

A new species of the *incertae sedis* percoid fish †*Bradyurus* (Perciformes s.l.) from the Eocene of Bolca in northern Italy

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ABSTRACT

A new species of the percoid fish genus †*Bradyurus* (Perciformes s.l.), †*B. alessandroi*, is described based on a single skeleton from the Eocene locality of Bolca (Monte Postale site) in northern Italy. This is the second species of the genus †*Bradyurus* Gill, 1904 recorded from Bolca. †*Bradyurus alessandroi* sp. nov. differs from the type species of the genus, †*B. szajnochae* (DE ZIGNO, 1887) (from the Pesciara cave site), in having two rather than three epurals; one fewer vertebrae (26 vs. 27 in †*B. szajnochae*); 13 rather than 12 dorsal-fin spines; 8 rather than 7 anal-fin soft rays; and a different predorsal formula (0/0/0+2/1+1/1/ vs. /0/0/0+2/1+1/1/).

Key words: Perciformes, Percoidei, †*Bradyurus alessandroi* sp. nov., Eocene, northern Italy, Bolca locality, Monte Postale site.

RIASSUNTO

Una nuova specie di pesci percoidi del genere †*Bradyurus* (Perciformes s.l.), †*B. alessandroi*, è descritta sulla base di un unico scheletro proveniente dalla località eocenica di Bolca (Monte Postale) nell'Italia settentrionale. Questa è la seconda specie del genere †*Bradyurus* Gill, 1904 documentata a Bolca. *Bradyurus alessandroi* sp. nov. differisce dalla specie tipo del genere †*B. szajnochae* (DE ZIGNO, 1887) (proveniente dal giacimento della Pesciara), per avere due epurali anziché tre, un numero inferiore di vertebre (26 anziché 27 in †*B. szajnochae*); 13 spine della pinna dorsale anziché 12; 8 raggi molli della pinna anale anziché 7, e diversa formula predorsale (0/0/0+2/1+1/1/ vs. /0/0/0+2/1+1/1/).

Parole chiave: Perciformes, Percoidei, †*Bradyurus alessandroi* sp. nov., Eocene, Italia settentrionale, Bolca, Monte Postale.

INTRODUCTION

The Early Eocene fish fauna of the famous locality Monte Bolca, to the north of Verona in northern Italy, is exceptionally rich in marine fishes, especially in acanthopterygians (e.g., FRIEDMAN and CARNEVALE, 2018). The first comprehensive monographic work on these fishes, the “Ittiolitologia Veronese”, was published by the Abbot G.S. Volta in 1796. Some years later, Agassiz (1833-1844) published his monumental treatise on comparative paleoichthyology, which was largely based on materials from Monte Bolca. Since that time a large number of papers have been devoted to the Monte Bolca fish fauna, based on the thousands of specimens extracted from this locality and now disseminated in museums and research institutes around the world. Monte Bolca marks the first fossil record of many groups of fishes found on modern coral reefs (BELLWOOD, 1996).

The latest lists of the Monte Bolca fishes (BANNIKOV, 2014; CARNEVALE *et al.*, 2014) include 238 taxa, among which 222 represent actinopterygians.

One of the Bolca acanthomorph species was described by De Zigno (1887) as a labrid, †*Crenilabrus szajnochae*. Since the generic name *Crenilabrus* Oken (ex CUVIER, 1817) is a junior synonym of *Symphodus* Rafinesque, 1810, the fossil species was re-described by Eastman (1904) as †*Symphodus szajnochae*. Subsequently, he established the new genus †*Eolabroides* for the species *szajnochae* (EASTMAN, 1914). However, the generic name †*Eolabroides* Eastman, 1914 should be regarded as the junior synonym of †*Bradyurus* Gill, 1904 (see BANNIKOV and ZORZIN, 2012). Bellwood (1999) reviewed the status of the Bolca pharyngognath fishes and determined that the genus †*Eolabroides* Eastman is not a pharyngognath.

†*Bradyurus szajnochae* (De Zigno, 1887) was re-described by Bannikov and Zorzin (2012) from the Pesciara cave site of the Bolca locality as a percoid of uncertain but perhaps haemulid relationships. During the field excavations executed by the employees of the Museo Civico di Storia Naturale di Verona and the Cerato family (Bolca township) in 2021 at the Monte Postale site of the Bolca locality, were discovered, among the other materials, a specimen (in part and counterpart) representing the genus †*Bradyurus*. This specimen is different from †*B. szajnochae* in some morphological characters; it is described below as a new species, †*B. alessandroi*. The quantitative and taphonomic analyses of the Pesciara and Monte Postale fish assemblages performed recently (MARRAMÀ *et al.*, 2016) clearly defined two distinctive paleocommunities and two different depositional settings.

MATERIAL AND METHODS

The specimens were studied using a stereomicroscope WILD Heerbrugg with attached camera lucida drawing arm. Some details of the specimens examined were best seen when the specimens were moistened with alcohol. Measurements were taken with a dial caliper to the nearest 0.1 mm.

Interneural and interhaemal spaces are numbered based on the vertebra whose neural or haemal spine forms the anterior border of the space, with the first space being between the first and second neural or haemal spines (following BALDWIN and JOHNSON, 1993; BANNIKOV and TYLER, 1995; TYLER and BANNIKOV, 1997; etc.).

All extinct taxa are marked with daggers (†) preceding their names.

Comparative material examined:

- †*Bradyurus szajnochae* (De Zigno, 1887): MCSNV IG 126488, MCSNV IG 126491/126492, and MCSNV IG 43366/43367;
- CMP 5303/4340 and 4331/4331a; Pesciara cave site.

Abbreviations are as follows:

- *Institutional*:
CMP – Carnegie Museum, Pittsburgh
MCSNV – Museo Civico di Storia Naturale di Verona;
- *Anatomical*:
Bh – basihyal;
Ch – ceratohyal;
HL – head length;

PU – preural vertebra;
Rar – retroarticular;
SL – standard length;
U – ural vertebra;
Uh – urohyal.

SYSTEMATIC DESCRIPTION

Order Perciformes s.l.
Suborder Percoidei s.l.
Family incertae sedis
Genus †*Bradyurus* Gill, 1904

†*Bradyurus*: GILL, 1904: 846; BANNIKOV and ZORZIN, 2012: 10.

†*Eolabroides*: EASTMAN, 1914: 336.

Diagnosis

Moderately elongate fish with a short and deep caudal peduncle. Head moderately large. Maximum body depth almost equals head length. Supraoccipital crest low. Lower jaw articulation under middle of orbit. Jaws with single series of strong conical teeth and few fangs. Preopercle slightly curved, with prominent retrorse spines along its posterior border. Opercle without spines. Vertebrae 26-27 (10-11+16). Hypaxial hypurals fused. Epurals 2 or 3. Ribs relatively short. Supraneurals 3, predorsal formula /0/0/0+2/1+1/1/ or 0/0/0+2/1+1/1/. Dorsal fin long-based and continuous, with 12 or 13 spines and 16 to 17 soft rays. Anal fin short-based, with 3 strong spines (2nd longest) and 7 or 8 rays. Pelvics inserted behind level of pectoral-fin base or under it. Caudal fin rounded, composed of 17 principal rays. Scales relatively large and ctenoid or cycloid, with numerous radii. Lateral line slightly arched and interrupted behind anal fin.

Type Species

†*Symphodus* (= *Crenilabrus*) *szajnochae* (De Zigno, 1887), by monotypy.

Composition

†*Bradyurus szajnochae* (De Zigno, 1887) and †*B. alessandroi* sp. nov.

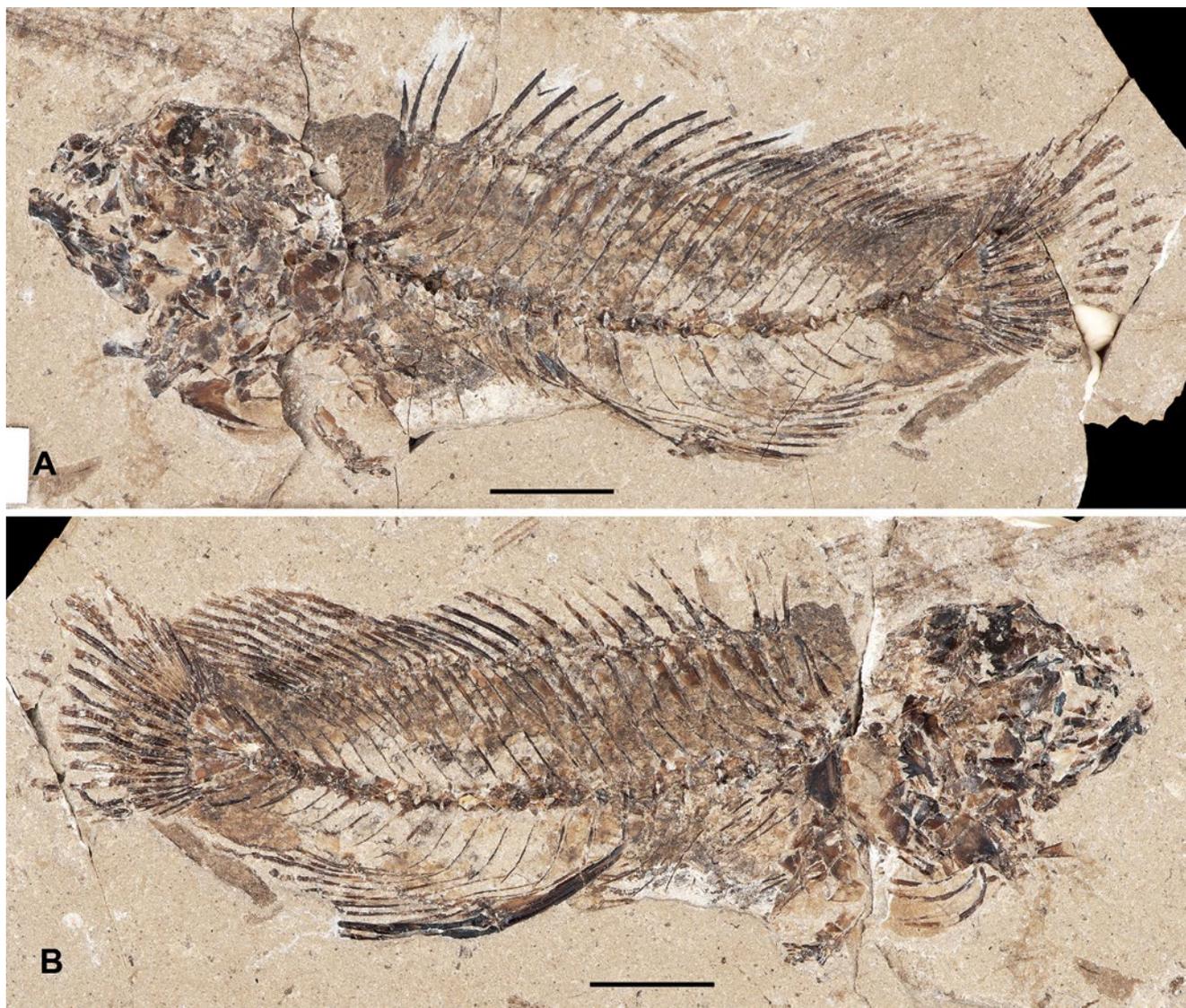


Fig. 1 – *Bradyurus alessandroi* sp. nov., holotype: **A** – MCSNV 21.690, **B** – MCSNV IG 21.689; Lower Eocene of Bolca in northern Italy, Monte Postale. Scale bar: 1 cm

†*Bradyurus alessandroi* sp. nov.

Figures 1-3

Diagnosis

As for the genus.

Etymology

The species is named after the son of the second listed author (RZ), Alessandro.

Holotype

MCSNV 21.689/21.690, part and counterpart, complete articulated skeleton, 78 mm SL (Fig. 1).

Referred specimens

None.

Type locality and horizon

North-eastern Italy, Bolca locality, Monte Postale site; upper part of the Lower Eocene, upper Ypresian, about 50 Ma (PAPAZZONI *et al.*, 2014).

Description

The body is moderately deep, with a short and deep caudal peduncle. The caudal peduncle depth is about 0.43 of the body depth. The head is moderately large; its length (tip of snout to anterior edge

of upper part of pectoral girdle) is less than the body depth. The head length is contained 3.1 times in SL. The dorsal profile of the body is almost as equally convex as the ventral profile of the body.

Head. The head is relatively deep, with its depth somewhat less than its length. The skull is rather poorly preserved, with many of its bones being fractured and scarcely recognizable. The orbit is moderate and placed high in the head depth; there are sclerotic ossifications in the orbit. The horizontal diameter of the orbit is about 19% HL. The snout is much (somewhat less than twice) longer than the orbit diameter. The mouth is moderately wide and terminal. The lower jaw articulation is situated anterior to the middle of the orbit. The neurocranium is moderately deep, with the supraoccipital crest evidently poorly developed. Fragments of the posterior part of the otoliths are recognizable in the MCSNV 21.690 counterpart. The ethmoid region is moderately long. The parasphenoid is relatively slender and almost straight; it is exposed at the lower border of the orbit. The vomerine teeth and infraorbital bones are not recognizable. The upper jaw bones are badly damaged; however, a relatively long and slender ascending premaxillary process and a robust articular process are distinguishable. Only several rather strong blunt conical teeth of different size are preserved of the upper jaw. The lower jaw is moderately deep; its length is about 53-54% HL. The dentary slightly projects ventrally near the moderately deep symphysis. The oral border of the dentary bears relatively strong blunt conical teeth of different sizes. The dentary is notched posteriorly, and the anterior process of the angulo-articular enters to the posterior notch of the dentary. There seems to be a small gap between the dorsal branch of the dentary and the main body of the massive angulo-articular. The retroarticular process is thick and extended; the small retroarticular bone occupies its posterior portion. Although the hyomandibula is strongly damaged, its shaft appears to be almost vertically oriented. Among the highly fragmented pterygoids and suspensorium bones only the endopterygoid (mesopterygoid) is recognizable; it is flat and extended and situated below the orbit. The opercular region is moderately narrow. The preopercle is partly preserved in MCSNV 21.689, where it is thick, relatively narrow and probably only slightly curved; a few strong retrorse spines are present on its posterior border. The other bones of the gill cover are highly fragmented, with the opercle apparently being rather wide. The ceratohyal is

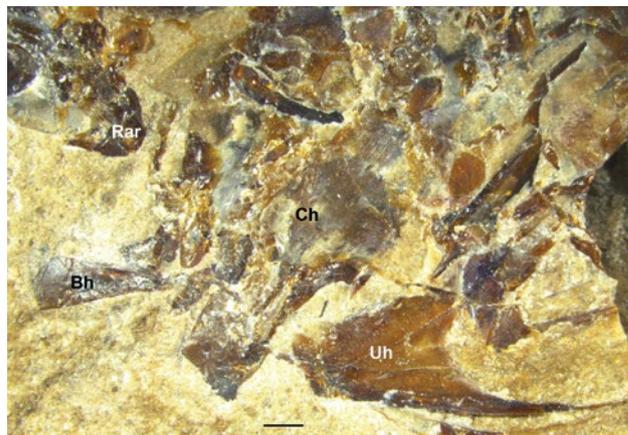


Fig. 2 – *Bradyurus alessandroi* sp. nov., holotype MCSNV 21.690, hyoid bar; Lower Eocene of Bolca in northern Italy, Monte Postale. Scale bar: 1 mm

relatively deep, concave anteroventrally and seems to be perforated by a narrow “beryciform foramen” (McALLISTER, 1968). An interdigitating suture between the ceratohyal and epihyal is not evident. The distinction between the hypohyals is obscured. The number of branchiostegal rays is unclear; the branchiostegals are sabre-like in shape. The urohyal is a flattened laminar bone thickened along its ventral margin; the bone is moderately deep and concave posteriorly, with a very long pointed posterior projection along the ventral border (Fig. 2). The basihyal (glossohyal) is narrow and wedge-shaped. Neither the branchial bones nor pharyngeal teeth are recognizable except for several small slender straight and pointed teeth in MCSNV 21.690, which represent either pharyngeal dentition or the gill rakers.

Axial skeleton. There are 26 vertebrae, ten abdominal and sixteen caudal, including the urostyle. The axis of the vertebral column is very slightly elevated anteriorly. The vertebral centra are almost rectangular in lateral view. The length of the caudal portion of the vertebral column is about 1.6 times greater than the length of the abdominal portion of the vertebral column. The vertebral spines are only moderately long, and are straight or slightly curved. The neural spines of the five anterior abdominal vertebrae are widened anteroposteriorly, whereas all the other neural spines are slender, both posteriorly in the abdominal region and in the caudal region. Among the thickened neural spines the fourth one is the longest; subsequently, a few spines of the abdominal vertebrae decrease in length, and then increase in length again posteriorly in the series. The longest neural

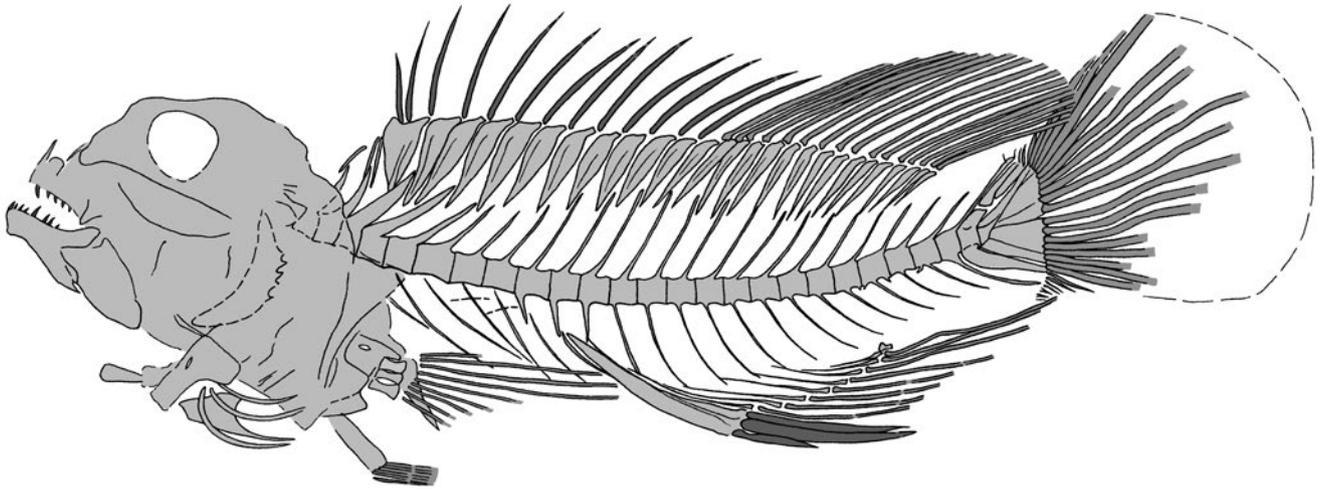


Fig. 3 – *Bradyurus alessandroi* sp. nov., reconstruction of the skeleton based on holotype, scales omitted

spines are those of the anterior caudal vertebrae. The haemal spines of the caudal vertebrae are usually as equally long as the opposite neural spines, but slightly more curved and pointed. The first two anterior haemal spines are shortened and not as pointed as the succeeding spines. Most of the neural spines arise from the middle of the centra, whereas the anterior haemal spines arise from the anterior half of the centra. Slender parapophyses are recognizable in at least the two posteriormost abdominal vertebrae, the last parapophysis being the longest. The pleural ribs are very slender and rather strongly inclined posteroventrally; they are only moderately long and occupy the upper half of the abdominal cavity. Several slender epineurals are partly recognizable below the middle abdominal vertebrae.

Pectoral fin and girdle. The pectoral girdle is strongly damaged; its details are scarcely identifiable. The posttemporal and supracleithrum are not recognizable at all. The cleithrum is strongly damaged, but it seems to be large and only moderately curved, with a posterodorsal projection. The upper part of the cleithrum is located under the third and fourth vertebrae. The ventral postcleithrum is relatively broad and short. The MCSNV 21.689 counterpart reveals that the coracoid has a well-developed wide postcoracoid process. The scapula is a dense bone penetrated by the ovoid foramen in its upper part. There is a posterior projection of the scapula above the pectoral radials. Three pectoral radials are strong and hourglass-shaped; these increase in size downward. The lowermost pectoral radial is attached to the coracoid, whereas the two

upper radials adjoin the scapula. The base of the pectoral fin is subvertical and situated under the fifth vertebra, near the midpoint between the vertebral column and the ventral profile of the body. About ten pectoral-fin ray bases are recognizable in the MCSNV 21.689 counterpart; it is unclear if it is the total complement or not. According to the length of the few completely preserved rays, the pectoral fins are relatively long.

Pelvic fin and girdle. The pelvic bones are incompletely preserved; these seem to be moderately long and relatively narrow. Only the base of the pelvic fins is preserved; each fin seems to contain a spine and five soft rays. The pelvic fin is inserted approximately under the pectoral-fin base.

Supraneurals and dorsal fin. There are three slender supraneurals (predorsal bones) devoid of apical projections. The predorsal formula (AHLSTROM *et al.*, 1976; JOHNSON, 1980, 1984) is 0/0/0+2/1+1/1/. The dorsal fin is long-based and continuous; it originates over the fifth vertebra and terminates over the 23th/24th vertebra transition. There are 13 dorsal-fin spines and 16 soft segmented and branched rays. The dorsal-fin spines are moderately strong. The spines gradually increase in length from the first to the fourth, with the succeeding spines being almost equal in length. The (presumably) longest last spine is 1.3 times longer than the second spine and 1.9 times longer than the first spine. The first two dorsal-fin spines are supernumerary on the first dorsal-fin pterygiophore; these are rather closely spaced. The longest soft ray of the dorsal fin is 1.5 times longer than the longest dorsal-fin spine.

The length of the base of the soft portion of the dorsal fin is 1.4 times shorter than the base length of the spiny portion of the dorsal fin. The anterior dorsal-fin soft rays are almost equal in length; after that, the rays at first gradually, then more rapidly, decrease in length posteriorly in the series; thereby, the fin is rounded posteriorly. The posterior margin of the lobe of the dorsal fin reaches behind the caudal-fin base. There are a total of 27 dorsal-fin pterygiophores. The first pterygiophore is large and sturdy, expanded anteroposteriorly, and bears a longitudinal strengthening ridge; the succeeding pterygiophores gradually become narrower. Most of the dorsal-fin pterygiophores are almost equal in length and moderately inclined, but the posterior pterygiophores of the soft rays become more strongly inclined and of decreased length. The interneural spaces below the dorsal fin have the ventral shafts of one (usually anteriorly) or two (usually posteriorly) pterygiophores present. The pterygiophores have the proximal and medial elements fused.

Anal fin. The anal fin is relatively short-based; it originates under the transition between the fifth and sixth caudal vertebrae and terminates under the eleventh caudal vertebra. There are three spines and eight soft segmented and branched rays in the anal fin. The anal-fin spines are very strong. Although the distal portions of the anal-fin spines are obscured in the matrix, it is evident that the second spine is the longest, much longer than the longest dorsal-fin spine. The first two anal-fin spines are supernumerary. Most of the anal-fin soft rays are incompletely preserved distally; the few complete (posteriormost) rays seem to be not shorter than the longest anal-fin spine, but are shorter than the longest dorsal-fin soft rays. The last anal-fin soft ray reaches the caudal-fin base. The first anal-fin pterygiophore is very long and sturdy; it is strongly inclined at an angle about 28° to the body axis. The succeeding anal-fin pterygiophores are exceptionally slender and lie almost in parallel to the body axis; these decrease in length posteriorly in the series. The pterygiophores have the proximal and medial elements fused.

Caudal fin and skeleton. The caudal skeleton is weakly consolidated. The terminal centrum is composed of the fusion of PU1, U1 and U2. The parhypural and haemal spine of PU2 (and perhaps of PU3) are autogenous. A parhypurapophysis seems to be absent. Since the preservation of the material is only moderate, it is unclear if there is a fusion of the fourth and fifth hypurals, but the third hypural is evidently divided from the fourth. The hypaxial

hypural plate seems to be formed from the fused first and second hypurals. The epaxial and hypaxial hypural plates are divided by a long and narrow slit. The neural and haemal spines of PU3 are longer than those of the preceding vertebra. The neural spine of PU2 is a relatively short crest. There are two epurals and a stegural; the condition of the second uroneural is unclear. The caudal fin is incomplete distally. There are 17 principal rays in the caudal fin (I,8-7,D); there are about six procurrent rays above and seven rays below. There are no indications of the presence of a procurrent spur (JOHNSON, 1975).

Squamation. Large and thin scales cover the entire body and the head, probably also the base of the dorsal and caudal fins. The limits of individual scales are scarcely recognizable; therefore the number of scale rows on the body is unknown. Each trunk scale bears numerous radii in the basal field; the number of radii varies, up to 15. The head scales are definitely cycloid and lack radii, having only circuli. Ctenii are not recognizable as well on the trunk scales, although this is perhaps due to inadequate preservation. The breast scales are smaller and especially thin. The lateral line is not recognizable.

Coloration. Vague traces of the original pigmentation pattern are preserved throughout the whole body, dorsal and anal fins.

Measurements of the holotype, in percent of SL (78 mm) are as follows:

- Head length from tip of snout to anterior border of cleithrum: 32;
- Maximum body depth: 35;
- Depth of caudal peduncle: 15;
- Distance between tip of snout and first dorsal-fin spine: 36;
- Distance between tip of snout and first dorsal-fin soft ray: 67;
- Distance between tip of snout and anal fin: 72;
- Distance between pelvic fin and anal fin: 34.5;
- Length of base of dorsal fin: 54;
- Length of base of spiny dorsal fin: 30;
- Length of base of soft dorsal fin: 22;
- Length of base of anal fin: 17;
- Length of first spine of dorsal fin: 7;
- Length of second spine of dorsal fin: 10;
- Length of fourth spine of dorsal fin: 12;
- Length of last spine of dorsal fin: 13.5;
- Length of longest soft ray of dorsal fin: 21;
- Length of last soft ray of anal fin: 18;
- Preorbital distance: 11;
- Horizontal diameter of orbit: 6;
- Length of lower jaw: 17.

DISCUSSION

Being undoubtedly a member of the genus †*Bradyurus*, the new species differs from the type species of this genus, †*B. szajnochae* (DE ZIGNO, 1887) (from the Pesciara cave site), in having two rather than three epurals; fewer vertebrae (26 vs. 27 in †*B. szajnochae*); 13 rather than 12 dorsal-fin spines; 8 rather than 7 anal-fin soft rays; a different predorsal formula (0/0/0+2/1+1/1/ vs. /0/0/0+2/1+1/1/); and probably in having cycloid (vs. ctenoid in †*B. szajnochae*) scales. Also, the urohyal of †*B. alessandroi* sp. nov. has a long pointed posterior projection, a feature not known for †*B. szajnochae*. These differences justify the recognition of the Monte Postale specimen of †*Bradyurus* as a new species.

Although the genus †*Bradyurus* resembles labrid fishes in some respects (overall general appearance, meristic characters, oral dentition, fused hypaxial hypurals, long and narrow hypural slit, etc.), our observations on the material from the MCSNV (BANNIKOV and ZORZIN, 2012) supported the conclusion of Gill (1904) and Bellwood (1991, 1999) about the non-pharyngognath nature of †*B. szajnochae*. The new species †*B. alessandroi* also does not reveal any indication of a tooth-bearing lower pharyngeal bone that is characteristic for the suborder Labroidei of the order Perciformes s.l., as it was defined by KAUFMAN and LIEM (1982) and Stiassny and Jensen (1987), as well as for some of the percoid families (see ROSEN and PATTERSON, 1990).

In its overall general appearance, extensive serration of the preopercle, strong inclination of the first anal-fin pterygiophore, rounded caudal fin and meristic characters, †*Bradyurus* resembles some representatives of the order Scorpaeniformes [in its traditional sense (NELSON, 2006; NELSON *et al.*, 2016), whereas IMAMURA and YABE (2002) rejected Scorpaeniformes s.l. as a monophyletic group, and BETANCUR-R. *et al.* (2017) incorporated them into the Perciformes]. This order is characterized by the presence of a suborbital stay, a posterior extension of the third suborbital bone, which extends across the cheek to the preopercle. However, none of the specimens available of either †*B. szajnochae* (see BANNIKOV and ZORZIN, 2012) or †*B. alessandroi* sp. nov. shows the possession of a suborbital stay. Therefore, the possible relationships of †*Bradyurus* with Scorpaeniformes s.l. apparently should be rejected.

All the features of the genus †*Bradyurus* clearly indicate that it belongs to the suborder Percoidei (in its traditional sense) of the order Perciformes s.l.,

but the position of †*Bradyurus* amongst the percoids is uncertain. Percoidei, the “largest and most diverse of the perciform suborders is undoubtedly polyphyletic...” (JOHNSON, 1993, p. 15) and is diagnosed by several plesiomorphic for the Perciformes features; this group includes those perciforms that cannot be placed in other suborders. More recently, citing molecular data, many families traditionally included in the Percoidei are removed from this suborder (e.g., NELSON *et al.*, 2016), or its composition is even limited to two or three families (BETANCUR-R. *et al.*, 2017). According to the more traditional view of Nelson (2006), the suborder Percoidei includes 79 Recent families.

†*Bradyurus* has a somewhat increased number of vertebrae relative to the number found in generalized percoids (10-11+16=26-27). Gosline (1968) noted that the “basal number” of vertebrae in percoids is 24-25 (10+14-15). The combination of this character with the dorsal-fin formula (XII-XIII, 16), anal-fin formula (III, 7-8) and extensively serrated preopercle, is found in none of the extant genera of percoids. Also, in †*Bradyurus* the first and second hypurals are apomorphically fused into the hypaxial hypural plate. None of the synapomorphies of advanced percoid families is known to be present in †*Bradyurus* (BANNIKOV and ZORZIN, 2012).

We already pointed out (BANNIKOV and ZORZIN, 2012) that the vertebral count of *Bradyurus* as well as its dorsal- and anal-fin formulas lie within the range recorded in Recent haemulids (Percoidei in their traditional sense). The representatives of the Haemulidae do not have the fusion of the first and second hypurals, and extensively serrated preopercle that are characteristic of the Eocene genus. However, certain similarities of †*Bradyurus* and haemulids, including the fusion of the proximal and medial elements of the dorsal- and anal-fin pterygiophores that are characteristic for the Haemuloidea (JOHNSON, 1980), may reflect some distant relationships of the two groups (BANNIKOV and ZORZIN, 2012).

The morphology of the urohyal of †*B. alessandroi* sp. nov., as a flattened laminar bone thickened along its ventral margin and forming a very long pointed posterior projection, is quite unusual. Among the multiple fish urohyals figured by Kusaka (1974) only a few have a somewhat similar contour, those being of apparently not related fishes (e.g., the trachichthyid *Gephyroberyx*, some serranids, the lutjanid *Lutjanus gibbus*, some labrids and scarids). Thus, it does not contribute much to the search of the relatives of †*Bradyurus*.

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