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Original Article

Osteological characteristics of Turkmenian stone loach, *Paraschistura cristata* (Cypriniformes: Nemacheilidae)

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Abstract: Formerly the Turkmenian stone loach was the only member of the genus *Metaschistura* based on osteological characters. But recently, it is placed in the genus *Paraschistura* based on mtDNA COI data. To provide a detailed description of the osteological characteristics of *Paraschistura cristata* (Berg 1898), ten specimens of *P. cristata* were collected from the Hari River basin in Iran and their osteological characteristics were examined. According to the results, *P. cristata* is osteologically characterized by a foramen in the ventral part of the exoccipital, two extra urohyals, sesamoid ossifications, trapezoid-shaped prevomer, three basibranchials, five hypural, lack of bony bridge between the parietal and pterotic, having over 20 procurrent rays supporting the adipose crest. The detailed skeletal description of *P. cristata* showed that this species can be easily distinguished from the related genera. Despite the mtDNA COI result, the osteological data of this species showed some features to describe it as a distinctive genus, but this needs the osteological data of the all other *Paraschistura* species to be compared.

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Introduction

Stone loaches, family Nemacheilidae, are mostly small fishes occurring in freshwaters of Asia and its islands (including the Greater Sunda Islands), Europe, and northeast Africa (Coad, 2015). The members of this family has a great diversity in Iranian inland waters after the Cyprinidae (Nelson, 2006; Azimi et al., 2014). Because of little systematic and phylogenetic studies, classification of this taxa is complex and many experts are trying to determine their phylogenic status (Prokofiev, 2010). Recent classifications of this taxa have been mostly based on external morphological features and to a small extent on osteological and molecular data (Bănărescu and Nalbant, 1995; Prokofiev, 2009, 201; Freyhof et al., 2015; Azimi et al., 2015). Hence, classification and phylogenetic status of this group is still a subject to debate and osteological features can play an important role in this regard. The first osteological studies on the family Nemacheilidae were performed by Reagan (1911), who separated subfamily Nemacheilinae from the family Cobitidae. Recent taxonomic studies on the loaches of Iran are available based on osteological features (Jalili and Eagderi, 2015; Jalili et al., 2014; Jalili et al., 2015a; Jalili et al., 2015b; Mafakheri et al., 2014; Mafakheri et al., 2015). The only comprehensive phylogenic study on the members of family Nemacheilidae was done by Prokofiev (2010), who described the genus *Metaschistura* and considered the Turkmenian crested loach as the only member of this genus.

Among the members of nemacheilids, *Paraschistura* Prokofiev, 2009 is a newly described genus, and therefore, not all of its species have been fully examined and ascribed to it or related genera (Coad, 2015). Recently Vatandoust and Eagderi (2015)

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Figure 1. Lateral view of Turkmenian stone loach *Paraschistura cristata*.

described *P. ilamensis* from the Tigris River drainage as the first species of the genus of *Paraschistura* from Iranian part of this basin. Thereafter, Freyhof et al. (2015) reviewed the genus *Paraschistura* from Iran and described six new species, including *P. abdolii* (from the Sirjan basin and the western tributaries of the Hamun-e Jaz Murian basin), *P. aredvii* (from the Zohreh drainage), *P. hormuzensis* (from the Minab drainage), *P. naumanni* (from the Kol drainage, the Mond drainage and the Lake Maharlo basin), *P. pasatigris* (from the Karun and Karkheh drainages) and *P. susiani* (from the Jarahi drainage) based on the morphological and molecular (the mtDNA COI barcode region) data set. Based on the described characteristics for *P. pasatigris*, it is suggested that *P. pasatigris* is a synonym of *P. ilamensis*. Freyhof et al. (2015) provided the diagnostic characters for all eleven recognized species and treated *Metaschistura* Prokofiev, 2009 as a synonym of *Paraschistura* Prokofiev, 2009.

Paraschistura cristata, known as Turkmenian stone loach, is distinguished from the other crested loaches in the north east of Iran by a unique color pattern and a short and thick crest. This species is found in rivers of North Slope of the Kopet Dag mountain ranges in Turkmenistan and its appearance in Iranian waters is due to the connection of these rivers with Iran's borders (Coad, 2015). As the basal classification of the family Nemacheilidae has been done based on osteological characteristics, the present study was conducted to provide a detailed osteological characteristic of *P. cristata*.

Materials and Methods

Ten specimens of *P. cristata* (55.1-74.6 mm in standard length) were collected by electrofishing device from the Kalat Stream, in the Hari River basin, located in Khorasan-e-Razavi Province, northeast of Iran. After catching, samples were anesthetized with clove solution and fixed in 10% buffered formalin. For osteological examination, the specimens were cleared and stained using alcian blue and alizarn red based on Taylor and Van Dyke (1985). The skeletal structures were dissected and photographed using scanner (Epson v600) equipped with a glycerol bath. The skeletal structures of the cleared and stained specimens were observed and studied by MS5 Leica stereomicroscope. The skeletal elements were drawn based on digital pictures using CorelDrawX6 software. The terminology and abbreviation of the skeletal elements follows Prokofiev (2009, 2010).

Results

Neurocranum: The neurocranium is almost wide and flat posteriorly, forming the maximum width of the skull at the level of the pterotic. The posterior part of the neurocranum is oval-shaped and flattened, while its anterior part is narrow. The ethmoid region consists of the paired lateral ethmoid and unpaired prevomer and supraethmoid-ethmoid bones (Fig. 2a). The supraethmoid-ethmoid is narrower in the middle. This bone is vertically fused to the prevomer

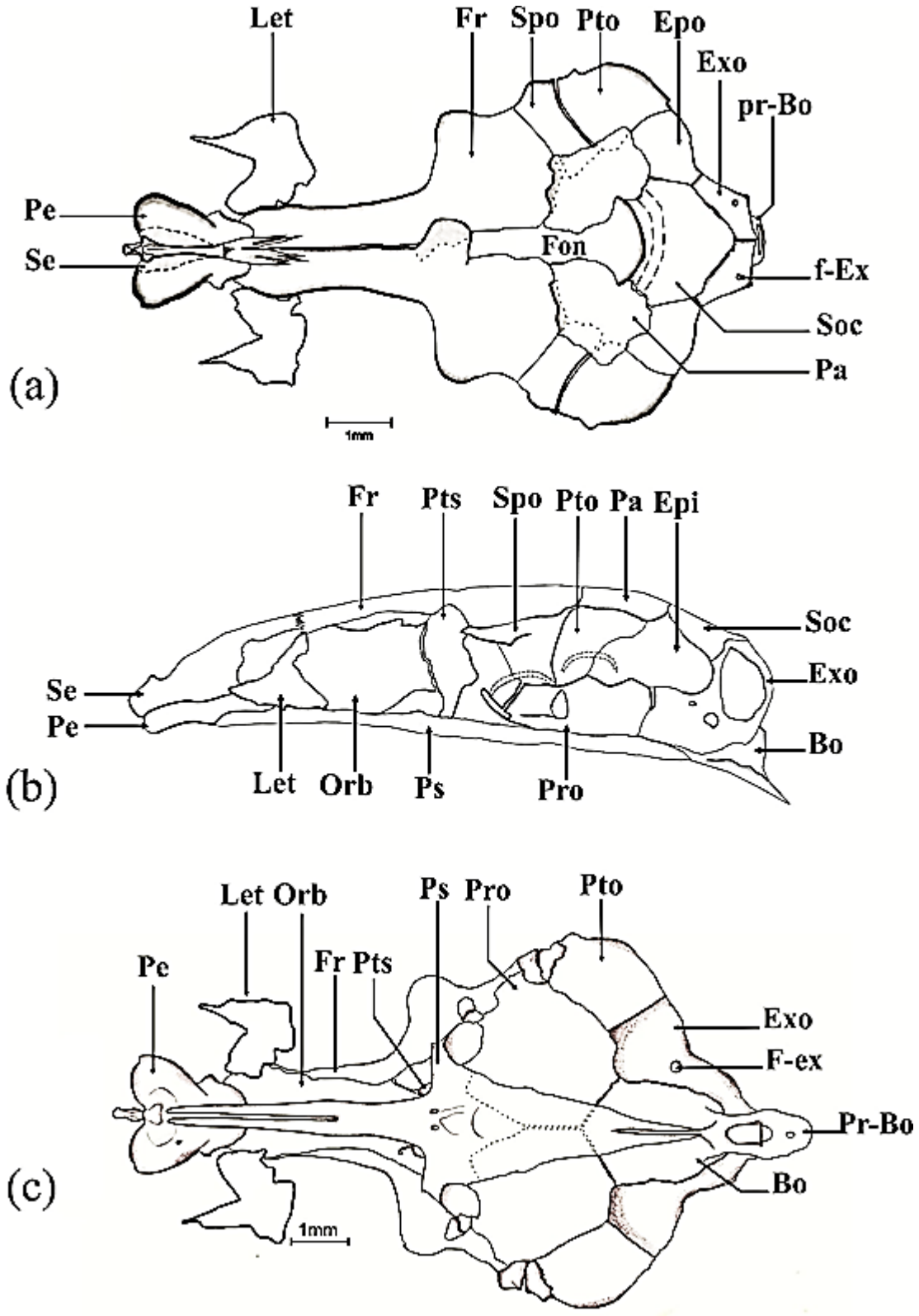

Figure 2. The Neurocranium of *Paraschistura cristata* (from the dorsal (a), lateral (b), and ventral (c) sides): pr-Bo: basioccipital process; Bo: basioccipital; Epo: epiotic; Exo: exoccipital ; fon: fontanelle; Fr: frontal; fr-Exo: foramen exoccipital; Let: lateral ethmoid; Orb: orbitosphenoid; Pa: parietal; Pe: prevomer; Pro: prootic; Ps: parasphenoid; Pto: pterotic; Pts: pterosphenoid; Se: supraethmoid-ethmoid; Soc: supraoccipital; Spo: sphenotic.

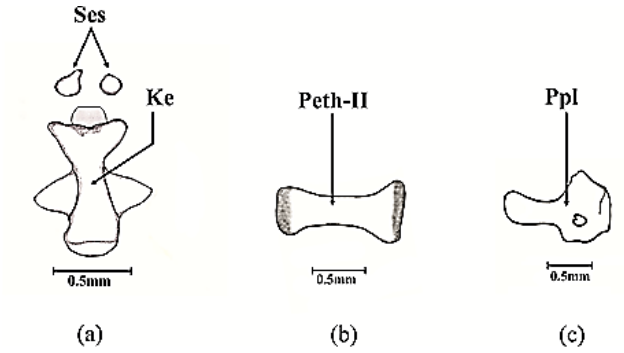

Figure 3. Bones of the ethmoid region in *Paraschistura cristata*. Ke: kinethmoid; Ses: sesamoid (a); Peth-II: preethmoid-II (b); Ppl: prepalatine (c).

and firmly connected to the frontal by a zigzag-shaped suture posteriorly. In the middle of the narrow part of the neurocranium, the paired L-shaped lateral ethmoids are situated. The anterior part of this bone is not completely ossified and joined laterally to the orbitosphenoid. The prevomer is almost trapezoid in shape having two processes with rounded edges antero-laterally. Furthermore, this bone is connected to the orbitosphenoid and parasphenoid posteriorly (Fig. 2b).

There is a small bone series anterior to the ethmoid region, including paired bones of the preethmoid-II, sesamoid and prepalatine, and unpaired kinethmoid (Fig. 3a-c). The preethmoid-II is small and rod-like, connecting to the prepalatine laterally (Fig. 3b). It is also connected to the prevomer and maxilla anteriorly. The kinethmoid is a small and free bone, positioning between the maxillae. Two small sesamoid bones are present in the ethmoid region (Fig. 3a).

The orbital region includes the frontal, orbitosphenoid, pterosphenoid, parasphenoid, and sclerotic bones (Fig. 2a). The frontals are the largest bones of the skull roof. They involve about half of the length of the neurocranium separating by the fontanel posteriorly. The frontals are connected to the orbitosphenoid, pterosphenoid and sphenotic laterally, and parietal posteriorly (Fig. 2a, b). The orbitosphenoid is connected to the parasphenoid ventrally and to the pterosphenoid postero-dorsally. All these bones together create a large olfactory foramen (Fig. 2b). The pterosphenoid is connected to the frontal and sphenoid dorsally and postero-laterally, respectively. Also, the posterior margin of the pterosphenoid is curved, creating a cavity along with the prootic and parasphenoid (Fig. 2c). The parasphenoid is a large bony element at the base of the neurocranium, and it is extended from the prevomer to the basioccipital. The parasphenoid is wider in the middle part forming the alar and bifurcated at its two ends (Fig. 2c).

The otic region comprises of the parietal, sphenotic, pterotic, prootic, and epiotic (Fig. 2). The parietal is connected to the supraoccipital and epiotic posteriorly and to the pterotic and sphenotic laterally. These paired bone is separated by the fontanel (Fig. 2a). The pterotic is quarter-circle in shape and connected to the epiotic and sphenotic posteriorly and to the prootic and exoccipital ventrally. The sphenotic positions at the rear of the orbit, creating a part of the lateral wall of the skull (Fig. 2b). The sphenotic is connected to the pterotic ventrally and to the parietal postero-dorsally. In the anterior part of the basioccipital, the paired prootics are the largest bones of the ventral face of the skull (Fig. 2c). These paired bones are connected to each other latero-posteriorly. There is a depression in the antero-lateral part of these paired bones. The anterior and postero-lateral parts of this depression are connected to the parasphenoid and pterotic, respectively. The epiotic is the most posterior element of the otic region (Fig. 2c).

The occipital region comprises of the exoccipital, supraoccipital, and basioccipital bones. The supraoccipital is a pentagon-shaped bone and connected to the exoccipital dorsally and to the fontanel anteriorly. The fontanel accounts a length equal to approximately one-fourth of the neurocranium. The paired exoccipitals form the foramen exoccipitalis. The basioccipital is positioned between the two exoccipitals and connected to the prootic anteriorly. Also, this bone has a ring-like process posteriorly (process basioccipital) (Fig. 2b). The neurocranium has two articulatory facets for the articulation with the heads of the hyomandibular. The anterior facet is formed

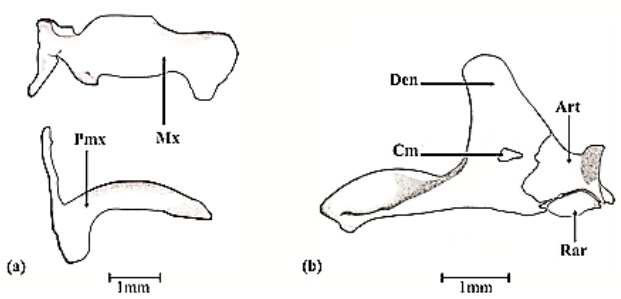

Figure 4. Upper jaw (a) and lower jaw (b) bones in *Paraschistura cristata*. Art: articular; Cm: coronomeckelian; Den: dental; Mx: Maxilla; Pmx: Premaxilla; Rar: retroarticular.

by the ptersphenoid, sphenotic, and prootic, and the posterior one by the pterotic and sphenotic (Fig. 2b).

Jaws: The upper jaw includes the maxilla and premaxilla (Fig. 4a). The premaxilla is a L-shaped bone with two processes, i.e. ascendes and alveoral premaxilla processes. The horizontal part of the premaxilla is arc-shaped while, the vertical part is narrow and longer. The maxilla is a large laminar bone with a broken contour and slightly twisted along its longitudinal axis. This bone is wider in the middle and connected to the prepalatine and preethmoid-II.

The lower jaw is composed of the dental, articular, retroarticular, and cronomeckelian (Fig. 4b). The dental is the largest element of the lower jaw and has two parts, including the anterior ramus dentalis and postero-dorsal coronoid process. This bone is connected to the articular postero-dorsally and to the retroarticular dorsally. The articular is connected to the dental anteriorly, to the retroarticular ventrally, and to the quadrate posteriorly. The coronomeckelian is a small and triangular bone which is situated dorso-medial to the articular.

Suspensorium: The suspensorium is composed of the autopalatine, endopterygoid, ectopterygoid, metapterygoid, hyomandibular, quadrate and symplectic bones (Fig. 5). The suspensorium is inclined forward. The autopalatine possesses a blade-like process in the middle which is connected to the prevomer laterally. Furthermore, this bone is connected to the prepalatine anteriorly, and to the preethmoid-II and endopterygoid posteriorly. The endoptrygoid is wide and elongated and connected to

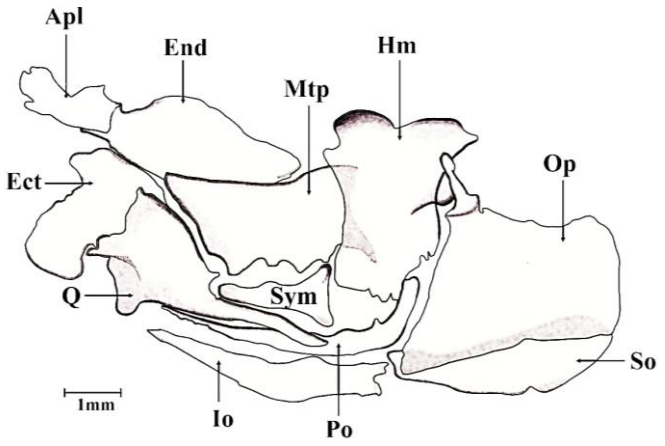

Figure 5. Lateral view of suspensorium in Paraschistura cristata. Apl: autopalatine; Ect: ectopterygoid; End: endopterygoid; Hm: hyomandibular; Io: interopercle; Mtp: metapterygoid; Op: opercle; Po: preopercle; Q: quadrate; So: subopercle; Sym: symplectic.

the metaptrygoid and ectoptrygoid ventrally. The metaptrygoid is roughly rectangular in shape which is situated between the hyomandibular and quadrate. The anterior part of the metaptrygoid is wider. The hyomandibular is a large bone which stretched longitudinally and its dorsal part is wider. The hyomandibular is connected to the interhyal and symplectic ventrally, and to the metaptrygoid anteriorly. In addition, the hyomandibular possesses two condyles on its dorsal rim (anterior and posterior hyomandibular condyles) for articulation to the neurocranium.

The quadrate has a pointed and stretched ventral process which is inclined posteriorly. There is also a smaller process at the anterior margin of the quadrate inclining anteriorly (Fig. 5). This bone is connected to the endoptrygoid dorsally and to the metaptrygoid posteriorly. The symplectic is almost triangular in shape and positioned beneath the endoptrygoid and the posterior to the quadrate. The ectopterygoid bears a process anteriorly and a downward semicircular process ventrally. The metapterygoid, hyomandibular, symplectic and interhyal are connected by a ligamentous sheet covering their medial faces.

Opercular series: The operclar apparatus includes the opercle, preopercle, subopercle and interopercle (Fig. 5). The opercle is the largest bone in this complex which has a rod-shaped process antero-

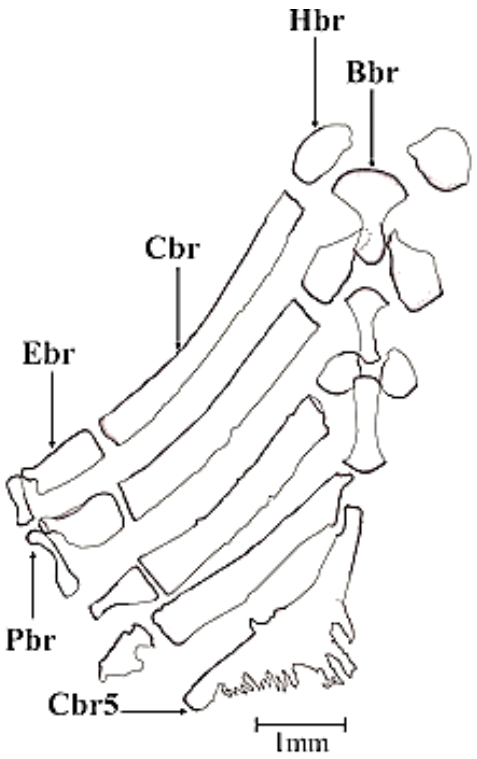

Figure 6. Branchial apparatus of *Paraschistura cristata*. Bbr: basibranchial; Cbr: ceratobranchial; Ebr: epibranchial; Hbr: hypobranchial; Pbr: infrapharyngobranchials.

dorsally for connection to the operculi levator muscle. In addition, the ventral margin of this bone is connected to the subopercle. The subopercle is a stretched bone and connected to the interopercle anteriorly. The interopercle is a narrow and long bone and wider in the middle part.

Branchial arches: The branchial arch consists of the basibranchial, hypobranchial, ceratobranchial, epibranchial, and infrapharyngobranchials (Fig. 6). There are three unpaired basibranchials. Five paired ceratobranchials are the largest elements of the branchial arch and the fifth one is modified as pharyngeal teeth. Three paired hypobranchials are situated between the ceratobranchial and basibranchial bones. Also, there are four paired epibranchials positioning between the ceratobranchials and two pairs of the infrapharyngobranchials.

Hyoid arch: The hyoid arch is composed of the basihyal, hypohyal, ceratohyal, epihyal, interhyal, urohyal, extra urohyal, and branchiostegal rays (Fig. 7). The unpaired basihyal is a T-shaped bone and its anterior part is wider. The paired hypohyal are

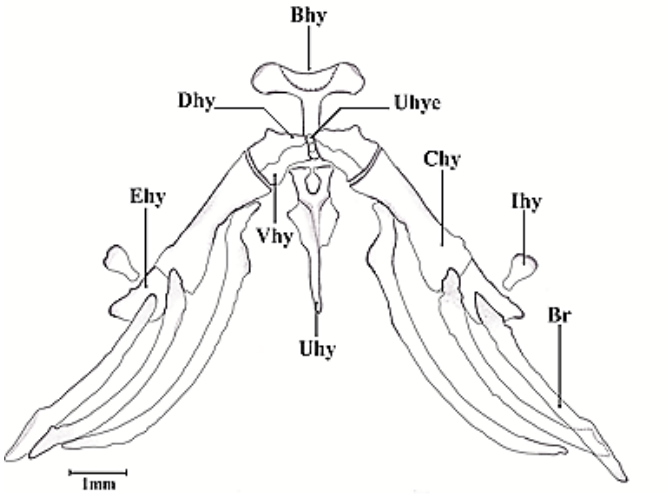

Figure 7. Hyoid arch of *Paraschistura cristata*: Bhy: basihyal; Br: branchiostegale; Chy: ceratohyal; Dhy and Vhy: dorsal and ventral hypohyal; Ehy: epihyal; Ihy: interhyal; Uhy: urohyal; Uhye: urohyal extra.

consisted of the dorsal and ventral parts. The ceratohyal is the largest bone of the hyoid arch. The epihyal is a triangular-shaped bone with a pointed process posteriorly. The interhyal is a small and cylindrical bone and connected to the epihyal ventrally, and to the hyomandibular and symplectic dorsally. The unpaired urohyal is narrow and triangular in shape and bears two ventral and dorsal parts. The dorsal part is blade-like and perpendicular to the ventral part. There are two extra urohyals between the hypohyals and urohyal. The branchiostegal rays are extended to the dorsal margin of the subopercle. The first and second branchiostegal rays are attached to the middle of the ceratohyal and at the junction of the ceratohyal and epihyal, respectively. The third one is connected to the middle of the epihyal.

Pectoral girdle: The pectoral girdle consists of the cleithrum, supracleithrum, coracoid, mesocoracoid, scapula, posttemporal, supratemporal, and radials (Fig. 8). The supracleithrum is a wide bone and its anterior part has a projected process dorsally. This bone is connected to the cleithrum dorso-ventrally. The posttemporal is a thin and long bone which is connected to the epiotic posteriorly. The posttemporal is positioned between the supracleithrum and supratemporal. The supratemporal is small bone locating in the anterior part of the

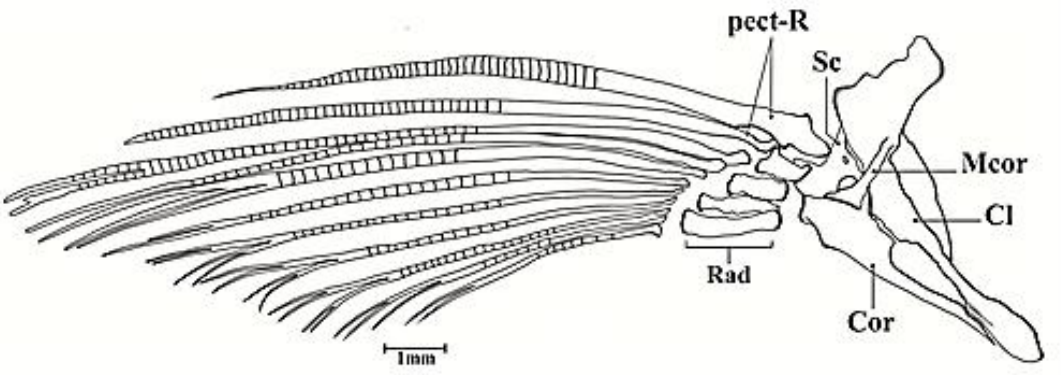

Figure 8. Pectoral girdle of *Paraschistura cristata*. Cl: cleithrum; Cor: coracoid; Mcor: mesocoracoid; pect-R: ray of the pectoral fin; Rad: ossified pectoral radial; Sc: scapula.

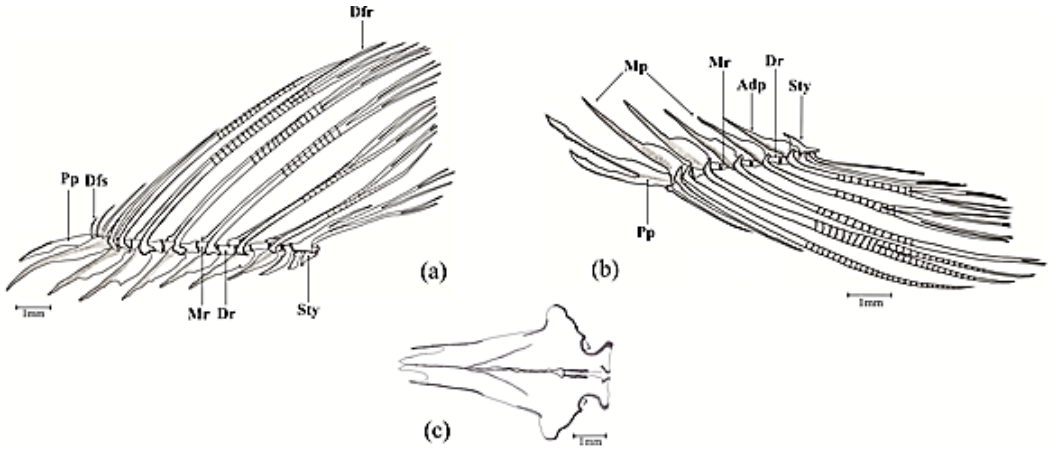

Figure 9. (a) Dorsal fin, (b) anal fin and (c) pelvic girdle of *Paraschistura cristata*. Adp: anal distal pterygiophore; Dfr: dorsal fin rays; Dfs: dorsal fin spin; Dr: distal radial; Mp: mesial pterygiophore; Mr: medial radial; Pp: pterygiophore; Sty: stay.

posttemporal. The cleithrum is the largest element of the pectoral girdle and is connected to the supracleithrum dorsally and to the coracoid through mesocoracoid latero-medially. The anterior part of the coracoid is narrow and inclined downward, whereas its posterior part is wider. The scapula is almost trapezoidal in shape and positioned between the cleithrum and coracoid. This bone has a dent at its posterior part and is connected to the first ray of the pectoral fin (Fig. 8). The pectoral girdle possesses four cylindrical radials.

Pelvic girdle: The pelvic girdle consists of the paired pelvic bones and radials (Fig. 9c). It is not connected to another skeletal element and enclosed by muscles. Three radials of the pelvic girdle are small and round in shape and positioned between the pelvic bones and rays. The anterior part of the pelvic bone is narrower. The pelvic bones have three processes including the anterior pubic process that has some depression laterally, the postero-lateral iliacus process that the rays are connected on it, and the posterior ischiadicus process. In addition, there is a developed bone in this collection viz. styloid positioned outside the rays.

Dorsal fin skeleton: The dorsal fin skeleton consists of 10 pterygiophores and one stay (Fig. 9a). The first pterygiophore is positioned in front of the ninth centrum and there are 4 unbranched and 7½ branched rays (Fig. 9a).

Anal fin: The anal fin is composed of 7 pterygiophores and one stay. In addition, this fin bears 3 unbranched and 5½ radiating rays (Fig. 9b). The first pterygiophore of the anal fin is positioned in the front of the twenty-first centrum.

Caudal skeleton: There are 5 hypurals in the caudal skeleton. The hypural-1 is wide with a pointed process posteriorly (Fig. 10). The hypural-1 is also connected to the parahypural ventrally. The

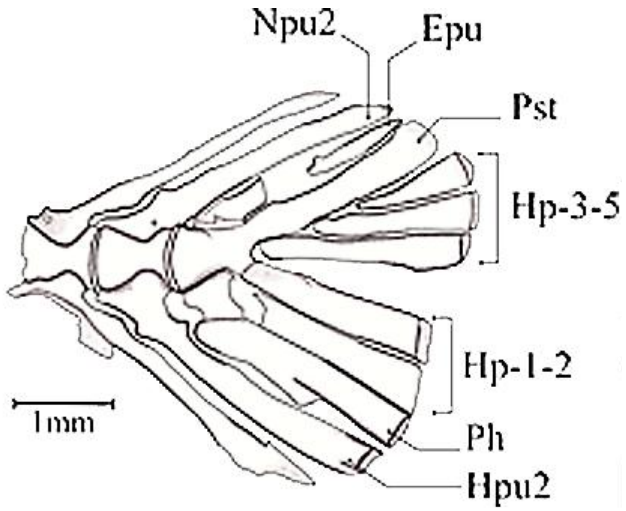

Figure 10. The caudal skeleton of *Paraschistura cristata*. Epu: epural; Hp: hypural; npu2: neural processes of the second preural centrum; hpu2: hemal processes of the second preural centrum; Ph: parhypural; Pst: pleurostyle.

parahypural is flat with a triangular process mid-ventrally and its posterior end is connected to the centrum. The hypurals-3, 4, and 5 are situated between the pleurostile and hyporal-2. The hypural-1 and hypural-2 are fused medially. The epural bone is situated between the pleurostyle and neural process from the second pleural of the centrum (Fig. 10). In addition, the haemal spine of the second pleural is wider compared with the previous one.

Weberian apparatus and swim bladder capsule: The weberian apparatus consists of the claustrum, scaphium, intercalarium, and tripus (Fig. 11a, b). The claustrum is round in shape and situated ventral to the scaphium. In addition, the claustrum is connected to the supraneural-2 dorsally. The intercalarium is small and positioned between the scaphium and Y-shaped tripus. The first centrum has two lateral processes which are ligamentously connected to the pectoral girdle. The second, third, and fourth centra participate in the formation of bony capsule. The second and third centra are fused. The third centrum is situated between the supraneural-2 and fourth centrum. The parapophysis of the forth centrum is modified and has processes that forms the posterior part of the bony capsule. In the lateral of the bony capsule, two openings are observed that posterior one is larger. The surface of the bony capsule is alveolar. The right and left lobes of the

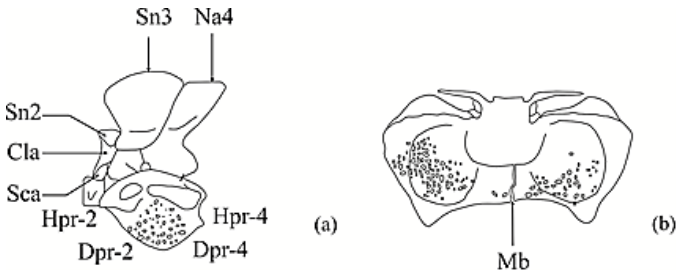

Figure 11. The swim bladder capsule of *Paraschistura cristata*. Cla: claustrum; Dpr-2 -4: descending processes of the second and fourth centra; Hpr-2-4: horizontal processes of the second and fourth centra; Na4: neural arch 4; Sca: scaphium; Sn2: supraneural 2; Sn3: supraneural 3.

bony capsule are symmetrical and divided by the manubrium (Fig. 11b).

Discussion

The present study provided a detailed skeletal description of *Paraschistura cristata*. The lateral ethmoid, supraethmoid-ethmoid and prevomer of this species were fused as other loaches, with the exception of *Lefua* spp., *Oreonectes platycephalus*, *Yunnanilus pleurotaenia*, *Triplophysa microphthalma*, *T. tenuis* (Prokofiev, 2010) and *Schistura fasciolata* (Sawada, 1982). In *P. cristata*, the supraethmoid-ethmoid is tightly connected to the frontals, as other loaches with the exception of *Indoreonectes evezardi* (Sawada, 1982). The junction of the lateral ethmoid to the neurocranium in *P. cristata* is at the level of the anterior margin of the orbitosphenoid similar to *Oxynoemacheilus kiabii* (Mafakheri et al., 2014; Mafakheri et al., 2015) and *O. bergianus* (Jalili and Eagderi, 2015), but according to Prokofiev (2010), the lateral ethmoid of loaches is stationarily joined with the supraethmoid-ethmoid.

Similar to *O. kiabii* (Mafakheri et al., 2014) and *O. bergianus* (Jalili and Eagderi, 2015), there is no preethmoid-I in *P. cristata*, while in species of the genera *Lefua*, *Oreonectes*, *Yunnanilus*, *Eonemachilus*, *Micronoemacheilus*, *Hedinichthys*, *Orthrias* and *Triplophysa*, a paired preethmoids-I joined to the lateral edge of the antero-lateral processes of the prevomer is present (Prokofiev, 2010). In *P. cristata* similar to *O. kiabii* (Mafakheri

et al., 2014) and *P. nielseni* (Azimi et al., 2015), there are sesamoid ossifications. The presence of the sesamoid ossifications in nemacheilids has been rejected by Sawada (1982); however, this bone is found in *Paracobitis malapterura*, *P. longicauda*, *Dzihunia amudarjensis* and *Oxynoemacheilus angorae* (Prokofiev, 2004, 2009). The prevomer of *P. cristata* is trapezoid in shape, while this bone is square-shaped in *O. kiabii* (Mafakheri et al., 2014) and *P. nielseni* (Azimi et al., 2015) and rectangular-shaped in *O. bergianus* (Jalili and Eagderi, 2015). In addition, the supraethmoid-ethmoid of *P. cristata* is thin and longer compared to *O. kiabii* (Mafakheri et al., 2014).

In *P. cristata* similar to *P. sargadensis*, there is no bony bridge between the parietal and pterotic (Prokofiev, 2009). The occipital part of the neurocranium is less than one-third of its length in *P. cristata*, similar to the majority of the genera (Prokofiev, 2010). There is a foramen in the ventral part of the exoccipitals in *P. cristata* and *P. nielseni* (Azimi et al., 2015), whereas such a state is not observed in *O. kiabii* and *O. bergianus* (Mafakheri et al., 2014; Jalili and Eagderi, 2015).

Prokofiev (2010) pointed out that the coronomeckelian is connected to the base and dorsal edge of the coronoid process in loaches but this bone is connected to the medial face of the articular in *P. cristata* and *O. kiabii* (Mafakheri et al., 2014) and to the dorso-medial part of the dental in *P. nielseni* (Azimi et al., 2015).

The anterior facet of the hyomandibular in *P. cristata*, *P. nielseni* (Azimi et al., 2015), *O. kiabii* (Mafakheri et al., 2014) and *O. bergianus* (Jalili and Eagderi, 2015) are formed by the prootic, pterosphenoid and sphenotic, and posterior facet formed by the pterotic and sphenotic. While, these observations were inconsistent with the report of Prokofiev (2010) regarding nemacheilids.

There are three unpaired basibranchials in *P. cristata*, whereas in *P. nielseni*, *O. kiabii* and *O. bergianus* four basibranchials are present. In *P. cristata*, two extra urohyals similar to *O. kiabii* and *O. bergianus* are exist, whereas this two extra urohyals were not found in *P. nielseni* (Azimi et al., 2015). The number of the infrapharyngobranchials is two pairs in *P. cristata*, but this bone is three pairs in *O. kiabii* and *O. bergianus*. In the caudal skeletal of *P. cristata*, five hypurals are present, while in *O. bergianus*, the hypural number is six (Jalili and Eagderi, 2015). In addition, the number of the procurrent rays are less than 15 and densely grouped at the base of caudal fin in *P. sargadensis* and *P. nielseni* (Azimi et al., 2015), whereas in *P. cristata*, over 20 procurrent rays support the adipose crest (Prokofiev, 2009). The surface of the bony capsule is alveolar in *P. cristata*, whereas a non-alveolar bony swim bladder capsule is found in *P. nielseni* (Azimi et al., 2015),

Based on the observed skeletal features, *P. cristata* can be distinguish from the other members of family Nemacheilidae by some features e.g. bearing a foramen in the ventral part of the exoccipital, two extra urohyals, sesamoid ossifications, trapezoid-shaped prevomer, three basibranchials, five hypurals, lack of bony bridge between the parietal and pterotic, and having over 20 procurrent rays supporting the adipose crest.

Since identification of species and populations of this family using meristic characteristics and color pattern is difficult, uncertain, and sometimes unfeasible; therefore, application of the osteological characteristics can be considered as an appropriate method for taxonomic studies of this taxa. Finally, the results showed that this species has some unique osteological characters compared to the related taxa. Hence, its osteological characters can help to better understanding of its taxonomic position as a distinct genus, if more details data about the skeletal structure of the other *Paraschistura* species are available. However, despite the mtDNA COI results, validation status of the genus *Metaschistura* needs more taxonomic examinations. Therefore, further taxonomic study is suggested to clarify the taxonomic status of the Turkmenian stone loach.

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چکیده فارسی

ویژگی‌های استخوان‌شناسی سگ‌ماهی جویباری ترکمنی *Paraschistura cristata* (Cypriniformes: Nemacheilidae)

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چکیده:

سگ‌ماهی جویباری ترکمنی براساس ویژگی‌های استخوانی قبلاً به‌عنوان تنها گونه جنس *Metaschistura* توصیف شده بود. اما اخیراً این گونه براساس داده‌های مولکولی mtDNA COI در جنس *Paraschistura* قرار گرفت. به‌منظور فراهم کردن و توصیف ویژگی‌های استخوان‌شناسی گونه *Paraschistura cristata* (Berg 1898)، تعداد ده نمونه از گونه *P. cristata* از حوضه آبریز هریرود ایران جمع آوری گردید و ویژگی‌های استخوان‌شناسی آن مورد بررسی قرار گرفت. براساس نتایج، ویژگی‌های استخوان‌شناسی *P. cristata* شامل داشتن یک فورامن در بخش شکمی استخوان پس‌سری خارجی، دو استخوان اوروهیال اضافی، استخوان‌های سزاموئیدی، پیش ومر ذوزنقه‌ای شکل، سه استخوان قاعده‌ای آبششی، پنج استخوان تحت‌لامی، فقدان ارتباط استخوانی بین آهیانه و پرواتیک، داشتن بیش از ۲۰ شعاع حمایت کننده بالچه چربی می‌باشد. توصیف جزئیات اسکلت گونه *P. cristata* نشان داد که این گونه می‌تواند به آسانی از دیگر گونه‌های جنس‌های مرتبط تشخیص داده شود. علی‌رغم نتایج مولکولی بر اساس ژن میتوکندریایی COI، داده‌های استخوان‌شناسی این گونه برخی ویژگی‌ها را برای توصیف آن به‌عنوان یک جنس متمایز نشان داد، اما این امر نیازمند مقایسه داده‌های حاصل از استخوان‌شناسی تمام گونه‌های جنس *Paraschistura* می‌باشد.

کلمات کلیدی: استخوان‌شناسی، *Metaschistura*، اسکلت، حوضه آبریز هریرود، ایران.