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Comparision of morphological and anatomical characters in two catfish species, *Silurus triostegus* Heckel, 1843 and *Silurus glanis* L., 1758 (Siluridae, Siluriformes)

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Abstract. In this study, some morphological and anatomical characteristics of *Silurus triostegus* from Tigris and Euphrates Rivers and *Silurus glanis* from several lakes and Rivers of Turkey were investigated. Although, *S. Triostegus* has two mandibular barbels, usually in the young specimens there are four mandibular barbels, sometimes 3 mandibular barbels. This situation may show that some mandibular barbels reabsorbed. Maxillary barbels of *S. glanis* reach to the end of the pectoral fin, but those reach to only middle of pectoral fin in *S. triostegus*. Also, anterior mandibular barbels of *S. glanis* shorter than posterior ones, but when two pairs of mandibular barbels are present in the *S. triostegus*, the anterior ones are always longer than posterior ones. The pectoral spine, vomerine teeth band, some cranial bones such as basioccipital, supraoccipital and mesethmoid show some difference between the two species.

Key words: Siluridae, *Silurus glanis, Silurus triostegus*, anatomy, morphology.

Introduction

Siluridae is a family of freshwater catfishes in Europe and Asia. They are characterised by the lack of the adipose fin, lack of dorsal spine and by a very long anal fin (Kotellat & Freyhof 2007). One of the well-known genera of this family is *Silurus* which includes about 19 nominal species that are widely distributed throughout Eurasia (Haig 1952, Slastenenko 1955, Banarescu 1964, Blanc et al. 1971, Ladiges & Vogt 1979, Kobayakawa 1989, Telcean & Cupşa 2009). It has been considered that the genus *Silurus* in Turkey is represented by two species, *Silurus glanis* Linnaeus, 1758 and endemic species, *Silurus triostegus* Heckel 1843. *Silurus glanis* is widely distributed in Thrace, Western, Central, and Northern Anatolia (Balik 1979, Balik 1985, Balik 1988, Erk'akan & Kuru 1982), however *S. triostegus* exists only in the Tigris and Euphrates basins (Beckman 1962, Mahdi 1967, Kuru 1979, Ünlü & Bozkurt 1996, Coad & Holcik 2000). The European catfish, *Silurus glanis*, is among the largest freshwater fish in the world (Alp et al. 2011). The European catfish is a good candidate in fish farms as an auxiliary species which will bring income much sooner than the sturgeons, sustaining in this way the sturgeon farming activity (Arteni 2009, Muscalu et al. 2010).

It is difficult to recognise *S. glanis* and *S. triostegus* without detailed observation. Some comparative studies of morphology and anatomy on *S. glanis* have been performed with other Silurid species (Haig 1952, Cerny 1988, Kobayakawa 1989, Coad & Holcik 2000). However, the species *S. triostegus* has only been analysed in regard to some external morphologic characters (Heckel 1843, Kobayakawa 1989, Ünlü & Bozkurt 1996, Coad & Holcik 2000). It is well documented that morphology of a species varies in different environments. Furthermore, morphometric data and their statistical differences between both species seem to be lacking. Since knowledge of morphological and anatomical features are essential to understanding the taxonomy of silurid fish, the present work was undertaken to describe morphological and anatomical characteristics of *S. glanis* and *S. triostegus* from Turkey. To identify and classify fish species, it is important to determine the anatomical features as well as morphological features in fish (Rahmati-Holasoo et al. 2011).

Materials and Methods

The materials examined are deposited in the following institutions: Museum of Faculty of Science & Art, Dicle University (DUM); Museum of Faculty of Fisheries (ESFM-PISI), Ege University, Turkey; the Special Collection of Fahrettin Kücük, Süleyman Demirel University Eğirdir Fisheries Faculty (SCFK-SDU), Turkey. The following preserved specimens were examined in more detail:

Material examined: *S. triostegus*: Euphrates River (Birecik) (n=13, 10 September 1994 (DUM 1994/62); Karakaya Dam Lake (n=3, 12 October 1996, DUM, 1996/66), Tigris River-Diyarbakir (n=2, 25 October 1997, DUM,

1997/72). *S. glanis*: Körkün stream, Seyhan Dam Lake, (n=2, 11 July 1977; ESFM-PISI, 1977/094), Meriç River (n=1, 03 August 1982, ESFM-PISI, 1982/040); Terkos Lake (Thrace) (n=1, 25 August 1982, ESFM-PISI, 1982/155); Akgöl (K. Menderes) (n=4, 25 June 1985, ESFM-PISI, 1985/002-003); Kus Gölü (n=1, 30 June 1987, ESFM-PISI, 1987/111); Demirköprü Dam Lake (n=3, 23 August 1991, ESFM-PISI, 1991/029); Seyhan Dam Lake (n=8, 25 April 1996, DUM 1996/67); Gölhisar Lake (Burdur) (n=4, 11 May 1996, SCFK-SDU, 1996/?).

Measurements follow Lagler et al. (1981) and Önsoy et al. (2011). Dorsal and anal fin-ray counts include the last two branched rays counted as two separate rays. Four fresh *S. triostegus* specimens from Atatürk Dam Lake and three fresh *S. glanis* specimens from Seyhan Dam Lake were studied to determine anatomical futures. The vertebral columns were extricated from these specimens and the number of vertebrae was counted using a magnifying glass. Vertebral counts include one uroneural and four weberian centra. Other specimens were preserved in 4% formalin. Terminology of anatomical elements follows Kobayakawa (1989). The Mean values calculated for each morphological parameter were compared using Student's *t*-tests and a significance level of 95% probability was adopted.

Results

Morphology

Some morphometric and meristic data of *S. triostegus* and *S. glanis* in the some freshwaters of Turkey are given in Table 1 and 2.

S. triostegus: Dorsal fin rays 4, Anal fin rays 81-86, branchiostegals 14-15, vertebrae 17 + (52) 53 = (16) 70, and gill rakers 12-16 on the first arch. The mouth is large and the lower jaw is considerably longer than the upper jaw; head 4.3±0.2 in standard length; head with 4 mandibular barbels in three specimens, 3 mandibular barbels in one sample, one pair in the others. The maxillary barbels are longer than head; the mandibular barbels shorter. When two pairs of mandibular barbels are present the anterior ones are always shorter than posterior ones. The maxillary barbels reach the end of the head whereas the mandibular barbels reach only the middle. Anal fin is not fused to caudal fin. The caudal fin is rounded. The upper part of the body is mottled pale yellow-brown and black and belly has black spots.

S. glanis: Dorsal fin rays 3-4, Anal fin rays 83-87, branchiostegals 15-16, vertebrae 19 + 54 = 73, and gill rakers 12 on the first arch. The mouth is large and the lower jaw is considerably longer than the upper jaw; head 4.80±0.17 in standard length; head with 4 mandibular barbels. The maxillary barbels are longer than head; the mandibular barbels shorter. The maxillary barbels pass the end of the head. Anal fin is nearly fused to caudal fin. The caudal fin is rounded. Body well mottled even on the ventral surface.

Table 1. Morphometric data on the specimens of *S. triostegus* (n = 27) in the Euphrates and Tigris Basins and *S. glanis* (n = 24) in the Turkish freshwaters. Min: minimum; Max: maximum; S.D.: standard deviation. Significant contrasts are indicated by asterisks (P<0.05).

Morphometric characteristics	*S.triostegus*	*S. glanis*
	Mean±S.D (Min.-Max.)	
Total length (TL)	324.0±47.8 (250.0-405.0)	374.44±219.30 (127.0-1040.0)
Standard length (SL)	297.0±44.2 (228.0-370.0)	344.11±214.81 (121.0-1030.0)
Head length (HL)	70.0±9.56 (56.0-93.0)	71.25±43.01 (27.0-205.0)
Eye diameter (EW)	6.5±0.7 (5.2-8.0)	5.76±2.19 (3.0-12.0)
Body depth (BD)	65.0±12.3 (41.0-87.0)	60.91±42.03 (20.0-203.0)
Interorbital length (IO)	30.0±4.5 (23.0-40.0)	37.03±21.02 (14.0-100.0)
Predorsal (PrD)	91.0±9.9 (68.0-106.0)	95.56±55.72 (39.3-260.0)
Caudal peduncle depth (CpD)	14.1±1.3 (12.0-16.0)	16.55±10.77 (6.0-50.0)
First Mandibular barbel length (fMBL)	35.0±5.4 (27.0-46.0)	29.25±12.79 (14.0-65.0)
Second Mandibular barbel length (sMBL) [n=3]	16.0±3.0 (12.0-18.0)	38.91±14.73 (19.0-78.0)
Maxillary barbel length (MaxBL)	75.0±9.4 (62.0-98.0)	123.05±47.78 (38.0-225.0)
TL/SL	1.1±0.0 (1.1-1.1)	1.10±0.04 (1.0-1.1)
SL/HL*	4.2±0.2 (4.0-4.6)	4.80±0.17 (4.5-5.1)
SL/BD*	4.4±0.5 (3.9-5.6)	5.76±0.47 (5.1-6.7)
HL/EW	10.8±1.1 (9.7-13.3)	11.73±2.38 (9.0-17.1)
HL/MaxBL*	0.9±0.1 (0.8-1.0)	0.56±0.13 (0.4-0.9)
HL/fMBL*	1.9±0.2 (1.7-2.3)	2.36±0.55 (1.9-3.8)
HL/sMBL*	4.3±0.4 (4.1-4.8)	1.76±0.43 (1.4-3.2)
MaxBL/fMBL*	2.2±0.2 (1.9-2.5)	4.25±0.74 (2.7-5.7)
HL/IO*	2.0±0.1 (2.1-2.4)	1.91±0.09 (1.8-2.1)
SL/CpD	20.6±1.3 (20.9-24.6)	21.06±1.75 (17.3-25.0)

Maxil barbels are longer in *S. glanis* than *S. triostegus*. When two pairs of mandibular barbels

Table 2. Meristic data on the specimens of *S. triostegus* (n = 27) in the Euphrates and Tigris Basins and *S. glanis* (n = 24) in the Turkish freshwaters.

Meristic characteristics	*S.triostegus*	*S. glanis*
Pectoral fin	I - 12-14	I - 15-17
Pelvic fin	I - 9-10	I -11-12
Anal fin	81-86	I - 83-93
Caudal fin	16-17	17
Branchiostegals	14-15	15
Gill rakers	12-16	12-13
Vertebrae [n=3]	(16)17+(52)53 =(69)70	(18)19+(54)55(56) =(72)73(74)

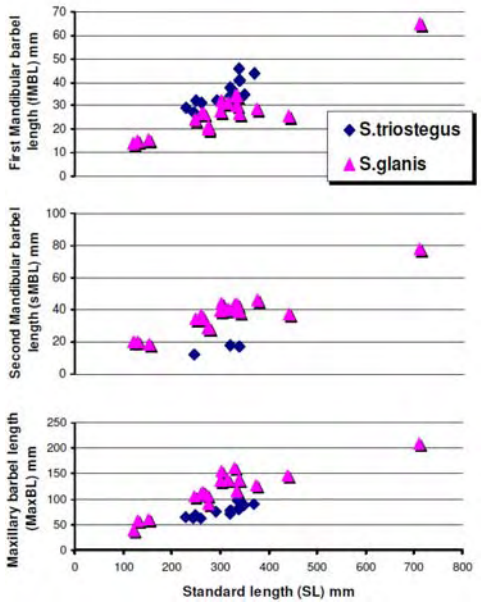

Figure 1. Body length–barbel length distributions of *S. triostegus* and *S. glanis* in Turkey.

are present anterior ones are always shorter than posterior ones in *S. triostegus* while anterior mandibular barbels in *S. glanis* are longer than posterior ones. Barbel length versus body length graphics were given in Figure 1. Total vertebrae number, pectoral fin and pelvic fin rays of *S. glanis* are more than those counted in *S. triostegus.* The eye diameter of *S. glanis* is smaller than that observed in *S. triostegus*.

Results indicated that SL/HL, SL/BD, HL/MaxBL, HL/fMBL, HL/sMBL, HL/IO and MaxBL/fMBL ratios were statistically significant (Student's *t-test*, $p < 0.05$) between species *S. triostegus* and *S. glanis*.

Anatomy

Skull (Figs 2 and 3: In general appearance, the neurocranium has the shape of a triangular, rostrally flattened wedge. Antero-median part of mesethmoid indented posteriorly; situated at the rostral end of the neurocranium. It has two lateral and two caudal processes in both species. Lateral process of mesethmoid is longer in *S. glanis* than in *S. triostegus*. Laterally, mesethmoid joins with lateral ethmoid. The mesethmoid is broad and not narrowed bilaterally at base of its lateral process. Vomerine teeth in two patches, forming a gentle curve separated by a small break in *S. Triostegus;* one patch in *S. glanis*. Anterior and posterior frontal are well developed. The paired exethmoid bone lies at the rostral end of the neurocranium. It resembles the letter P in shape. Frontale are paired bones, approximately oblong in shape, forming the vault of the neurocranium. Frontale are fused in a suture of varying course. The length of anterior fontanel in *S. glanis* is longer than in *S. triostegus*. Prootic is situated in lateral part of neurocranium and above the suture joining basioccipital with parasphenoid.

Urohyal (Fig. 4): It is quadrangular in shape. Its dorsal margin is approximately pyramidal shape in *S. glanis*. The pyrimidal shape of dorsal margin of urohyal is changed and narrowed in *S. triostegus*. (Fig. 4).

Pectoral spine (Fig. 5): Outer surface of pectoral spine smooth and inner surface serrated in both species. Serrated surface better developed in *S. glanis* than *S. triostegus* (Fig. 5).

Ventral fin girdle (Fig. 6): The ventral fin consists of two basipterygia, circular in shape, and a long doubled cranial process in *S. glanis* and *S. triostegus*. A third cranial process is found in *S. triostegus*.

Discussion

Earlier classifications were based mainly on external features. Recently, osteological characters were

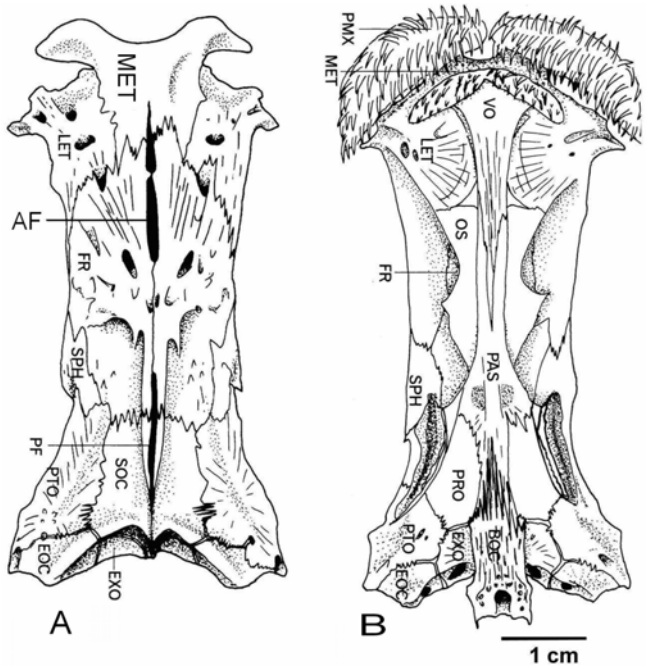

Figure 2. Skull of *S. triostegus*. A, ventral; B, dorsal view. AF, Anterior fontanel; BOC, basioccipital; EOC, epioccipital; EXO, exoccipital; FR, frontal; LET, lateral ethmoid; MET, mesethmoid; OS, orbitosphenoid; PAS, parasphenoid; PF, posterior fontanel; PMX, premaxilla; PRO, prootic; PTO, pteroic; SOC, subraoccipital; SPH, sphenotic; VO, vomer.

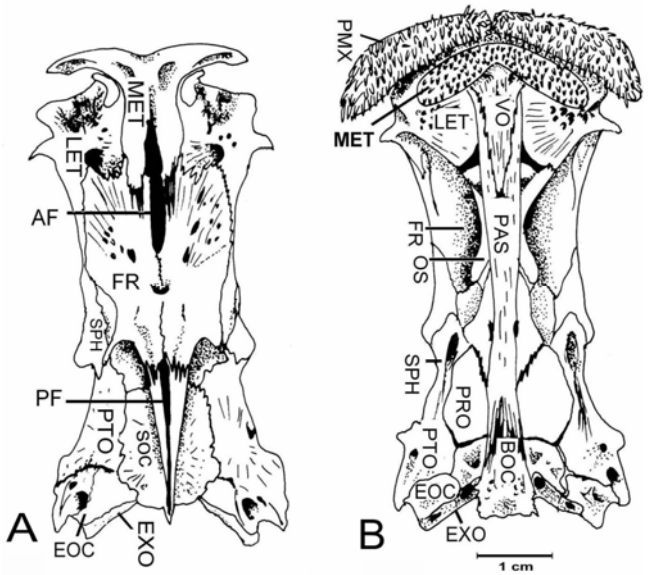

Figure 3. Skull of *S. glanis*. A, ventral; B, dorsal view. Abbreviations as in Figure 2.

also used in the taxonomical studies (Szlachciak & Strakowska 2010).

General diagnostic characters of *S. glanis* and *S. triostegus* examined in this study are in agree-

ment with those given for European (Kottelat & Freyhof 2007), Iran (Coad & Holcik) and Iraq (Coad 2010) waters.

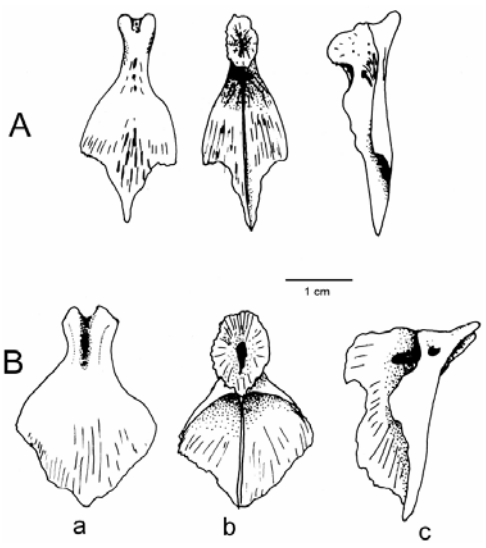

Figure 4. Urohyale of *S. triostegus* (A) and *S. glanis* (B). a- dorsal; b- ventral; c- lateral view.

There is the possibility of confusing both species, due to their external morphological similarities. *Silurus triostegus* differs from *S. glanis* in its robust and longer teeth, distinctly and coarsely serrate pectoral fin spine posteriorly, and in the light colour (Coad & Holcik, 2000). As in many Silurid species, *S.glanis* has two mandibular barbels but Heckel (1843), described one pair of mandibular barbels in *S. triostegus*. Due to this feature, many authors have recognised *S. triostegus* in the genus *Parasilurus* (Ladiges 1964, Blanc et al. 1971, Kuru 1979). Kobayakawa (1989), however, claimed that the number of mandibular barbells was not a valid criterion for differentiating these two genera, since intraspecific variation of barbel number was found within this species. Individuals with a single pair and two pairs of barbels were also found in *S. triostegus* specimens from Turkey and Iraq (Ünlü & Bozkurt 1996, Coad 2010). This situation indicates that some barbels are reabsorbed during ontogenetic development (Haig 1952). It has been determined in this study that the barbel length is the most important difference between *S. glanis* and *S. triostegus*. In addition to this, some morphometric ratios such as SL/HL, SL/BD, and HL/IO were found statistically significant between both species. Total vertebrae number is found to be 70 for *S. triostegus* and 73 for *S. glanis*. This result is in agreement with the data of Kobayakawa (1989) and Coad (2010).

The basic skull topography of *S. triostegus* is very similar to that of *S. glanis*. This similarity has been also recorded in other Silurid species (Haig 1952, Kobayakawa 1989). Comparing the topography and description of the bones of *S. glanis* in the study by Cerny (1988) with this study's findings, no substantial differences have been found. However, there were no detailed anatomical studies on *S. triostegus* to compare the results. Intraspecific variations have been seen particularly in the mesethmoid.

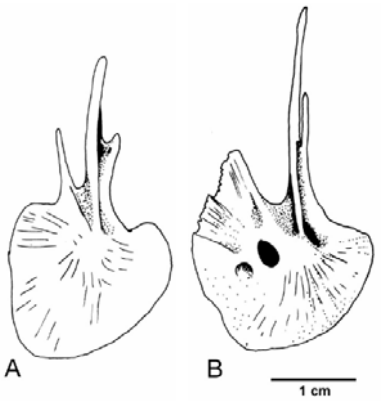

Figure 6. Basipterygia of *S. triostegus* (A) and *S. glanis* (B).

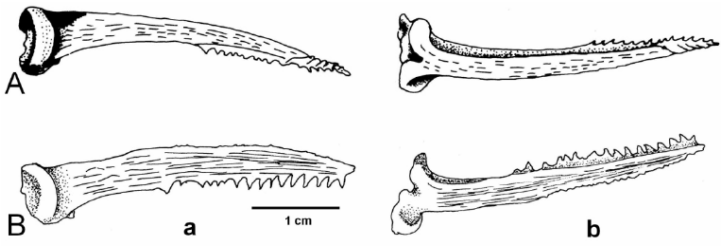

Figure 5. Pectoral spin of *S. triostegus* (A) and *S. glanis* (B). a- dorsal view; b- ventral view.

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