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Osteological description of *Barbus lacerta* Heckel, 1843 (Cyprinidae) from Tigris basin of Iran

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Abstract

The present study was conducted to provide a detailed descriptive osteology of *Barbus lacerta* from Tigris basin of Iran and comparing it with those of *B. cyri* from the Caspian Sea basin. For this purpose, twelve specimens of *B. lacerta* were collected from Hamill River and then, the specimens were cleared and stained with alcian blue and alizarin red for osteological examination. A detailed description of the osteological features of *B. lacerta* was provided. Based on the results, *B. lacerta* can be distinguished from *B. cyri* by having 2 pharyngobranchial (ver. 3 *B. cyri*), 7-8 supraneural (ver. 9 of *B. cyri*), two long neural spines of the second centrum of the caudal skeleton (ver. consumptive one of *B. cyri*), and lacking neural prezygapophyses of the fourth vertebra.

Keywords: *Barbus*, Cyprinidae, Skeleton, Tigris basin.

1. Introduction

The barbels, genus *Barbus sensu lato* are found in Europe, southwest Asia and Africa and comprise 16 formerly reported species in Iran [1]. Characters in the members of the genus *Barbus* comprise a rounded or compressed body of moderate to large size, large to very small scales (ranged 26-103), no scale sheath around the anal fin, the presence of two barbels in most species, lips variably developed from thin to thick and fleshy, the lower lip with a well-developed median lobe, pharyngeal teeth with 3 rows having hooked or spoon-shaped tips but sometimes heavy or molariform, gut short, and colour usually brown without distinctive markings in the form of stripes, bands or spots [1].

Three species of the genus *Barbus*, including *B. cyri* De Filippi 1865, *B. lacerta* Heckel, 1843, and *B. miliaris* De Filippi, 1863 are reported from Iran [2]. *Barbus lacerta* is found in the Tigris, and possibly Esfahan basins of Iran [1,2]. Geographically isolated populations of *Barbus* present remarkable variation with regard to morphometric and meristic characters within Iranian inland waters [3]. Since, osteological characters can provide valuable information in taxonomy and phylogenetic relationships of fishes [4, 5, 6, 7, 8, 9], therefore, the present study was conducted to provide a detailed descriptive osteology of *B. lacerta* from Iranian part of Tigris basin, the Hamill River and comparing the results with those of *B. cyri* from the Caspian Sea basin that recently has been described by Jalili *et al.* [10].

2. Materials and Methods

Twelve specimens of *B. lacerta* were sampled from the Hamill River (Tigris basin; Ilam Province, Iran) (8.94 ± 1.69 mm; $SL \pm SD$). Then they fixed in 10% buffered formalin, after anesthetizing using 1% clove oil (Figure 1). The specimens were cleared and stained with alizarin red S and alcian blue based on Taylor and van Dyke [11] for osteological examination. The cleared and stained specimens were studied using a stereomicroscope (Leica MC5); and their skeletal elements were dissected and scanned by a scanner equipped with a glycerol bath (Epson V600). Drawing of the specimens were performed using CorelDraw X6 software. The terminology of skeletal elements follows Jalili *et al.* [10], Rojo [12] and Howes [13]. The detailed osteological features of *B. cyri* from Caspian Sea basin were provided by Jalili *et al.* [10].

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Fig 1: Lateral view of *Barbus lacerta* from Hamil River.

3. Results and Discussion

The ethmoid region includes the preethmoid-I, lateral ethmoid, supraethmoid, vomer, kinethmoid and nasal bones (Figure 2a, b). The dorsal surface of the supraethmoid bears a shallow groove and its posterior edge is serrated. The ventral surface of the lateral ethmoid bears many small pores (Figure 2c).

The orbital region includes the frontal, orbitosphenoid, pterosphenoid, parasphenoid and circumorbital series. The anterior edge of the frontal is serrated; it bears a mid-lateral pointed process similar to that of *B. cyri* [10]. The pterosphenoid is a curved bone (Figure 2b). The parasphenoid is extended from the vomer to the basioccipital with a serrated anterior rim. There are 4-5 infraorbital, whereas in some specimens of *B. cyri*, 6 infraorbital elements had been reported [10].

The otic region comprises of the parietal, sphenotic, pterotic, prootic, and epiotic (Figure 2). The parietal is approximately square-shaped, and its lateral edge is connected to the sphenotic and overlaps with the pterotic and epiotic. The pterotic is quarter-circle in shape and connected to the epiotic and sphenotic dorso-laterally and to the prootic and exoccipital ventrally (Figure 2a, c).

The occipital region is composed of the supraoccipital, exoccipitals and basioccipital. The supraoccipital has a blade-shaped crest and its posterior part is connected to the paired exoccipitals (Figure 2c). In the lateral face of the neurocranium, there are two facets, the anterior one is formed by the pterosphenoid, sphenotic and prootic; and the latter one by the sphenotic and pterotic. Other bones of the neurocranium were similar to those of *B. cyri* [10].

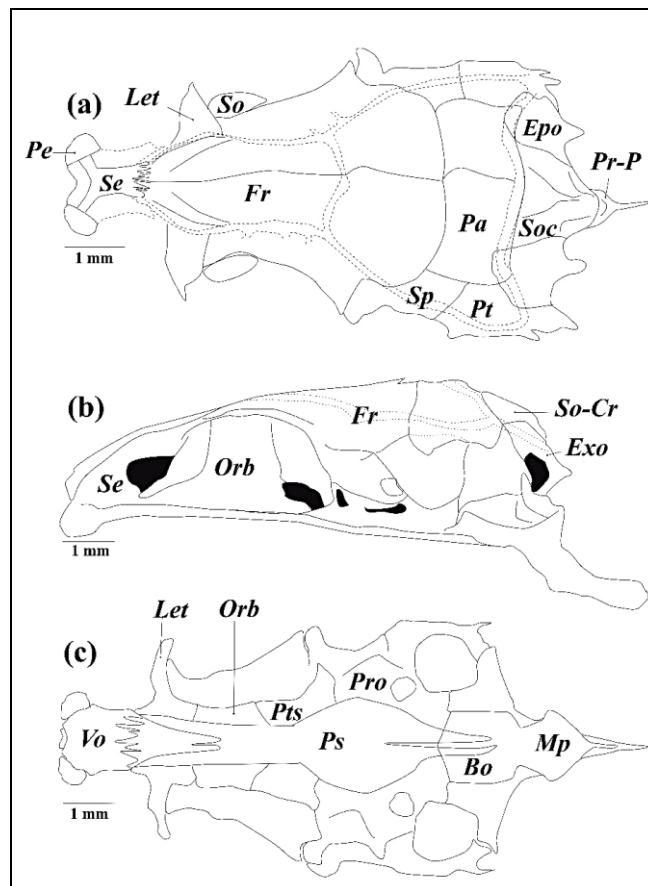


Fig 2: Dorsal (a), lateral (b) and ventral (c) views of the neurocranium in *Barbus lacerta*. Abbreviations: Bo: basioccipital; Epo: epiotic; Exo: exoccipital; Fr: frontal; Let: lateral ethmoid; Mp: masticatory plate; Orb: orbitosphenoid; Pa: parietal; Pe: preethmoid I; Pr-P: posterior pharyngeal process; Pro: prootic; Ps: parasphenoid; Pts: pterosphenoid; Pt: pterotic; So-Cr: supraoccipital crest; So: supraorbital; Soc: supraoccipital; Sp: sphenotic; Se: supraethmoid; Vo: vomer.

The upper jaw consists of the paired premaxilla and maxilla (Figure 3b). The premaxilla is a wide L-shaped bone and possesses the narrow vertical and curved horizontal processes. This bone possesses an anterior descending protuberance. The

lower jaw is composed of the dental, angular, retroarticular and crono-meckelian (Figure 3c). The characteristics of other bones of the upper jaw and the whole lower jaw are similar to those of *B. cyri* [10].

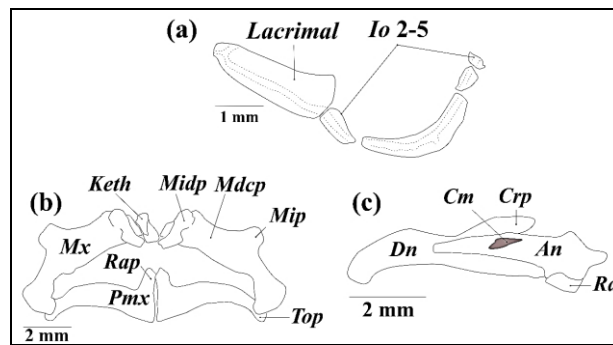


Fig 3: Circumorbital series (a), internal view of the upper (b) and lower jaw (c) of *Barbus lacerta*. Abbreviations: An: Angular; Crb: coronoid process; Cm: coronomeckelian; Dn: dental; Io 2-5: infraorbitals 2-5; Keth: kinethmoid; Ra: retroarticular; Mx: maxilla; Pmx: premaxilla; Midp: maxillary descending process; Mdcb: maxillary dorsal concaved border; Mip: maxillary mid-lateral ascending process; Rap: rostral ascending process; Top: tail of premaxilla.

The suspensorium comprises of the palatine, endopterygoid, ectopterygoid, metapterygoid, quadrate, symplectic and hyomandibular (Figure 4). The palatine possesses a V-shaped depression on its middle section. It is connected to the endopterygoid posteriorly and preethmoid-1 anteriorly. The endopterygoid is connected to the metapterygoid and ectopterygoid ventrally and to the palatine via an anterior condyle. The posterior part of the endopterygoid is wider; also, it has an antero-ventral small protuberance. The metapterygoid bears an antero-dorsal well-developed process. Other parts of

the suspensorium, except the endopterygoid and metapterygoid, are similar to those *B. cyri* [10]. The opercular elements includes the opercle, preopercle, subopercle, and interopercle (Figure 4). The opercle is the largest element of this series and has a rod-shaped process antero-dorsally for insertion to the operculi levator muscle. The postero-lateral part of this bone is concaved unlike in *B. cyri* [10]. The interopercle is pointed anteriorly and widened posteriorly.

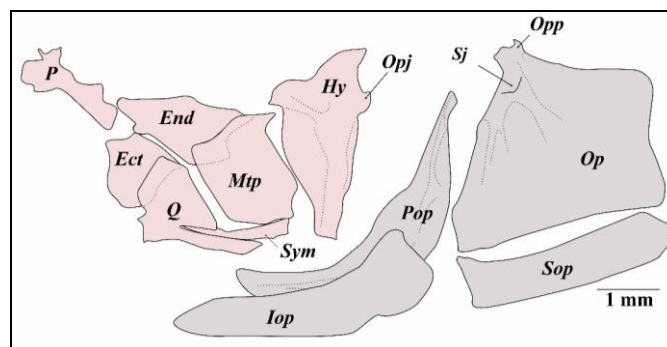


Fig 4: Suspensorium and opercular series (Left side) in *Barbus lacerta*. Abbreviations: Ect: ectopterygoid; End: endopterygoid; Hy: hyomandibulare; Iop: interopercle; Mtp: metapterygoid; Op: opercle; Opp: opercular prominent process; Opj: opercular joint; P: palatine; Pop: preopercle; Q: quadrate; Sj: spine and socket joint; Sop: subopercle; Sym: symplectic.

The branchial arch consists of the basibranchial, hypobranchial, ceratobranchial, epibranchial, and infrapharyngobranchial (Figure 5a). The number of the unpaired basibranchials are three that the anterior one is the shortest. There are three hypobranchials which the posterior one has a pointed process. The ceratobranchials are the largest elements of the branchial arch and the fifth one i.e. the pharyngeal teeth has a formula of 2.3.5-5.3.2 similar to that of

B. cyri [10]. Four epibranchial are present, that the epibranchial-1 and 2 are wide and epibranchial-3, 4 are thin with an anterior bifurcated posterior end.

The hyoid arch includes the urohyal, basihyal, hypohyal, ceratohyal, epihyal, interhyal; and three pairs of the branchiostegal (Figure 5b). There are no differences in the hyoid arch elements between *B. lacerta* and *B. cyri* [10].

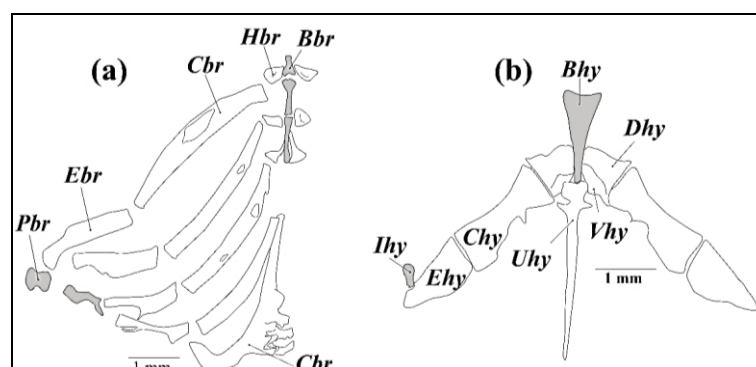


Fig 5: Branchial apparatus (a) and Hyoid arch (b) of *Barbus lacerta*. Abbreviation: Bbr: basibranchial; Cbr: ceratobranchial; Ebr: epibranchial; Hbr: hypobranchial; Pbr: infrapharyngobranchial; Bhy: basihyal; Br: branchiostegale; Chy: ceratohyale; Dhy and Vhy: dorsal and ventral hypohyal; Epi: epihyal; Ihy: interhyal; Uhy: urohyal

The pectoral girdle includes the cleithrum, coracoid, mesocoracoid, scapula, supracleithrum, posttemporal, supratemporal and radials (Figure 6a). The posterior protuberance of the vertical part of the cleithrum is less developed, unlike that of *B. cyri* [10]. The supratemporal is small and located at the anterior margin of the posttemporal. The posttemporal is a thin and long element connected to the epiotic. The ventral part of the mesocoracoid are broadened

whereas that of *B. cyri* is V-shaped [10]. Similar to *B. cyri* [10], the pectoral fin of the studied species bears four radials that, the lateral one is the thickest and three others are long and flat (Figure 6a). The pelvic girdle includes the paired pelvic bone, pelvic splint and radials (Figure 6b). Compared to *B. cyri* [10], the mid-lateral process of the pelvic bone is more developed in *B. lacerta*.

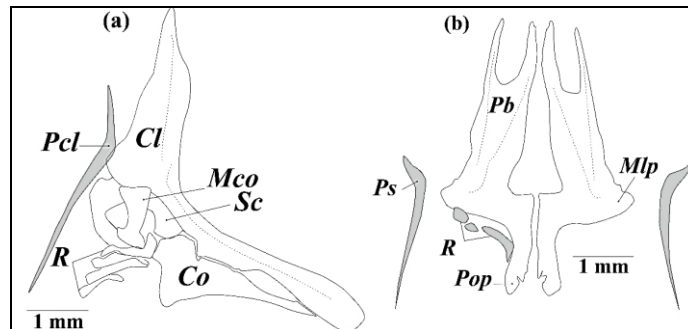


Fig 6: Medial view of the pectoral girdle (left side) (a) and pelvic girdle (b) of *Barbus lacerta*. Abbreviations: Cl: cleithrum; Co: coracoid; Mco: mesocoracoid; Mlp: mid-lateral process; Pb: pelvic bone; Pcl: postcleithrum; Pop: posterior process; Ps: pelvic splint; R: radials; Sc: scapula.

The Weberian apparatus comprises of the claustrum, scaphium, intercalarium, and Tripus with the four anterior centra (Figure 7a). The neural arch of 4th centrum in Weberian apparatus is bended posteriorly. There are 40-42 vertebra. There are 9 pterygiophores in the dorsal fin; the first one is in the front of the 14th centrum (Figure 7b). The two first pterygiophores are the largest and support unbranched rays. The dorsal fin bears 4 unbranched and 8 branched rays. Similar to *B. cyri* [10], the dorsal margin of 4th unbranched ray

is dentated. The anal fin is consisted of 6 pterygiophores and 2 stay bones (Figure 7c). The first pterygiophore is positioned in the front of the 29 centrum. There are 3 unbranched and 5 branched rays in the anal fin. The caudal skeleton comprises of six hypurals. The epural is a long bone positioning at the dorsal part of the neural arch of the first vertebra. The neural arch of the second centrum is long and bifurcate (Figure 7d). There are no other differences in the dorsal anal and caudal fins' skeleton, between *B. lacerta* and *B. cyri* [10].

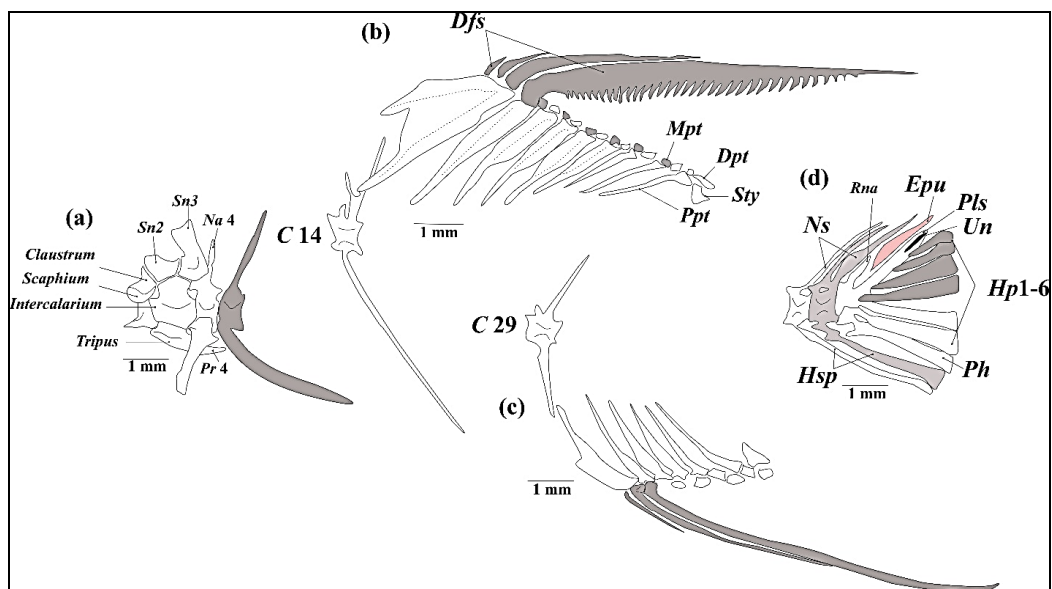


Fig 7: Lateral view of the Weberian apparatus (a), dorsal (b) and anal (c) fins and caudal skeleton (d) in *Barbus lacerta*. Abbreviations: C14-29: centrum 14-29; Dfs: dorsal fin spine; Dpt: distal pterygiophore; Epu: epural; Hp 1-6: hypural plates 1-6; Hsp: hemal spine; Mpt: medial pterygiophore; Na: neural arch; Ns: neural spine; Pr: pleural rib; Ppt: proximal pterygiophore; Ph: parhypurale; Pls: pleurostyle; Rna: rudimentary neural arch; Sn: supraneural; Sty: stay.

Based on the results, *B. lacerta* bears two pharyngobranchials, whereas that of *B. cyri* was three [10]. The number of the supraneural in *B. lacerta* was 7-8 versus 9 of *B. cyri*. *Barbus cyri* bears 42 vertebrae and its fourth vertebra has neural prezygapophyses and neural postzygapophyses [10], whereas in *B. lacerta*, the number of the vertebra is similar to that of *B. cyri*, but the neural prezygapophyses of the fourth vertebra were absent. In *B. lacerta*, the second centrum of the caudal

skeleton bears two long neural spines, whereas in *B. cyri*, the second centrum of the caudal skeleton is consumptive [10].

4. Acknowledgments

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