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MORPHOMETRIC CHARACTERISTICS OF CATFISH *Silurus triostegus* (Heckel, 1843) FROM THE TIGRIS AND SHATT AL-ARAB RIVERS, IRAQ

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ABSTRACT

Thirteen morphometric characters of catfish *Silurus triostegus* were studied from three localities on the Tigris and Shatt al-Arab rivers, Iraq. Monthly samples revealed no significant differences between genders. Positive allometric growths for all morphometric characters studied were observed. This study gives information to fishery biologists about morphometric characters of *S. triostegus* from the Tigris and Shatt al-Arab rivers to assist in planning of conservation strategies for this fish species.

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INTRODUCTION

Catfishes in the Mesopotamian Tigris-Euphrates basin are representatives of both European and southern Asian species, with a mixed fauna of low endemicity, leading to questions such as the phylogenetic distinctness of this group of species for the region. Some examples of controversy include the phylogeny of catfishes of the genus Silurus. *Silurus chantrei* has been classified as a synonym for *S. asotus* from the Far East. Similarly, *S. triostegus* in Mesopotamia has been suggested to be a variant of *S. glanis* (Hora and Misra, 1943), indicating that there are still several questions regarding phylogenetic relationships for this group in the Middle East. Investigations of the morphometric characteristics of *S. triostegus* may provide a first step in resolving some of the phylogeny of this ecologically important species for Mesopotamian ecosystems.

S. triostegus occurs in the Tigris-Euphrates basin, mostly restricted to Iraq, Iran, Turkey and Syria (Ünlü and Bozkurt, 1996; Najafpour, 1997; Abdoli, 2000; Esmaeili et al., 2010,; Coad, 2010; Ünlü et al., 2012). In Iraq, it inhabits open vegetated lakes, marshes and rivers (Van den Eelaart, 1954), especially in the southern marshes of Iraq (Hussain and Ali, 2006). An increase in the biomass of this species occurred after recent declines in predatory otter and aquatic bird populations inhabiting marsh areas of southern Iraq (Hussain et al., 2008). Similarly, distribution and abundance of *S. triostegus* populations in other parts of Iraq have been affected by dam construction, causing shifts in salinity and pollution increase (Hashemi et al., 2012).

Among several taxonomic methods for identifying fish, morphometric techniques are more suited to be used in the field. There are several morphometric characters that reflect ecophenotypic variation and are commonly used in biometric and population identification studies, including body length and width, and length of other body parts (Waldman, 2005). Moreover, morphometric techniques are preferred over their molecular counterparts when it comes to cost, making it even more suitable when large quantities of fish are to be identified, as is common in field studies. Diversity studies based on morphometrics, therefore, may prove essential in determining key areas for conservation and management. In the light of the need for conservation and promise of morphometric tools to estimate biodiversity, this study presents some morphometric parameters of catfish *S. triostegus* from three populations in the Tigris and Shatt al-Arab rivers, Iraq.

MATERIALS AND METHODS

In Mesopotamia, the Tigris and Euphrates rivers are the largest. The Tigris River extends for 1,850 km, starting from the Taurus Mountains in eastern Turkey to the coast of Iraq. Several tributaries join this river along its north-south flow in Iraq (Isaev and Mikhailova, 2009). The Shatt al-Arab River is formed by the confluence of the Tigris and Euphrates rivers at al-Qurnah, Basrah Governorate, south Iraq. It is 200 km long and varies in width between 230 meters at Basrah City to 800 meters at its mouth in Arabian/Persian Gulf (Country data. com, 2015). Sample stations at Al-Qurnah, Basrah City and at the river's mouth were chosen for this study.

Fish samples were obtained from fishers operating near the sampling sites. Samples were collected in August 2004. One thousand two hundred individuals of *S. triostegus* were obtained. Three hundred and fifty, ranging in total length from 200 to 500 mm, of which 200 were females and 150 males, were obtained from Mosul. Four hundred and fifty, ranging in total length from 210 to 400 mm, of which 350 were females and 100 males, were obtained from Baghdad. Four hundred, ranging in total length from 200 to 320 mm, of which 300 were females and 100 males, were sampled in the Basrah area. Fish were examined while still fresh. Total length (TL), standard length (SL), head length (HL), head depth (HD), eye diameter (ED), preorbital length (ProL), postorbital length (PosL), upper jaw length (UJL), lower jaw length (LJL), pectoral fin length (PFL), pelvic fin length (PVFL), body depth (BD), caudal peduncle depth (CPD) were measured in mm using a digital calliper (Fig. 1).

Sex was determined microscopically and gender proportions analyzed using a one-way ANOVA. To eliminate scaling problems associated with growth in morphometric characters (non-discrete, measurable), each measurement was standardized. The relationship between total fish length and morphometric characters was estimated using the following formula:

$Y = a + b X$

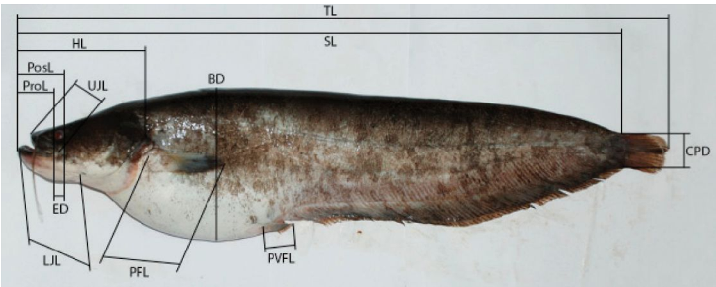

Fig 1. Morphometric characters of *Silurus triostegus*. BD, body depth; CPD, caudal peduncle depth; ED, eye diameter; HD, head depth; HL, head length; LJL, lower jaw length; PFL, pectoral fin length; PosL, postorbital length; ProL, preorbital length; PVFL, pelvic fin length; SL, standard length; TL, total length; UJL, upper jaw length (photo by Muhammad I. G. Al-Janabi)

Where, Y = morphological characters; X = total fish length; a, b = constants.

The type of allometry was evaluated by testing the allometric coefficient "b" (b = 1, b>1 and b<1 for isometry, negative allometry and positive allometry, respectively). Student t_s test was used to verify whether calculated "b" was significantly different from 1 using the following formula:

$t_s = b-1/sb$

Where ts is the t-test value, b is the slope and sb is the standard error of the slope (b). The allometric coefficient was used to investigate the relationship between morphological characters (Van Snik et al., 1997). ANOVA was used to estimate the relationships between morphological characters and the populations represented by the fish samples taken.

RESULTS

Total length standardized morphological characters show a higher average for the Mosul population, followed by Baghdad and Basrah populations (Table 1). Analysis of variance results showed that all morphometric measurements were significantly different between the samples (p<0.001). ANOVA also revealed no statistical differences between males and females for morphometric analysis (P>0.05), so sexes were pooled for further analysis.

The linear regression coefficient for morphometric variables (Y) on the total length (X) showed the highest and lowest values for the Basrah population, where BD was estimated to be 0.339 and PVFL 0.049.

The present study shows the highest correlation of the total length standardized morphometric characters is 0.992 for ProL for the Baghdad population and the lowest is 0.902 for LJL for the Mosul population. Growth of all morphometric characters relative to total length showed a positive allometry. The relationship between total and standard lengths was estimated to have a negative allometry and a slope of 0.988.

DISCUSSION

Similar research on the morphology of males and females of fishes agree with our findings on having no significant difference between sexes (Lashari et al., 2004; Narejo et al., 2000; Narejo, 2010; Dars et al., 2012). Our results also agreed with the conclusion advanced by Minos et al. (1995), Cavalcanti et al. (1999), Sabadin et al. (2010), Díaz de-Astarloa et al. (2011) and Zhan and Wang (2012) that morphometry can be used to distinguish among species of fish.

Morphological descriptors are important for taxonomic classification of organisms and estimation of species diversity (Dean et al., 2004). One of the major keys in fish biology are morphometric characters as they are important for systematics, estimation of growth variability, ontogeny (Kovac and Copp, 1999) and population-level studies (Verep et al., 2006). Variations in morphology are less obvious at the intra-specific level, whereas phenotypic variation is less obvious under genetic control and more subject to environmental influences (Clayton, 1981).

Variation in the phenology of fish allows adaptations to

Table 1. Descriptive statistics of morphometric traits of Silurus triostegus. SE, standard error; R2, correlation coefficient

Morphometric indices	Range	Mean TL ± SE	Y= a + b X	R^2
Total length	200 – 500	356 ± 2.9	–	–
Standard length SL	180 – 490	240 ± 2.0	SL = 1.424 + 0.242TL	0.988
Head length HL	102 – 110	105 ± 1.9	HL = 1.424 + 0.242 TL	0.982
Head depth HD	34 – 36	35 ± 2.1	HD = -2.432 + 0.203 TL	0.950
Eye diameter ED	30 – 35	32 ± 0.9	ED = 1.152 + 0.053 TL	0.932
Preorbital length ProL	28 – 30	28 ± 1.3	ProL = -1.973 + 0.107 TL	0.972
Postorbital length PosL	44 – 45	41 ± 1.6	PosL = 0.736 + 0.108 TL	0.960
Upper jaw length UJL	15 – 17	16 ± 2.1	UJL = 0.342 + 0.294 TL	0.956
Lower jaw length LJL	19 – 21	20 ± 1.9	LJL = 0.154 + 0.060 TL	0.902
Pectoral fin length PFL	70 – 73	72 ± 2.1	PFL = -1.438 + 0.191 TL	0.976
Pelvic fin length PVFL	75 – 82	77 ± 1.2	PVFL = -.0796 + 0.047 TL	0.966
Body depth BD	41 – 52	46 ± 1.9	BD = -8.499 + 0.332 TL	0.974
Caudal peduncle depth CPD	12 – 13	23 ± 2.2	CPD = -5.394 + 0.171 TL	0.971
Total length	210 – 400	320 ± 2.1	–	–
Standard length SL	200 – 390	293 ± 1.4	SL = 1.435 + 0.249TL	0.968
Head length HL	116 – 121	117 ± 1.9	HL = 1.436 + 0.254 TL	0.972
Head depth HD	37 – 39	36 ± 1.6	HD = -2.442 + 0.213 TL	0.980
Eye diameter ED	37 – 39	37 ± 1.5	ED = 1.164 + 0.060 TL	0.962
Preorbital length ProL	33 – 35	32 ± 1.3	ProL = -1.964 + 0.110 TL	0.992
Postorbital length PosL	46 – 47	46 ± 1.7	PosL = 0.745 + 0.112 TL	0.980
Upper jaw length UJL	20 – 35	26 ± 1.4	UJL = 0.352 + 0.298 TL	0.986
Lower jaw length LJL	25 – 36	31 ± 2.0	LJL = 0.165 + 0.059 TL	0.942
Pectoral fin length PFL	40 – 65	52 ± 2.2	PFL = -1.441 + 0.190 TL	0.986
Pelvic fin length PVFL	25 – 36	30 ± 1.9	PVFL = -.0798 + 0.051 TL	0.976
Body depth BD	62 – 71	65 ± 1.2	BD = -8.498 + 0.334 TL	0.984
Caudal peduncle depth CPD	14 – 15	13 ± 1.3	CPD = -5.396 + 0.171 TL	0.981
Total length	200 – 320	298 ± 2.0	–	–
Standard length SL	185 – 310	265 ± 2.1	SL = 1.430 + 0.248TL	0.978
Head length HL	127 – 144	134 ± 1.9	HL = 1.428 + 0.248 TL	0.962
Head depth HD	40 – 45	4.3 ± 1.8	HD = -2.436 + 0.207 TL	0.960
Eye diameter ED	42 – 53	46 ± 2.0	ED = 1.159 + 0.059 TL	0.940
Preorbital length ProL	37 – 39	37 ± 1.5	ProL = -1.977 + 0.109 TL	0.979
Postorbital length PosL	48 – 52	49 ± 1.1	PosL = 0.738 + 0.109 TL	0.966
Upper jaw length UJL	42 – 48	44 ± 1.8	UJL = 0.348 + 0.299 TL	0.959
Lower jaw length LJL	40 – 48	44 ± 1.9	LJL = 0.157 + 0.062 TL	0.952
Pectoral fin length PFL	20 – 38	29 ± 3.0	PFL = -1.439 + 0.197 TL	0.978
Pelvic fin length PVFL	19 – 21	20 ± 2.4	PVFL = -.0799 + 0.049 TL	0.967
Body depth BD	75 – 81	78 ± 2.6	BD = -8.501 + 0.339 TL	0.979
Caudal peduncle depth CPD	16 – 17	16 ± 1.9	CPD = -5.398 + 0.179 TL	0.978

environmental change by adjustment of their physiology and behaviour to effects of environmental variation, which leads to changes in morphology, reproduction and survival (Stearns, 1983; Meyer, 1987). Variation in morphological characters due to changes in the environmental factors may be preferred for stock identification, especially when the timescale is inadequate for important genetic differentiation of population, such as may happen for partially isolated stocks.

Sfakianakis et al. (2011) and Georgakopoulou et al. (2007) have found that morphometric characters of *Danio rerio* changed with water temperature, which may influence fish metabolism through changes in dissolved oxygen (Wimberger, 1992). Our results showed that *S. triostegus* was larger in the Tigris River at Mosul City and smaller in populations from the Shatt al-Arab River. In the populations of the Tigris River at Baghdad City, the size of fishes was in between. Water temperature at Mosul was lower (8 to 18 C) than that in Baghdad (15 to 25 C) and Basrah City (20 to 40 C; Al-Sanjari and Al-Tamimi, 2009; Al-Noor et al., 2013). In Turkey, further to the north of Iraq, water temperature is lower than in the Tigris River at Mosul. Individuals of *S. triostegus* obtained there were much larger than those obtained from the north of Iraq. This decrease in water temperature toward the north explains the relationship of water temperature with size of the fish. Similar conclusion was reached by Atkinson (1994), Haddon and Willis (1995), and Emmrich et al. (2014). Water temperature seems not to affect only body size but other morphometric characters like head length and depth, body depth and caudal peduncle depth (Georgakopoulou et al., 2007; Eagderi et al., 2015). Low water temperature increases water viscosity and density and, thus, changes of body shape towards a more fusiform body are advantageous to decrease drag (Wimberger, 1992). Hence, physicochemical features of aquatic ecosystems change with water temperature and, therefore, fish will respond with new variations in body shape (Sfakianakis, 2011).

Rowiński et al. (2015) provided an explanation for the deep body and caudal peduncle of fish by which they suggested that the effect of water temperature and food was responsible for such changes. They concluded that high temperatures elevate metabolism and feeding activity (Claireaux and Lagardere, 1999; Sunuma et al., 2007; Arula et al., 2012; Slavik and Horky, 2012), which may lead to higher growth rates in fish. When food becomes abundant, the surplus of food taken can be allocated to somatic growth. Consequently, differentiation in different parts of the fish becomes obvious (Kemp and Bertness, 1984; Lindsey, 1988; Pelletier et al., 1994). Therefore, it is difficult to differentiate between the effect of temperature and food consumption as both are interconnected. This is in agreement with the results obtained here. Individuals of *S. triostegus* from the Shatt al-Arab River at Basrah City were shown to have deeper body than those from the Tigris River at Mosul City. Population from the Tigris River at Baghdad City showed a value in between. This is also true for caudal peduncle depth, and head length and depth. The same can be stated for the effect of water current on body shape, as stated above for the effects on shape from water temperature (Esmaeili et al., 2011; Sajina et al., 2013).

The noticeable growth in the abdominal region of the target species suggests greater development of the intestine (Elbal et al., 2004), a finding corroborated by other studies that have shown that the middle part of the body increases throughout ontogeny (after head and tail) in bilateral species (Osse et al., 1997; van Snik et al., 1997; Gozlan et al., 1999) later than in asymmetrical species (*Paralichthys californicus*, Gisbert et al., 2002).

Samaee and Patzner (2010) have suggested that feeding regime could affect head morphology, including mouth size and the length of upper and lower jaw. Prey size is another factor that may affect the proximity of the eyes and both the preorbital and postorbital lengths (Costa et al., 2003; Turan, 2004). The population of *S. triostegus* from the Shatt al-Arab River has a large mouth, including the upper and lower jaws. Such modification favours ingestion of large and hard prey, such as crabs and some fish species that are available in the Shatt al-Arab River environment (Naderloo and Schubart, 2009; Naderloo, 2011). In contrast, individuals of this species from the Tigris River at Mosul showed smaller mouth and jaws, which are adapted to the feeding habits of species inhabiting running waters.

The water of the Shatt al-Arab River is turbid due to the muddy substrate (Alaamer, 2015) and the presence of fish species with bottom feeding habits (Hussein et al., 2000a, 2000b). In such a habitat, the variation in eye diameter can be attributed to the developmental adaptation in fishes during their early stages inhabiting low light intensity, due to low turbidity (Matthews, 1988). Masuda and Tsokamoto (1996) noted that some morphological development happened in the eye as a function of light intensity. Higgs and Fuiman (1996) analysed the relation between eye diameter and light intensity for schooling behaviour in several species. Miyazaki et al. (2000) reported similar results for *Pseudocaranx dentex*. Solar absorption reduces from the north to the south of the Shatt al-Arab River as the bottom changes to silt and mud, and the density of aquatic plants increases. Such gradient in sunlight absorption has also been observed by Kumar et al. (2010) in the Bay of Bengal due to large quantities of sediment influx. Hence, the variation in eye diameter in fishes from north to south in Iraq can perhaps be attributed to the variation in light penetration.

The active swimmer fish that searches for food and lives in running water usually has longer fins, in addition to a shallower body (McLaughlin and Grant, 1994; Liao, 2007). Such conditions agree with the results obtained in this study, where individuals with longer pectoral and pelvic fins from the Tigris River at Mosul City and shorter fins in individuals in the Shatt al-Arab River were found. Fin lengths for the population in the Tigris River at Baghdad City were between those from the Mosul and Basrah localities.

In the present study, all morphometric measurements were highly correlated (above 0.9). This indicates that the growth of *S. triostegus* in one area of the body is related to the growth in another area. Oniye et al. (2006) and Safie et al. (2014) obtained similar results for *Protopterus annectens* and *Pomadasys stridens*, respectively.

The analysis of morphometric characters obtained in this study shows that there are three morphologically distinct populations of *S. triostegus* in the Tigris and Shatt al-Arab rivers, and that these differences may be due to body shape and not size. Morphological characters were used in this work to make essential information about the differences between the populations of *S. triostegus* in the Tigris and Shatt al-Arab rivers available. This information may be used in developing management strategies for the study area in the future. Ecological factors may be drivers for such variations, as has been shown for other fish species (Clayton, 1981; Esmaeili et al., 2011). Future studies confirming our findings on the populations of *S. triostegus* in the Tigris and Shatt al-Arab rivers using molecular markers should be considered.

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Sažetak

MORFOMETRIJSKA OBILJEŽJA SOMA *Silurus triostegus* (Heckel, 1843) IZ RIJEKA TIGRIS I SHATT AL-ARAB U IRAKU

Trinaest morfometrijskih obilježja soma *Silurus triostegus* su istraživana na tri lokacije u rijekama Tigris i Shatt al-Arab u Iraku. Mjesečni uzorci su pokazali da nema značajne razlike između spolova. Zabilježen je pozitivan alometrijski rast za sva istraživana morfometrijska obilježja. Ova studija daje znanstvenicima informacije o morfometrijskim obilježjima *S. triostegus* iz rijeka Tigris i Shatt al-Arab kao pomoć pri planiranju strategija očuvanja za ovu riblju vrstu.

Ključne riječi: slatke vode, Siluridae, morfometrijska obilježja, upravljanje, okolina, oblik tijela

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