

## Morphometric and Meristic Characters of Two Cichlids, *Coptodon zillii* and *Oreochromis aureus* Collected from Shatt al-Arab River, Basrah, Iraq

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**Abstract** Thirteen morphometric and seven meristic characters of the cichlids species *Coptodon zillii* and *Oreochromis aureus* were studied from three localities, Qurna, Hartha, Abu Al-Khaseeb, on Shatt al-Arab River, Basrah, Iraq. Samples revealed no significant differences between genders. Values of morphometric and meristic traits increase from the southern to northern reaches of the river. Based on cluster analysis and PCA, the Shatt al-Arab River samples of the two species *C. zillii* and *O. aureus* were clearly separated into two distinct groups. Group I, Qurna and Hartha, represents the northern and middle regions of the river and GII represents the southern region, Abu-Al-Khaseeb. Possible reasons for such differentiation among populations are discussed, and the integration of research on these species among the countries neighboring Iraq is required. This study gives information to fishery biologists about morphometric characters of *C. zillii* and *O. aureus* from Shatt al-Arab River to assist in planning of conservation strategies for these fish species.

**Keywords** Population structure; Morphometrics; Meristic; Cichlidae; Qurna; Hartha; Abu Al-Khaseeb

## Background

Among the fish or may be the whole vertebrates families that are rich in their species composition is the Cichlidae. Members of this family have shown wide distribution worldwide. They are in South and Central America, Madagascar, Africa, The Middle East, India and Sri Lanka (Kocher, 2004; Salzburger and Meyer, 2004).

The cichlids are famous for being species that widely used in aquaculture in large number of countries and traded as protein high food fish in the world. It has been believed that the ancient Egyptians were the first to farm tilapia fish more than 4,000 years ago (Gupta and Acosta, 2004). Due to the increased transplantation of tilapia, several species became established as a potential farmed species by the late 1940s in the Far East and a decade later spread in the Americas (Gupta and Acosta, 2004).

Tilapias were succeeded in the aquaculture industry for several reasons, these are: resistant to diseases, high stocking density of fish, lower water quality, organically pollutant water, and low dissolved oxygen level of the water, high tolerance to salinity in wide range, suitable for maintaining and feeding conditions in culture (Cruz and Ridha, 1994). In addition, their biology has shown that these fishes reproduce easily, having short food chain in feeding, transform remaining food and domestic wastes into high quality protein, and are tasty (Yi et al., 1996; de Graaf et al., 1999; Penã-Mendoza, 2005).

On contrary to the other countries (Barriga-Sosa et al., 2004), no date and method have been set for the introduction of tilapia species into Iraq. Coad (1996) believes that tilapia species have entered Iraq from Syria through Euphrates River, but this belief has not documented. Since 2007, three species of tilapia were recorded in middle and south of Iraq. No report of tilapia from the northern part of Iraq yet.

The first tilapia species reported from Iraq was *Coptodon zillii* and that was by Al-Saadi (2007) and Saleh (2007) from two locations on Euphrates River. In 2009, Mutlak and Al-Faisal have recorded *Oreochromis aureus* from the main outfall drain (3<sup>rd</sup> River) at Basra City, south of Iraq. Recently, Al-Faisal and Mutlak (2015) have recorded

*Oreochromis niloticus* from Shatt al-Arab River, Basrah, Iraq. It seems that *C. zillii* is most common tilapia species in Iraq and it has been reported from two more localities such as the main outfall drain (3<sup>rd</sup> river) at Basra City (Mutlak and Al-Faisal, 2009) and Al-Delmj Marsh, middle of Iraq (Al-Zaidy, 2013).

The three tilapia species, *C. zillii*, *O. aureus* and *O. niloticus*, are now well established in the freshwater system of Iraq and inhabit different water bodies both freshwater and estuarine in nature (Coad, 2010). In Shatt al-Arab River, Basrah, populations of the two common tilapia species *C. zillii*, *O. aureus* were observed occupying this river from its origin at Qurna City, north of Basrah and down to its confluent with the Arabian Gulf at Fao City. The salinity is high and not suitable for the living of tilapia species at Fao City. Therefore, the southernmost occurrence of these species is Abu al-Khaseeb City, south of Basrah, which represents the northern edge of Shatt al-Arab River Estuary.

Morphology is an essential issue in biology. In addition to the species identification, morphology is considered valuable for fish population studies (Deesri et al., 2009). Morphometrics is the quantitative criteria, while meristic are serial body counts.

The traits morphometrics and meristics are dynamic characters for measuring differences between populations of the same fish species (Cadurin, 2000; Doherty and McCarthy, 2004; Jayasankar et al., 2004). Variations in morphometrics and meristic characters of fish populations are also valuable in phylogenetics and in providing information for subsequent studies on the genetic improvement of stocks. Still to say, that such morphological variation can be a basis for the study of population structure, and a measure for gauging environmentally induced variation in order to reach a successful fisheries management (Murta et al., 2000; Pinheiro et al., 2005).

In Iraq, there is lack of data on the morphological diversities of tilapia species in general and *C. zillii* and *O. aureus* in particular. In this context therefore the aim of the present study is to reveal the phenotypic variations of *C. zillii* and *O. aureus* from three selected stations along the Shatt al-Arab River. Though the populations of the two species collected from the three locations may have historically originated from the same genotype, differences in morphology may indicate the existence of multiple fish stocks, particularly given the variation in the environmental factors that might affect the morphological traits studied.

## 1 Materials and Methods

The Shatt al-Arab River originates at the city of Qurnah, north of Basrah at the confluence of the Tigris and Euphrates rivers. It is 200 km long. It varies in width from 230 meters at Basrah to 800 meters at its mouth in the Arabian Gulf (Country-data.com, 2015). The three localities selected for this study cover the distribution of the two species in the northern, mid, southern, and western regions of the river Shatt al-Arab (Figure 1). Fish samples were collected by gillnets (200 m×1.30 m, 25, 40 and 50 mm mesh) and cast nets (6 m diameter, 20 mm mesh). Fish samples were collected from December 2015 to January 2016. The depth at which the samples were caught ranged from 0.5 to 2.4 m. The mean values ( $\pm$ standard deviation) of the different morphometric and meristic characters used in the present study for the specimens collected at the three locations are presented in Table 1. Specimens (726 individuals, 363 individuals for each species) were examined shortly after landing while still fresh. A total of eight meristic characters (the number of dorsal fin spines, DFS, the number of dorsal fin rays, DFR, the number of pectoral fin rays, PFR, the number of pelvic fin rays, PELFR, the number of gill rakers on the first gill arch, NGR, the number of anal fin rays, AFR, the number of vertebrae, NV, and number of the lateral line scales, LLS) and 13 morphometric characters (total length, TL; standard length, SL; head length, HL; preorbital length, POL; eye diameter, ED; upper jaw length, UJL; postorbital length, POSL; predorsal fin length, PDFL; prepectoral fin length, PPFL; preanal fin length, PAFL; postanal fin length, PSAFL; body depth, BD; caudal peduncle length, CPD) were used for the present study (Figure 2) following the widely accepted method by Hubbs and Lagler (1958). All morphometric characters were measured to the nearest 0.1 mm using digital caliper.

Table 1 Range and mean total length of fish. SE – standard error of *Coptodon zillii* and *Oreochromis aureus* collected from Qurna, Hartha and Abu Al-Khaseeb, Iraq

Morphometric/meristic characters	<i>Coptodon zillii</i>						<i>Oreochromis aureus</i>					
	Qurna		Hartha		Abu Al-Khaseeb		Qurna		Hartha		Abu Al-Khaseeb	
	Range	Mean ± SE	Range	Mean ± SE	Range	Mean ± SE	Range	Mean ± SE	Range	Mean ± SE	Range	Mean ± SE
Total length (TL)	50-190	120±1.9	130-170	152±1.4	125-170	125±1.9	120-170	143±1.9	100-215	156±2.1	105-210	157±2.1
Standard length (SL)	35-130	150±2.1	110-130	119±1.9	36-135	85±1.6	100-135	116±1.9	75-175	123±1.9	76-174	123±1.2
Head length (HL)	33-50	36±1.6	30-40	36±1.4	34-38	35±1.9	30-45	38±1.7	25-55	39±2.1	25-55	40±1.9
Preorbital length (POL)	6-8	7±1.4	6-8	7±1.6	3-5	4±1.4	38-40	37±1.4	37-40	37±1.4	33-35	34±1.4
Postorbital length (POSL)	25-30	27±1.9	25-30	27±1.9	10-20	15±2.1	13-16	14±2.1	14-16	15±1.6	10-12	11±1.4
Eye diameter (ED)	10-12	11±1.6	10-12	11±1.4	4-8	5±1.2	16-17	16±1.9	16-18	17±1.2	13-14	13±1.7
Upper jaw length (UJL)	15-20	18±1.4	15-20	17±2.1	4-10	7±1.9	28-32	26±1.5	29-32	30±1.4	20-27	22±2.1
Predorsal fin length (PDFL)	20-60	39±1.9	37-50	38±1.5	21-49	34±1.4	34-70	51±2.0	35-60	48±1.9	33-58	46±1.3
Prepectoral fin length PPFL)	22-50	37±2.1	30-42	37±1.0	21-41	31±1.7	25-65	39±1.5	30-50	39±2.1	32-48	40±2.1
Preanal fin length (PAFL)	30-110	72±1.4	25-95	71±1.9	29-109	58±1.9	52-120	61±1.3	70-100	84±1.8	69-98	77±1.4
Postanal fin length (PSAFL)	25-60	43±2.1	30-50	42±1.4	25-49	35±2.1	30-70	49±1.9	35-50	44±1.3	34-48	43±1.9
Body depth (BD)	23-70	49±2.0	24-71	48±2.1	24-70	44±1.4	30-80	53±2.1	70-83	76±1.9	68-81	75±2.1
Caudal peduncle depth (CPD)	18-25	22±1.9	18-25	21±1.5	13-16	14±1.3	12-15	13±1.4	13-15	14±1.4	11-12	11±1.4
Dorsal fin spines (DFS)	15-16	15±1.6	15-16	15±1.9	13-14	12±1.9	17	17±2.0	17	17±2.1	14-15	14±2.1
Dorsal fin ray (DFR)	13-14	26±1.9	13-14	26±2.1	10-11	11±2.1	14-15	15±2.1	14-15	15±1.9	11-13	12±2.0
Pectoral fin ray (PFR)	8	-	8	-	7	-	8	-	8	-	7	-
Number of anal fin ray (AFR)	9-10	9±1.0	9-10	9±1.4	7-8	7±1.9	10-11	11±1.9	10-11	11±1.1	8-9	8±1.4
Number of gill rakers on the 1 <sup>st</sup> gill arch	10-12	11±1.4	10-12	11±1.8	8-9	8±1.4	29-30	31±1.5	29-30	31±1.5	27-28	27±2.1
Number of the lateral line scales (LLS)	31-32	31±2.1	31-32	31±1.9	29-30	29±2.4	30-31	31±1.4	30-31	31±2.1	28-29	28±1.2
Number of vertebrae (NV)	30-32	31±1.9	30-32	31±2.1	28-29	28±1.9	30-31	31±1.4	30-31	31±1.9	28-29	28±1.9

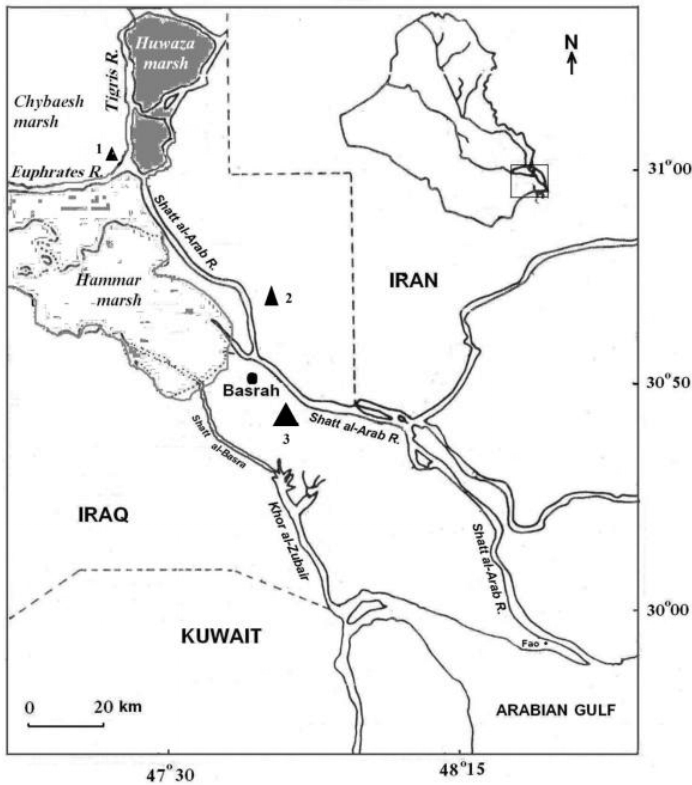


Figure 1 Map showing collection localities  
 Note: 1, Qurna; 2, Hartha; 3, Abu Al-Khaseeb

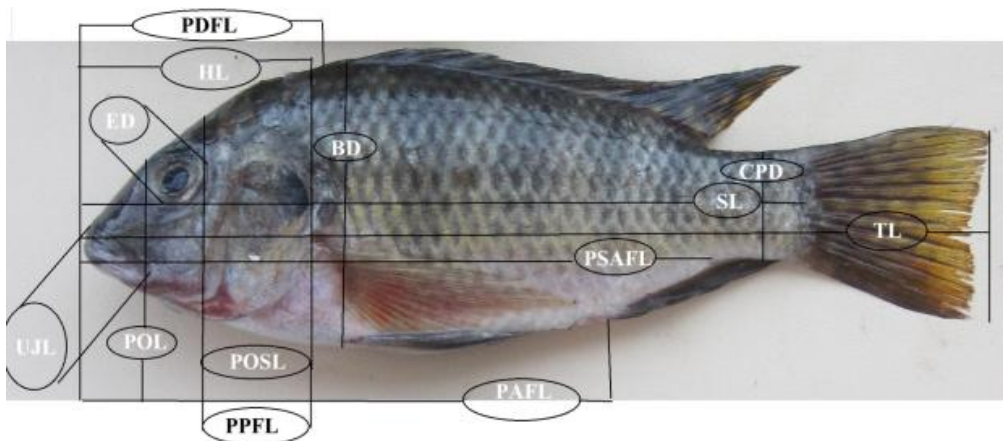


Figure 2 *Coptodon zillii* showing morphometric characters

Note: Total length, TL; standard length, SL; head length, HL; preorbital length, POL; eye diameter, ED; upper jaw length, UJL; postorbital length, POSL; predorsal fin length, PDFL; prepectoral fin length, PPFL; preanal fin length, PAFL; postanal fin length, PSAFL; body depth, BD; caudal peduncle length, CPD

To remove size effects from the data and guarantee that the variation in the morphometric characters are due only to shape of the fish body, all morphometric characters were standardized using the formula of Elliott et al. (2015).

$$M_{adj} = M (Ls/TL)^b;$$

Where  $M$  is the morphometric character measurement,  $M_{adj}$  is the size-adjusted measurement,  $TL$  is the total length of the fish, and  $Ls$  is the overall mean of the  $TL$  for all fish from all samples. Parameter  $b$  was estimated for each character from the observed data as the slope of the regression of  $\log M$  on  $\log Ls$ , using all fish in all groups. Meristic characters are not related to the size of fish, therefore should not change during growth (Strauss, 1985;

Murta, 2000). Hence, the original data were evaluated without treatment as described above. All counts were taken from the left side of the fish. The gill rakers of the first gill arch were counted under a dissecting microscope after the anterior gill arch had been removed from the fish.

Canonical discriminant analysis (CDA) was used to assess the efficacy in the meristic and morphometric characters in classification by location. Cross validated discriminant analysis was used to assess the extent to which meristic and morphometric characters allow identification by locations. Percentages of correct classifications were recorded.

For this analyses, the only characters that showed no overlapping values between the three localities were used. Hierarchical cluster analysis allows identifying groups of sites on the basis of similarity (Sneath and Sokal, 1973). In order to accomplish this objective, a dissimilarity matrix using Euclidean distance was calculated (Clifford and Stephenson, 1975). The analyses were performed using SPSS ver 13.

## 2 Results

Morphological variations of *C. zillii* and *O. aureus* showed significant differences in five morphometric traits, these are: preorbital length (POL), postorbital length (POSL), eye diameter (ED), upper jaw length (UJL) and caudal peduncle depth (CPD) (Table 1). All meristic count however were statistically different among the three populations of the two species studied.

For *C. zillii*, the cross-validated discriminant analysis using morphometric variables from all 360 fish correctly classified 77.2% by species (Wilk's lambda=0.087,  $P<0.001$ ). The highest correct classification rate was for group 3 from Abu Al-Khaseeb (100%), whereas the weakest discrimination was for specimens from group 1 from Qurna. Most misclassifications occurred between groups 1 and 2 Qurna and Hartha, respectively (Table 2; Figure 3). The cross-validated discriminant analysis for this species using meristic variables from all 360 fish correctly classified 74.7% by species (Wilk's lambda=0.035,  $P<0.001$ ). The highest correct classification rates was for group 3 from Abu Al-Khaseeb (100%), whereas the weakest discrimination was for specimens from group 2 from Hartha. Most misclassifications occurred between groups 1 and 2 Qurna and Hartha, respectively (Table 3; Figure 4).

Table 2 Classification results <sup>a</sup> for the discriminant analysis of morphometric characters from *Coptodon zillii* with the cross-validation testing procedure (cross-validated) for the three locations: 1, Qurna; 2, Hartha; 3, Abu Al-Khaseeb

		Location	Predicted Group Membership			Total
			1	2	3	
Original	Count	1	73	47	0	120
		2	35	85	0	120
	%	3	0	0	120	120
		1	60.8	39.2	0	100.0
Cross-validated <sup>a</sup>	Count	2	29.2	70.8	0	100.0
		3	0	0	100.0	100.0
		1	72	48	0	120
	%	2	35	85	0	120
		3	0	0	120	120
		1	60	40.0	0	100.0
		2	29.2	70.8	0	100.0
	3	0	0	100.0	100.0	

Note: a. Cross validation is done only for those cases in the analysis. In cross validation, each case is classified by the functions derived from all cases other than that case; b. 77.2% of original grouped cases correctly classified; c. 76.9% cross validated grouped cases correctly classified

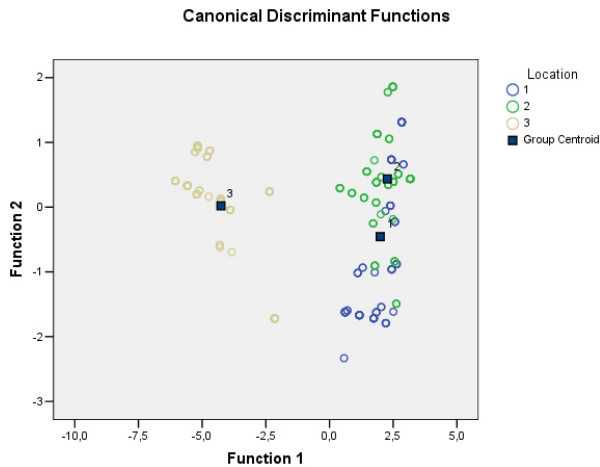


Figure 3 Scatter plot of the discriminant function scores from the analysis for morphometric characters of *Coptodon zillii* of geographic variants

Note: Blue circles=Qurna; Green circles: Hartha and Brown circles=Abu Al-Khaseeb. Black squares are the centroids

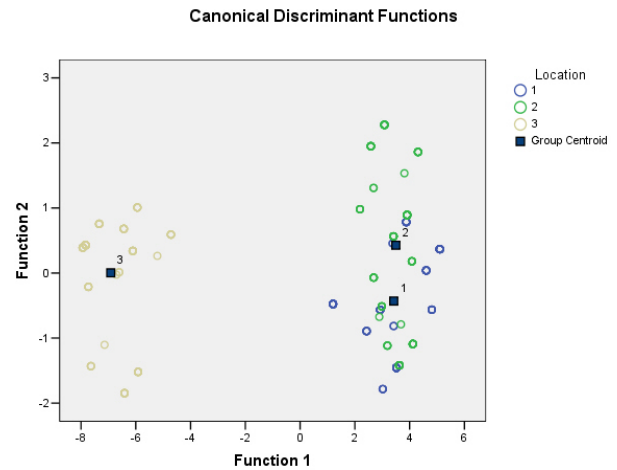


Figure 4 Scatter plot of the discriminant function scores from the analysis for meristic characters of *Coptodon zillii* of geographic variants

Note: Blue circles = Qurna; Green circles: Hartha and Brown circles = Abu Al-Khaseeb. Black squares are the centroids

Table 3 Classification results <sup>a</sup> for the discriminant analysis of meristic characters from *Coptodon zillii* with the cross-validation testing procedure (cross-validated) for the three locations: 1, Qurna; 2, Hartha; 3, Abu Al-Khaseeb

		Location	Predicted Group Membership			Total
			1	2	3	
Cross-validated <sup>a</sup>	Count	1	73	47	0	
		2	35	85	0	120
		3	0	0	120	120
	%	1	60.8	39.2	0	100.0
		2	29.2	70.8	0	100.0
		3	0	0	100.0	100.0
	Count	1	72	48	0	120
		2	35	85	0	120
		3	0	0	120	120
%	1	60.0	40.0	0	100.0	
	2	29.2	70.8	0	100.0	
	3	0	0	100.0	100.0	

Note: a. Cross validation is done only for those cases in the analysis. In cross validation, each case is classified by the functions derived from all cases other than that case; b. 77.2% of original grouped cases correctly classified; c. 76.9% of cross-validated grouped cases correctly classified

For *O. aureus*, the cross-validated discriminant analysis using morphometric variables from all 450 fish correctly classified 77.3% by species (Wilk's lambda = 0.058,  $P < 0.001$ ). The highest correct classification rate was for group 3 from Abu Al-Khaseeb (100%), whereas the weakest discrimination was for specimens from group 2 from Hartha. Most misclassifications occurred between groups 1 and 2 Qurna and Hartha, respectively but also Qurna showed high discrimination rate of 85.3% (Table 4; Figure 5). The cross-validated discriminant analysis using meristic variables for this species from all 450 fish correctly classified 72.7% by species (Wilk's lambda = 0.017,  $P < 0.001$ ). The highest correct classification rates was for group 3 from Abu Al-Khaseeb (100%), whereas the weakest discrimination was for specimens from group 1 from Qurna. Most misclassifications occurred between groups 1 and 2 Qurna and Hartha, respectively (Table 5; Figure 6).

The consensus phenogram of *C. zillii* and *O. aureus* locations mean shapes (Figure 7) showed the distinctions among the three areas, one group with similar meristic and morphometrics are the locations Qurna and Hartha but

different from these locations were Abu Al-Khaseeb for the same morphometric and meristic traits.

Table 4 Classification results <sup>a</sup> for the discriminant analysis of Morphometric characters from *Oreochromis aureus* with the cross-validation testing procedure (cross-validated) for the three locations: 1, Qurna; 2, Hartha; 3, Abu Al-Khaseeb

		Location	Predicted Group Membership			Total
			1	1202	3	
Cross-validated <sup>a</sup>	Count	1	73	47	0	
		2	35	85	0	120
		3	0	0	120	120
	%	1	60.8	39.2	0	100.0
		2	29.2	70.8	0	100.0
		3	0	0	100.0	100.0
	Count	1	72	48	0	120
		2	35	85	0	120
		3	0	0	120	120
%	1	60.0	40.0	0	100.0	
	2	29.2	70.8	0	100.0	
	3	0	0	100.0	100.0	

Note: a. Cross validation is done only for those cases in the analysis. In cross validation, each case is classified by the functions derived from all cases other than that case; b. 77.2% of original grouped cases correctly classified; c. 76.9% of cross-validated grouped cases correctly classified

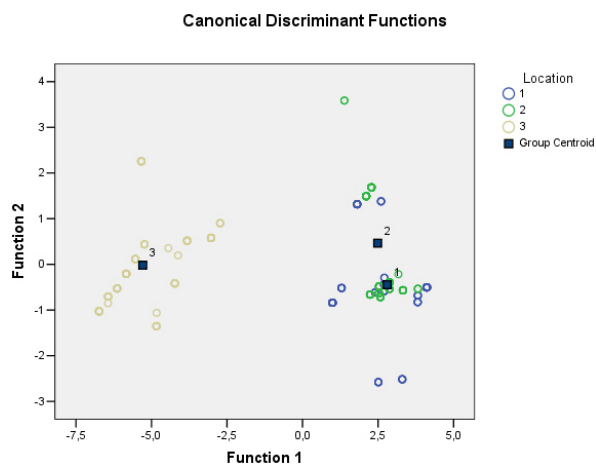


Figure 5 Scatter plot of the discriminant function scores from the analysis for morphometric characters of *Oreochromis aureus* of geographic variants

Note: Blue circles = Qurna; Green circles: Hartha and Brown circles = Abu Al-Khaseeb; Black squares are the centroids

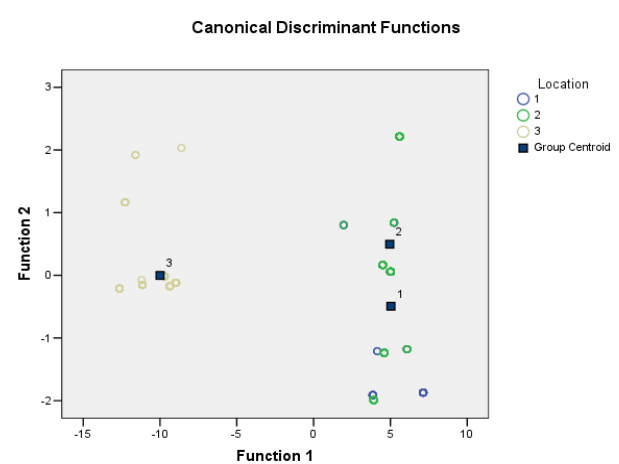


Figure 6 Scatter plot of the discriminant function scores from the analysis for meristic characters of *Oreochromis aureus* of geographic variants

Note: Blue circles = Qurna; Green circles: Hartha and Brown circles = Abu Al-Khaseeb. Black squares are the centroids

\*\*\*\*\* HIERARCHICAL CLUSTER ANALYSIS \*\*\*\*\*

Dendrogram using Average Linkage (Between Groups)

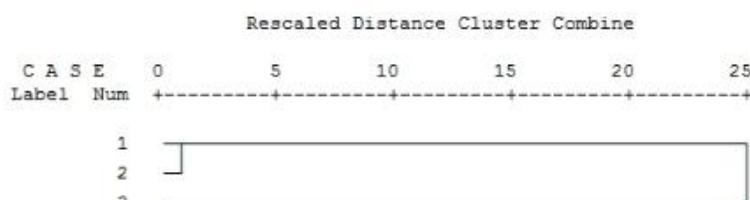


Figure 7 Cluster analysis performed on the matrix of morphometric and meristic characters using Ward's method of *O. aureus* and *Coptodon zillii* species

Table 5 Classification results <sup>a</sup> for the discriminant analysis of meristic characters from *Oreochromis aureus* with the cross-validation testing procedure (cross-validated) for the three locations: 1, Qurna; 2, Hartha; 3, Abu Al-Khaseeb

		Predicted Group Membership				
		Location	1	2	3	Total
Cross-validated <sup>a</sup>	Count	1	57	93	0	150
		2	30	120	0	150
		3	0	0	150	150
	%	1	38.0	62.0	0	100.0
		2	20.0	80.0	0	100.0
		3	0	0	100.0	100.0
	Count	1	57	93	0	150
		2	30	120	0	150
		3	0	0	150	150
	%	1	38.0	62.0	0	100.0
		2	20.0	80.0	0	100.0
		3	0	0	100.0	100.0

Note: a. Cross validation is done only for those cases in the analysis; In cross validation, each case is classified by the functions derived from all cases other than that case; b. 72.7% of original grouped cases correctly classified; c. 72.7% of cross-validated grouped cases correctly classified

### 3 Discussion

It was documented that fish can show high modifications in morphological characters both within and between populations of species than any other vertebrates (Allendorf et al., 1987; Wimberger, 1992). Such changes in the fish body shape permits the fish to adapt to any changes in the habitats that it's living in through modification of their physiology and behaviour (Stearns, 1983; Meyer, 1987; Gulliet et al., 2003).

Members of the family Cichlidae are among the fish species that categorized in showing wide range of variations in their body shapes (McCune, 1981). Such variations are witnessed in several tribes of cichlids in many geographical areas around the world and the best example is that from the African lakes (Omotayo, 2015).

Morphological investigation endeavored in this work showed significant differences in the morphometric and meristic characters among an introduced, but sustained populations of *C. zillii* and *O. aureus* from Shatt al-Arab River, south of Iraq. Populations of the two cichlids species studied from Shatt al-Arab River appeared not homogenous. The southern population at Abu Al-Khaseeb City is different from the other two populations at the mid and north localities of the river in seven meristic characters and five out of 13 morphometric characters studied.

There are two possible reasons that may render the populations of any fish species non-homogenized, these are the genetic differentiation and the environmental plasticity or both. It has been known that morphometric characters can reveal responses of a population to its local environment (Swain and Foote, 1999). In some instances, changes in the morphology of the fish observed in the wild populations can be continue to present because of the environmental plasticity (Tudela, 1999). Variation in morphological characters due to changes in the environmental factors may be favored for stock separation as this method is cheaper to apply and give reliable results.

In the case of *Danio rerio*, changes in water temperature can cause variation in the morphometric characters (Georgakopoulou et al., 2007; Sfakianakis et al., 2011), which may affect fish metabolism via changes in dissolved oxygen (Wimberger, 1992). The results obtained in the present study have shown that individuals of the populations of *C. zillii* and *O. aureus* at the northern and middle regions of Shatt al-Arab River have larger eye diameter, longer pre- and postorbital length, and upper jaw, and deeper caudal peduncle area than the individuals of the southern population located at Abu Al-Khaseeb City. Water temperature at the southern part of the River Shatt al-Arab River was higher than that in middle part of the river at Hartha and at the northern part at Qurna



(Al-Hejuje, 2014; AL-Shaheen and Al-Handal, 2017). Similar results were obtained by Atkinson (1994), Haddon and Willis (1995), and Emmrich et al. (2014). Water viscosity and density will increase with low water temperature increases and, therefore, changes of body shape will be advantageous to decrease drag (Wimberger, 1992). Thus, physicochemical characters of aquatic ecosystems change with water temperature and, therefore, fish will react with new variations in body shape (Sfakianakis et al., 2011).

Low light intensity, due to low turbidity might affect the development of the fish eye (Matthews, 1988). Masuda and Tsokamoto (1996). In upper parts of Shatt al-Arab River, water is more turbid due to muddy substrate than the lower reaches of the river (Alaamer, 2015). Masuda and Tsokamoto (1996) found that some morphological changes happened in the eye as a function of light intensity. On the other hand, Higgs and Fuiman (1996) reached to the same conclusion when they analysed the relation between eye diameter and light intensity for schooling behaviour in several species. Therefore, we found that the individuals of both species studied have larger eye diameter from the northern and middle part population of the river than those from the southern population.

In fish, meristic characters such as the fin ray count and the number of vertebrae are determined early during larval development. These characters are influenced by environmental factors, especially temperature (Täning, 1952). It has been shown that the lower the temperature is in early life stages, the larger the number of vertebrae (Templeman and Pitt, 1961). Therefore, differences in meristic characters among areas show that larvae were exposed to different environmental conditions, and this can be interpreted as evidence of the existence of geographically separated spawning populations.

Variations in meristic counts were observed among the three populations of both *C. zillii* and *O. aureus* collected from Shatt al-Arab River. These variations may be due to environmental or genetic factors, or both. Although the contributing factors cannot be identified in the present work, it is apparent that different populations of *C. zillii* and *O. aureus* can be identified based on meristic characters. This results should be counted for any future conservation plans for these species. The noteworthy variation in meristic characters obtained between the three populations studied might represent reproductive isolation among the populations of the two cichlids species examined. Cluster analysis and PCA showed that the three populations of the two species studied were divided into two groups. Group I includes the upper and middle regions of Shatt al-Arab River at Qurna and Hartha respectively. These two populations are distinguished in having the highest meristic counts for all seven characters examined. Group II is composed of the lower Shatt al-Arab Region at Abu al-Khaseeb City. There is an increasing trend in the values of the seven meristic characters examined from south to north of the river Shatt al-Arab. This trend concurs with the decreases in water temperature salinity from south to north (Hameed et al., 2013; Moyel, 2014; Abdullah et al., 2016).

Higher water temperatures could lead to shorter incubation periods and lower meristic counts, i.e., the number of fin rays and vertebrae (Kwain, 1975). In the north and the middle regions of the Shatt al-Arab River, where our samples were collected from Qurna and Hartha respectively, water temperatures are lower in spring when *C. zillii* and *O. aureus* eggs are spawned, than they are in locations in the southern reaches of the river.

Differences in the mean number of gill rakers appears to have related to the food and feeding habits of fish (Quilang et al., 2007). Fewer rakers are noted in fish that feed on benthos, which is the case for populations from the southern region of the Shatt al-Arab River at Abu Al-Khaseeb City. Higher counts are represented in individuals from Qurna and Hartha localities at the upper and middle regions of the river and lower values of these elements were observed at Abu Al-Khaseeb locality, where feeding habits differ from those in mid and southern Iraq.

Decadal results have shown that fish species feed on large food particles usually required small numbers of gill rakers, while those feed on small food items need large gill rakers (Nikolsky, 1963; Labropoulou and Eleftheriou, 1997; Amundsen et al., 2004; Kahilainen et al., 2011). The two cichlids species studied are omnivorous and feed on benthos forms (Spataru and Zorn, 1978; Spataru, 1978; Agbabiaka, 2012). This clarifies the disparities in the

number of gill rakers among individuals from the three populations of cichlids species from Shatt al-arab River. In the upper and middle regions of the river, small prey such as fish are rich, while large preys such crabs and other crustaceans are abundant in southern reaches of the river (Naderloo and Schubart, 2009; Naderloo, 2011).

The physico-chemical characteristics of the southern region of Shatt al-Arab River are different from those in the northern and the middle regions of the river (Al-Mahmood, 2009; Abbass et al., 2014; Abdullah et al., 2015; Brandimate et al., 2015), which interfere in the development of the meristic characters examined in the present study.

We have shown the competence of applying hierarchical cluster and principle component analyses in investigating the population structure of the two cichlids species *C. zillii* and *O. aureus* from three localities locations in Shatt al-Arab River in Iraq. Nevertheless, more studies are required to recognize the relationships between the observed meristic variability and variation in environmental factors, especially those that can affect the developmental stages of the fish. In the future, morphological and molecular studies of other populations of the two cichlids in Iraq and neighboring countries are needed in order to elucidate the continuous differences in the meristic characters observed in this study.

#### Authors' contributions

All authors have contributed equally toward the publication of this paper.

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