.05$) between these proportions. The results of the statistical analysis showed the presence of significant differences ($P \leq 0.05$) between fish cultured in three environments. Notably, there were no differences between the two groups of fish farmed in cages and fish farmed in the river. However, they differed from the third group which were farmed in the earthen ponds. The only exception was in the diameter of the eye orbital length, which showed no significant changes between all groups. The results of the statistical analysis showed the absence of these significant differences ($P \leq 0.05$) for the fish cultured in the three environments. Therefore, the cultured carp studied inhabited an environment different than the other three rearing systems. These differences led to a change in some morphological characteristics of these three environments. This difference may refer to a change in the environment or a change in the genetic composition or both, or adaptation for living by depending on the quality and availability of food, as in river fish.

By comparing the morphological characteristics of our fish cultured in earthen ponds with the study conducted by **Jacob *et al*. (2018)**, it was observed that there were significant differences ($P \leq 0.05$) in morphological characters such as pre-dorsal fin length, caudal peduncle length and caudal peduncle depth for the populations of male and female common carp fish cultured in earthen ponds in Bauchi and Jos. These results contradict with our current results in different aspects. However, **Jacob *et al.* (2018)**

found no significant differences ($P>0.05$) for the eye diameter trait for the populations of male and female carp fish in Jos and Ibadan, which agrees with the results in current study due to geographical isolation, apparent flexibility, local adaptation or overlap between the breeds which observed by the researchers. It can be concluded from the results of the current study that the lack of compatibility may be due to differences in environments sometimes, and this was confirmed by **Onkar and Saima (2015)** that the environment plays an important role in changing organizational characteristics.

Hossain *et al*. (2010) noted that there were more important differences due to completely different environments; in another words one is an open water as habitat and the other a closed water as habitat, however, the morphological differences may be due to the environment as these differences can be linked to geographic origins and breeds.

The results of the current study align with the findings of **Jawad *et al*. (2020)**, who reported comparable morphological characteristics of the farmed Nile tilapia and fish living in natural waters in the Republic of Benin-Africa. It was noted that there were significant differences in the morphological characteristics of tilapia fish in both different environments.

Azawy and Issa (2019) recorded lower ratio of body depth to standard length and head length to standard length in their study of two flocks of female carp broodstock (with and without lineage) across seven hatcheries in Babylon. The ratios recorded were lower than those observed in the current study, and this may be due to the election of broodstock employed in the artificial hatching process for the common carp. **Ujjania *et al*. (2013)** observed that morphological characteristics increase in size with increasing body length. Moreover, similar findings were noted by **Paunikar and Panwar (2021)**, who observed that there is a strong correlation, referring that all morphological characteristics increase with increasing total length.

Jawad *et al*. (2022) have found that all the morphological characteristics studied for pond fish recorded higher percentages compared with fish of river, while in the current study, there were different percentages recorded for the characteristics. The current study is similar to previous study in some characteristics such as eye diameter, head length, and snout length, as they were higher in earthen ponds, and the reason for the difference in the eye diameter may be due to the range of vision according to water quality like transparency or turbidity. On the other hand, the percentage of total length is similar in both studies, as it was higher in river fish. **Turan *et al.* (2004)** referred that geographical separation constitutes a restrictive factor for migration between stocks. In the current study, the length range of the first barbel is located on the upper lip and ranges between 15.49-5.95mm in floating cages, 21.93-7.64mm in earthen ponds, and 17.33-6.60mm in river fish, while the length range of the second barbal ranged between 8.41-1.21mm in floating cages, 11.02-2.05mm in earthen ponds, and 10.80-1.83mm in river fish.

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