

LOUIS TAVERNE<sup>1</sup>, LUIGI CAPASSO<sup>2</sup>

<sup>1</sup> Royal Institute of Natural Sciences of Belgium, Directorate Earth and History of Life,  
Vautierstreet, 29, B-1000 Brussels, Belgium. e-mail: *louis.taverne@gmail.com*

<sup>2</sup> Museo Universitario dell'Università "G. d'Annunzio" di Chieti-Pescara,  
Piazza Trento e Trieste, 1, I-661000 Chieti, Italy. e-mail: *lcapasso@unich.it*

**OSTEOLOGY AND RELATIONSHIPS OF  
*ITALOALBULA PIETRAROJAE* GEN. AND SP. NOV.  
(TELEOSTEI, ALBULIFORMES)  
FROM THE MARINE CRETACEOUS OF PIETRAROJA  
(CAMPANIA, SOUTHERN ITALY)**

**SUMMARY**

*Italoalbula pietrarojae* gen. and sp. nov., a fossil teleost fish from the marine Albian deposits (Lower Cretaceous) of Pietraroja (Campania, S Italy), is described in details. There are rostral ossicles. The retroarticular is fused to the angular. The neural arches on the first preural and the first ural vertebrae are fused together and form an elongate plate above these two *centra*. These three apomorphies and some other osteological features indicate that *I. pietrarojae* belongs to the super-order Elopomorpha. The mouth is small and slightly inferior. The infraorbital sensory canal runs in a groove on the premaxilla. The maxilla is reduced. There is only one small supramaxilla. The lower jaw is short and triangle-shaped. There are small pointed needle-like tooth on the jaws. The parasphenoid bears a broadened toothed plate. The supraorbital and mandibular sensory canals are open. The orbitosphenoid is lying on the parasphenoid. The temporal fossa is small and antero-medially directed. The ventral branch of the preopercle is elongate. All these specialized characters show that the relationships of the new Albian elopomorph fish are to be found within the order Albuliformes and more particularly within the family Albulidae. However, *Italoalbula* differs from all the known fossil and recent Albulidae and so deserves a peculiar generic status.

**INTRODUCTION**

The marine Albian (Lower Cretaceous) *plattenkalk* of Pietraroja (province of Benevento, Campania, S Italy) yields an important and various ichthyofauna

that was principally studied by D'ERASMO (1914-1915) in an exhaustive monograph published in two volumes. CAPASSO (2007) has related in a beautifully illustrated book the detailed story of Pietraraja and its fossil fishes from their first mention in the 18<sup>th</sup> century to the present days. A synthesis of our modern knowledge on the geology and stratigraphy of Pietraraja is given in FREELS (1975) and BRAVI (1996). The palaeo-environment is well described in SIGNORE (2004).

COSTA (1864: 112-113, pl. 9, fig. 12, 13) figured two broad dental plates from Pietraraja that he reported to the pycnodont fish *Glossodus heckeli* Costa, 1860. Later, WOODWARD (1901: 73) showed that these toothed plates did probably belong to a still unknown Cretaceous Albulidae and not to a Pycnodontidae (see also CAPASSO, 2007: 148, fig. 17A, B).

Unfortunately, since WOODWARD (1901) and until now, no other records of possible albuliform fishes have ever been mentioned concerning the Pietraraja ichthyofauna in any published paper meanwhile the recent new excavations on the site.

However, the Capasso registered collection in Chieti contained since many years two complete and well preserved specimens of such a fossil albuliform fish from Pietraraja. But they were erroneously identified as a probable *Hypsospondylus bassanii* Gorjanovic-Kramberger, 1884, for the one, and as a probable "*Chanos*" *leopoldi* (Costa, 1860), for the other (CAPASSO, 2007: fig. 168, 171).

The aim of the present paper is thus to describe the osteology and precise the systematic relationships of this new Lower Cretaceous albuliform genus from Italy.

## MATERIAL AND METHODS

The specimens hereafter studied belong to the Capasso collection (CLC) in Chieti (Italy). This collection is legally registered and was declared part of the Italian cultural heritage by a decree of the *Ministero per i Beni e le Attività Culturali* under the date of October 11<sup>th</sup> 1999, following the disposition of the Italian law of cultural heritage protection N° 1089/1939. The specimens of this collection were also subject to prescription in order of conservation and availability to the studies on the basis of the article 30 of the Italian law N° 42/2004. The *Soprintendenza per i Beni Archeologici dell'Abruzzo-Chieti* authorized the Authors to study this collection by two letters bearing the dates of May 5<sup>th</sup>, 2011 (ref.: MBAC-SBA-ABR PROT 0004537 05/05/ 2011 Cl. 34.25.01/2.1) and July 30<sup>th</sup>, 2014 (ref.: MBAC-SBA-ABR PROT 0005618 31/07/2014 Cl. 34.25.01/2.1).

The specimens have been examined with a stereomicroscope Leica Wild M 8. The figures were drawn by the first author (L.T.). The photos were made

by Luciano Lullo from the Università "G. d'Annunzio" di Chieti-Pescara. Aspirations with ethanol were used to improve some observations.

## SYSTEMATIC PALEONTOLOGY

Division Teleostei Müller, 1848  
Superorder Elopomorpha Greenwood *et al.*, 1966  
Order Albuliformes Greenwood *et al.*, 1966  
Family Albulidae Bleeker, 1859  
Genus *Italoalbula* gen. nov.

### Type-species

*Italoalbula pietrarojae* gen. and sp. nov. (by monotypy)

### Diagnosis

As for the species (monospecific genus).

### Etymology

The generic name of the new fossil fish refers to Italy and to the genus *Albula* Scopoli, 1777.

Species *Italoalbula pietrarojae* gen. and sp. nov.

### Diagnosis

Large albulid fish. Dermethmoid (= rostral) thin, elongate, triangular in shape and devoid of median crest. Small supraethmoid fused to the anterior extremity of the dermethmoid. Small hypoethmoid lying on the vomer. Nasal long and tubular. Rostral ossicles present. Vomer toothed. Orbitosphenoid reaching the lateral ethmoid and the parasphenoid. Pleurosphenoid and basisphenoid small. No complete bony interorbital septum. Reduced *dilatator fossa* entirely located on the autosphenotic. Parasphenoid bearing a large ovoid toothed plate. Short jaws, with needle-like teeth. Posterior infraorbitals broad, covering the cheek. Supraorbital and mandibular sensory canals open. Preopercle with a long ventral branch. Five branchiostegal rays. Gular plate present. Dermobasihyal and dermobasibranchial broadened and toothed. Dorsal branch of the cleithrum with a triangular posterior margin. From 53 to 55 vertebrae (35 abdominal and 18 to 20 caudal). Dorsal (13 rays) and anal (6 rays) fins short. 14 supra-neurals, the first ones slightly broadened. Neural spine on the second preural vertebra shortened. 3 epurals. 3 uroneurals. Ventral hypural fused together. Small caudal scutes present.

### **Etymology**

The species name refers to the village of Pietraroja.

### **Holotype**

CLC I-48, a complete specimen (Fig. 1; CAPASSO, 2007: fig. 168). Total length: 29 cm.

### **Paratype**

CLC I-272, a nearly complete specimen (Fig. 2; CAPASSO, 2007: fig. 171). The lower jaw is missing. Total length: 27.5 cm.

### **Formation and locality**

Marine Albian (Lower Cretaceous) *plattenkalk* of Pietraroja (province of Benevento, Campania, S Italy).

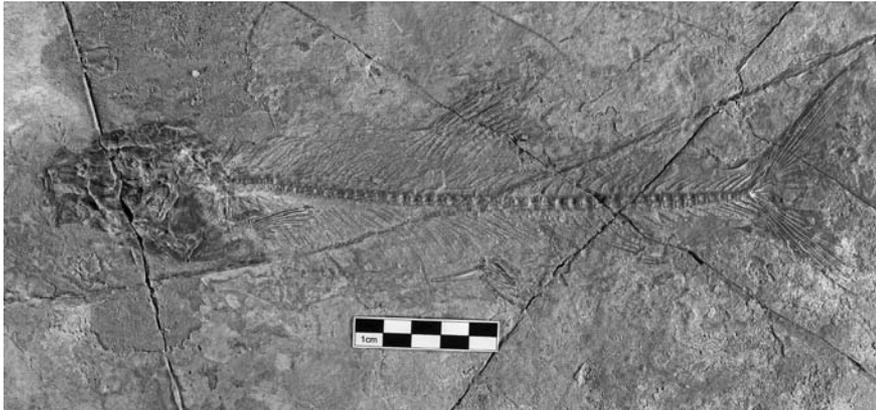


Fig. 1. *Italoalbula pietrarojae* gen. and sp. nov. Holotype CLC I-48.



Fig. 2. *Italoalbula pietrarojae* gen. and sp. nov. Paratype CLC I-272.

**Morphometric data** (Fig. 1, 2)

The morphometric data are given in percentage (%) of the standard length of the holotype (25 cm) and of the paratype (23.5 cm).

	Holotype	Paratype
Length of the head (opercle included)	25.6 %	26.4 %
Depth of the head (in the occipital region)	18.0 %	17.4 %
Maximum depth of the body (at the dorsal fin level)	22.0 %	19.1 %
Prepelvic length	62.8 %	60.9 %
Predorsal length	55.2 %	54.0 %
Preanal length	85.2 %	82.6 %
Depth of the caudal peduncle	8.8 %	9.4 %
Length of the caudal fin lobes	20.8 %	19.1 %

**Osteology**

**The skull** (Fig. 3-9)

The head is rather small when compared to the length of the fish. The pre-orbital length represents 130 % of the postorbital length.

The snout region is slightly protruding in regard to the shortened lower jaw. The mesethmoid is a large triangular bone, devoid of median crest. It is narrow anteriorly but it expands posteriorly. Its broad posterior margin is sutured with the frontals. This thin plate represents the dermic component (dermethmoid, rostral) of the mesethmoid. A small knob-like endochondral supraethmoid is fused to the ventral face of the narrow anterior extremity of the mesethmoid. The vomer is a long and broad bone. Its ventral face bears dental alveoli clearly visible on the paratype. Its dorsal face bears a weakly marked median crest. A small endochondral hypoethmoid lies on the anterior extremity of the dorsal face of the vomer and is articulated with the supraethmoid. The nasal is a long tubular bone bearing the anterior portion of the supraorbital sensory canal. On the paratype, the bone is displaced, due to the fossilisation, and lies in front of the lateral ethmoid. The nasal is broken in three parts on the holotype. The lateral ethmoid is a large and massive bone that links the frontal and the parasphenoid.

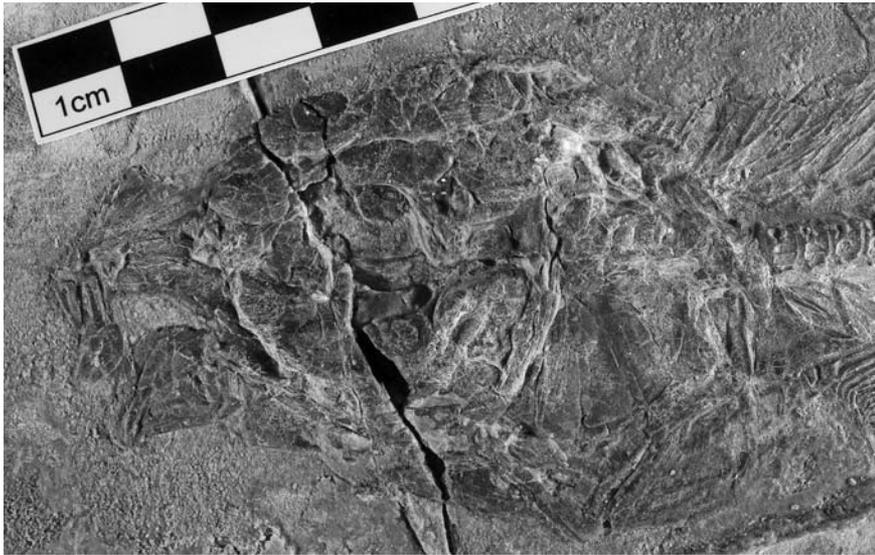


Fig. 3. *Italoalbula pietrarojae* gen. and sp. nov. Head region of holotype CLC I-48.

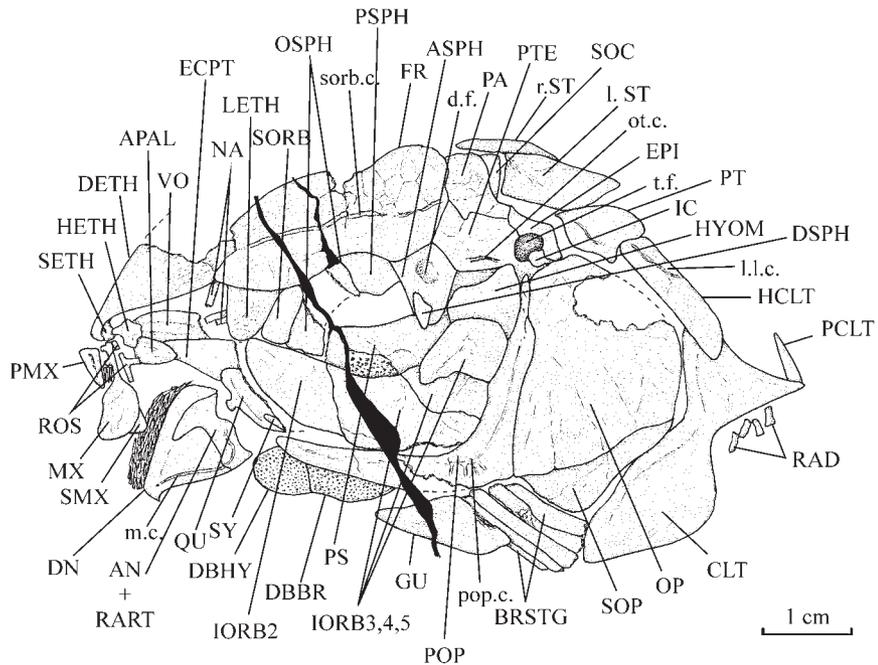


Fig. 4. *Italoalbula pietrarojae* gen. and sp. nov. Skull and pectoral girdle of holotype CLC I-48.

The skull roof is formed by paired frontals, parietals and pterotics. They are thick and ornamented bones. The frontal bears the supraorbital sensory canal that lies in an open groove for the greatest part of its way. There is a short epiphyseal sensory commissure (visible on the paratype) and a parietal sensory commissure that does not extend on the parietal. The skull is medio-parietal and the parietal is a large bone. A small supraoccipital, devoid of median crest, appears just behind the parietals. The autosphenotic is an unusually massive bone. The small but deep *dilatator fossa* is entirely located on the autosphenotic. The anterior margins of the pterotic and the parietal are located at the same level. The temporal (= posttemporal) fossa, well visible on both specimens, is rather small, laterally located and surrounded by the pterotic, the epiotic (= epioccipital) and the reduced intercalar. The supratemporal (= extrascapular) is a large and broad bone reaching the middle of the skull.

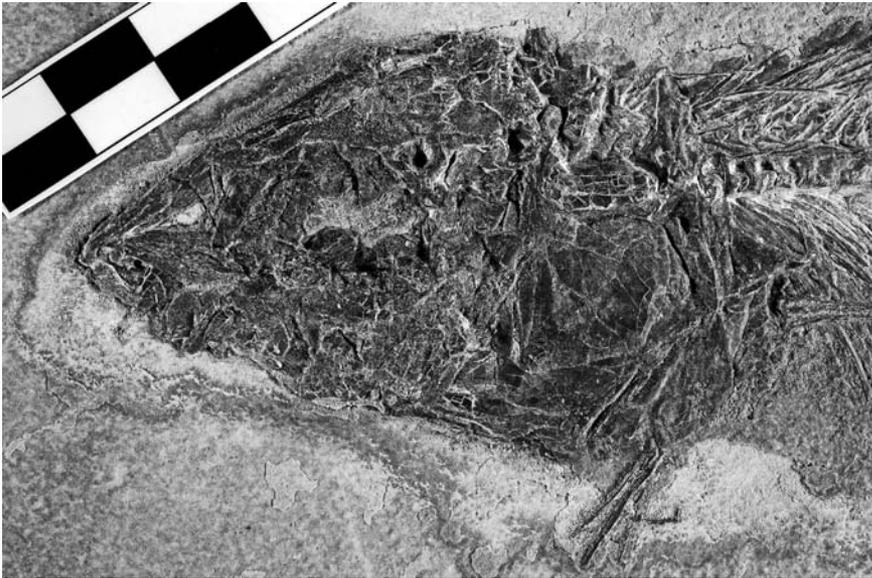


Fig. 5. *Italoalbula pietrarojae* gen. and sp. nov. Head region of paratype CLC I-272.

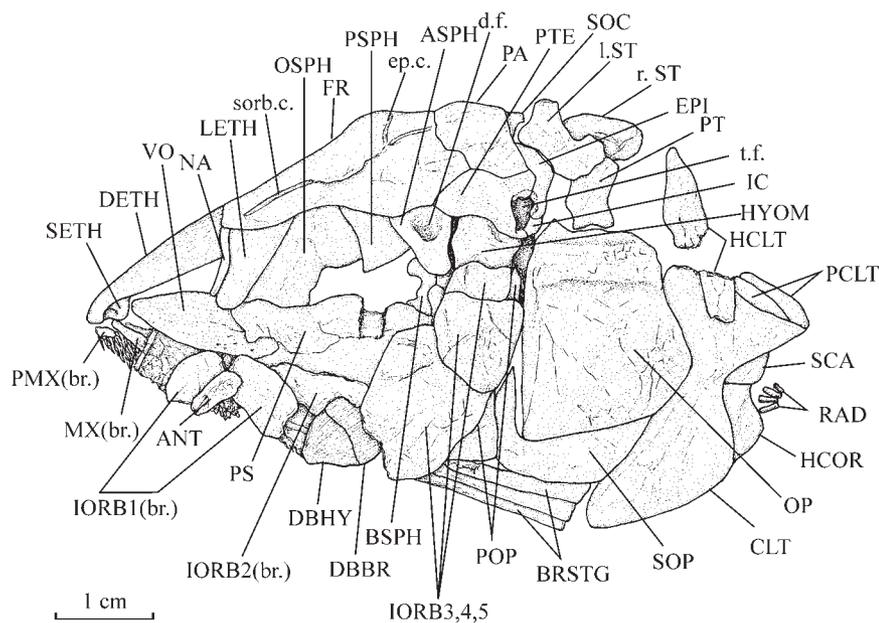


Fig. 6. *Italoalbula pietrarojae* gen. and sp. nov. Skull and pectoral girdle of paratype CLC I-272.

The parasphenoid is a long, very broad and very thick bone. It bears a large ovoid dental plate. The teeth are lost but their small rounded alveoli are present. The orbitosphenoid is a large bone. Anteriorly, it reaches the lateral ethmoid and the parasphenoid but there is no complete interorbital bony septum, the pleurosphenoid (= pterosphenoid) and the basisphenoid being smaller bones. The prootic, the exoccipital and the basioccipital are hidden under the hyomandibula and the opercle.

A part of the hyopalatine series is preserved on the holotype. The quadrate is elongate, with a well marked articular head for the lower jaw. The quadrate process is short, forming a notch for the symplectic in the posterior corner of the bone. A broad ectopterygoid and a rather large palatine are also visible on the holotype. The posterior part of the ectopterygoid is not preserved and we do not know if a dorsal process was present or not. The ento-ptyerygoid and the meta-ptyerygoid are hidden by the orbital bones.

Both jaws are short, with a small and slightly inferior mouth. The premaxilla is complete on the holotype but only the posterior part is preserved on the paratype. The bone is elongate, triangle-shaped and devoid of ascending process. It bears needle-like teeth on the paratype but seems toothless on the holotype. However, in this specimen, three isolated teeth located just

above the premaxilla perhaps belong to this bone. The external face of the premaxilla bears a groove that probably contained the most anterior part of the infraorbital sensory canal, as in Pterothrissidae and Albulidae (FOREY, 1973: fig. 66, 80, 81). The anterior region of the maxilla is rod-like, with a small ethmoid articular process and two other small ventral processes that articulate with the premaxilla. The posterior region of the maxilla is broadened and plate-like. There is a patch of needle-like teeth below the maxilla on the paratype but only three of these teeth are preserved on the holotype. A reduced supramaxilla is present. The lower jaw is triangular in shape, with a narrow symphysis and a deep coronoid region. The anterior ventral corner of the dentary forms a small hook-like process. The dentary bears a patch of needle-like teeth extending all along its oral margin. There is no autogenous retroarticular, the bone being fused with the angular. The mandibular sensory canal is well visible on the dentary and the angular. It runs within a narrow open canal.

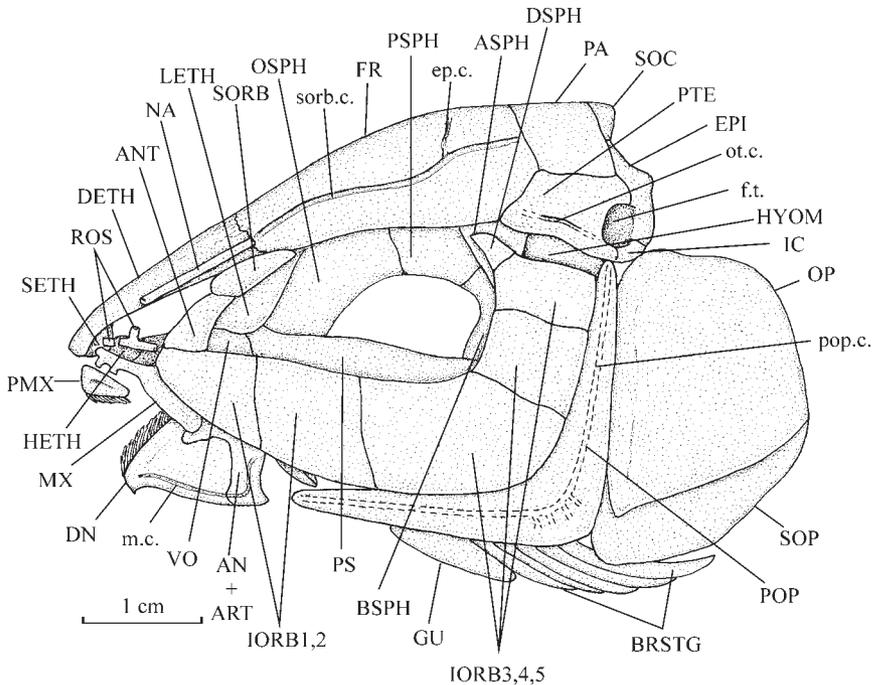


Fig. 7. *Italoalbula pietrarojae* gen. and sp. nov. Reconstruction of the skull based on holotype and paratype.

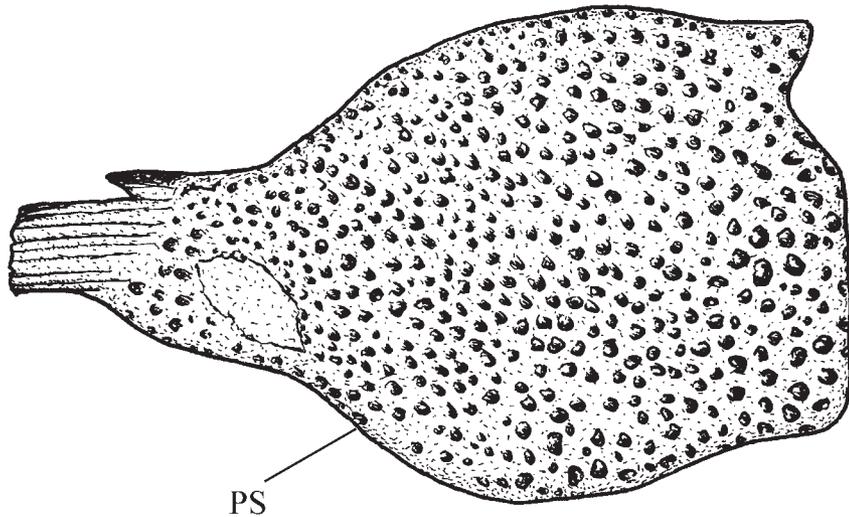


Fig. 8. *Italoalbula pietrarojae* gen. and sp. nov. Parasphenoid in ventral view (modified from COSTA, 1864: pl. 9, fig. 13).

The orbital series is more completely preserved on the holotype than on the paratype. Two small tubular rostral ossicles are located between the mes-ethmoid and the first infraorbital. The two bones carry the lateral portion of the rostral sensory commissure. The anterior one is very short. The posterior one is a T-shaped tubular bone, with a ventral branch for the rostral commissure and a short dorsal branch that seems to make a link with the anterior extremity of the supraorbital sensory canal borne by the nasal. The first infraorbital is visible on the paratype but is broken in two parts. A short but broad antorbital, displaced by the fossilisation, lies on the broken first infraorbital of the paratype. The four other infraorbitals are preserved on both specimens. All the five infraorbitals are large bones with an important membranous component. The third one is the wider of the series. The posterior infraorbitals cover the cheek. A small triangular and strongly ornamented dermosphenotic covers a part of the autosphenotic on the holotype. This sample has also preserved the short plate-like supraorbital that is displaced just posterior to the lateral ethmoid because of the fossilisation.

The preopercle is hidden by the infraorbitals on the paratype but is completely exposed on the holotype. The bone is divided in two well developed branches, the ventral limb being longer than the dorsal one. The preopercular sensory canal and a few short ventral branches are visible. The opercle is large and broader ventrally than dorsally. The subopercle also is a large bone with a strong dorsal process at its anterior upper corner. The interopercle is

not visible. There are a gular plate and at least five branchiostegal rays that are well visible on the holotype.

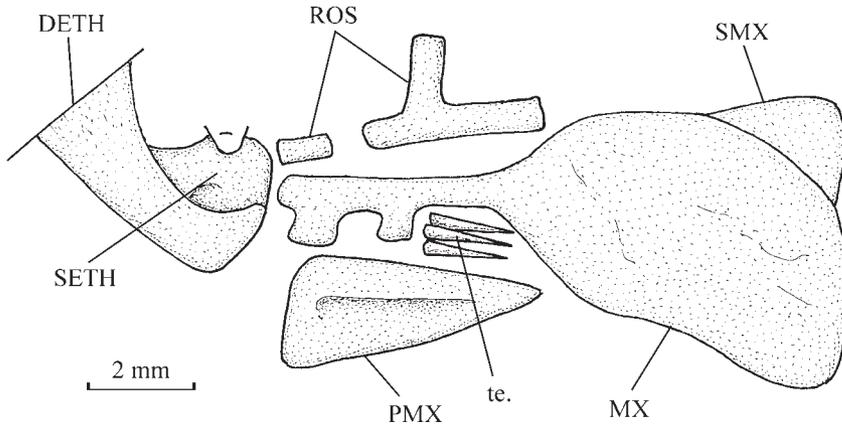


Fig. 9. *Italoalbula pietrarojae* gen. and sp. nov. Upper jaw, antorbital and rostral ossicle of holotype CLC I-48.

#### **The hyoideo-branchial skeleton** (Figg. 4, 6)

The small symplectic is wedged in the notch of the posterior margin of the quadrate. The strong dorsal head of the hyomandibula is articulated with the autosphenotic and the pterotic. The ventral part of the bone is hidden by the infraorbitals.

The dermobasihyal is a short, broad and very massive bone, indicating that it is fused to an underlying basihyal. Its posterior margin is sutured with a broad dermobasibranchial. Both bones bear numerous small rounded teeth and dental alveoli.

#### **The girdles** (Fig. 3-6, 10-12)

The post temporal is a large and longer than deep plate-like bone. The hypercleithrum (= supracleithrum) is deep but rather narrow. The two branches of the cleithrum are well developed. The ventral limb is long and broad. The dorsal limb expands, forming a very wide triangular posterior plate. There are two narrow postcleithra in the paratype but only one is preserved in the holotype. The small hypercoracoid (= scapula) and the larger hypocoracoid (= coracoid) are visible on the paratype. There are four small pterygiophores. The pectoral fin is better preserved on the holotype. It contains 15 rays.



Fig. 10. *Italoalbula pietrarojae* gen. and sp. nov. Pectoral region and fin of holotype CLC I-48.



Fig. 11. *Italoalbula pietrarojae* gen. and sp. nov. Pelvic region of holotype CLC I-48.

The pelvic bones are triangular but very elongated. They bear a knob-like lateral process on their basis. The origin of the ventral fins is located at the level of the 30<sup>th</sup> or 31<sup>st</sup> vertebrae. Each fin is composed by 7 segmented and branched rays and 1 splint-bone, as seen on the paratype.

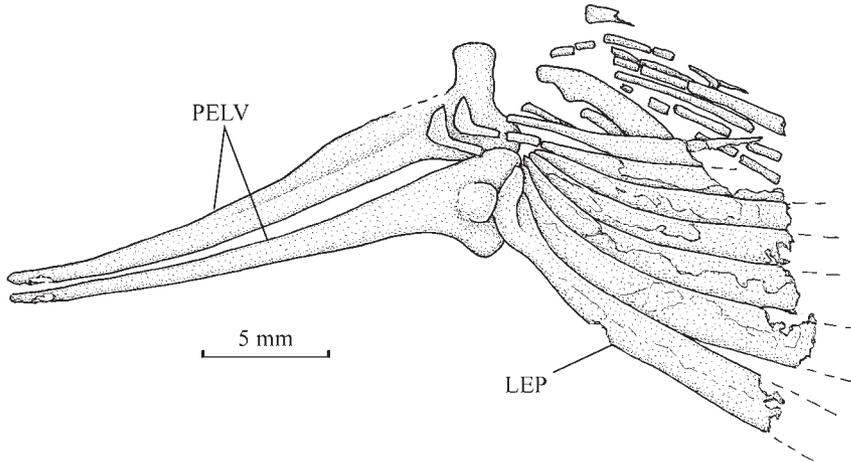


Fig. 12. *Italoalbula pietrarojae* gen. and sp. nov. Pelvic girdle of holotype CLC I-48.

**The axial skeleton** (Fig. 1, 2, 13, 14)

There are 53 vertebrae, 35 abdominal and 18 caudal, including the two ural *centra*, in the holotype and 55 vertebrae (35 + 20) in the paratype. The lateral faces of the vertebrae are ornamented with large alveoli. All the neural and haemal elements are autogenous. The neural and haemal spines are long and thin. The first neural spines are bifid. The haemal arches are represented by small paired haemapophyses in the abdominal region. There are 31 (holotype) or 33 (paratype) pairs of long and thin ribs.

The supraneurals are not preserved on the holotype. There are at least 14 supraneurals between the head and the dorsal fin on the paratype, the last ones being only fragments. The first supraneural are broad and plate-like, while the last ones are rod-like.

There are epineurals only in the abdominal region and not in the caudal one. A few long epineurals are attached to the rear of the skull. The following epineurals are fused to the corresponding neural arches. They are much longer than the neural spines. They are firstly oriented ventrally and repose on the *centra*, giving the false impression of being epicentrals but their distal extremities are upwardly curved. The last epineurals are shorter and free. A few short epipleurals are associated to the ribs in the region of the pelvic girdle.

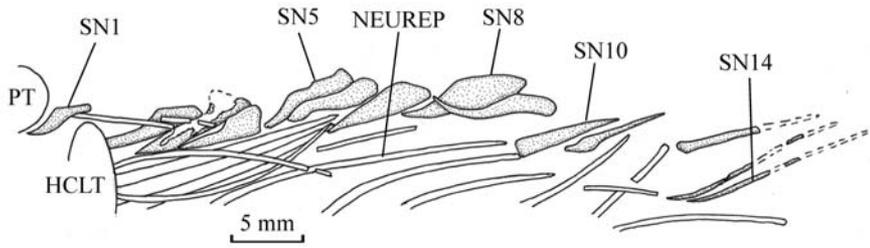


Fig. 13. *Italoalbula pietrarojae* gen. and sp. nov. Supraneurals of paratype CLC I-272.

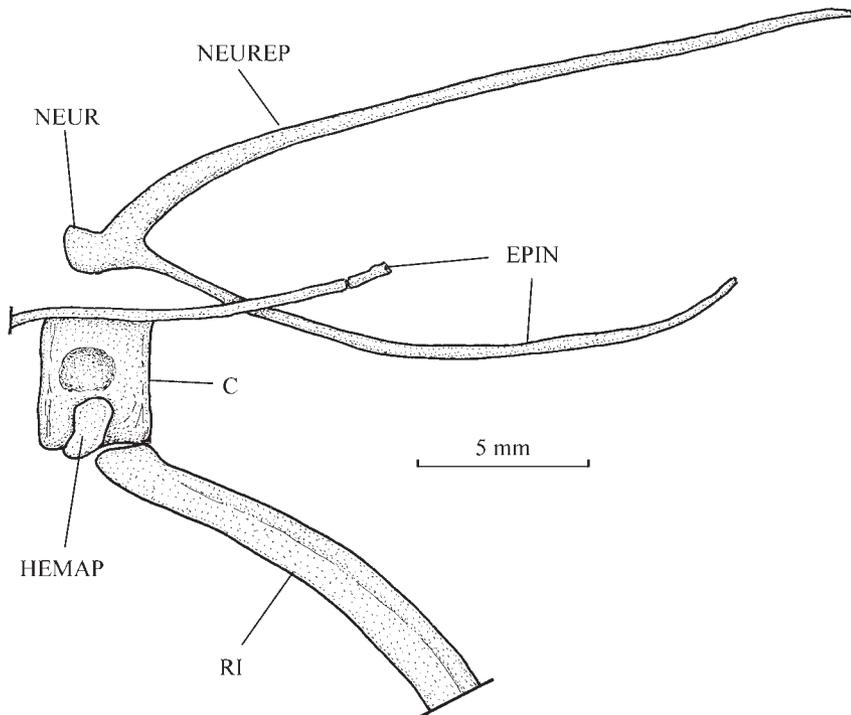


Fig. 14. *Italoalbula pietrarojae* gen. and sp. nov. Eighth vertebra of paratype CLC I-272.

***The dorsal and anal fins*** (Fig. 1, 2, 15-18)

The dorsal fin lies at the mid-point of the back but is incomplete on both specimens. However, the preservation is better on the paratype. The origin of the fin is located at the level of the 25<sup>th</sup> vertebra. The dorsal fin contains 14 rays supported by 13 pterygiophores (= axonosts). The first three rays are small, spine-like and are connected to the first two pterygiophores. The following rays are longer and segmented. The first long ray is attached to the third pterygiophore. The first pterygiophore is bifid and has a stout anterior process fused to its head. The other pterygiophores are simple. Sometimes, the mesonost is visible.

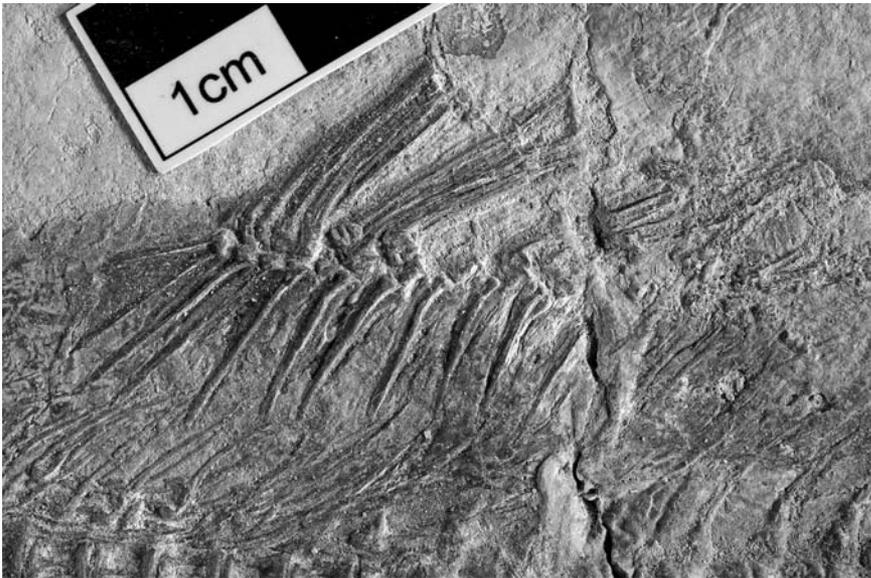


Fig. 15. *Italoalbula pietrarojae* gen. and sp. nov. Region of the dorsal fin of paratype CLC I-272.

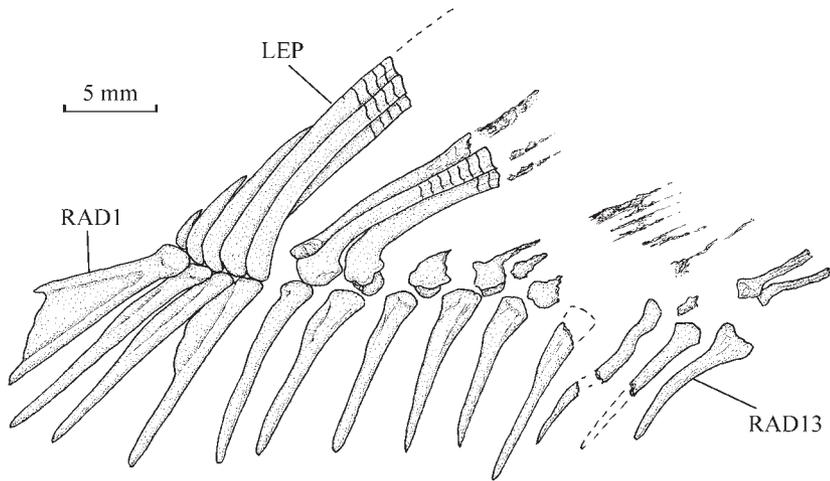


Fig. 16. *Italoalbula pietrarojae* gen. and sp. nov. Dorsal fin of paratype CLC I-272.

The anal fin is short and remote close to the tail. Its origin is located at the level of the 41<sup>st</sup> (holotype) or the 42<sup>d</sup> (paratype) vertebra. The fin is supported by 6 pterygiophores. Fragments of 6 rays are present on the paratype.

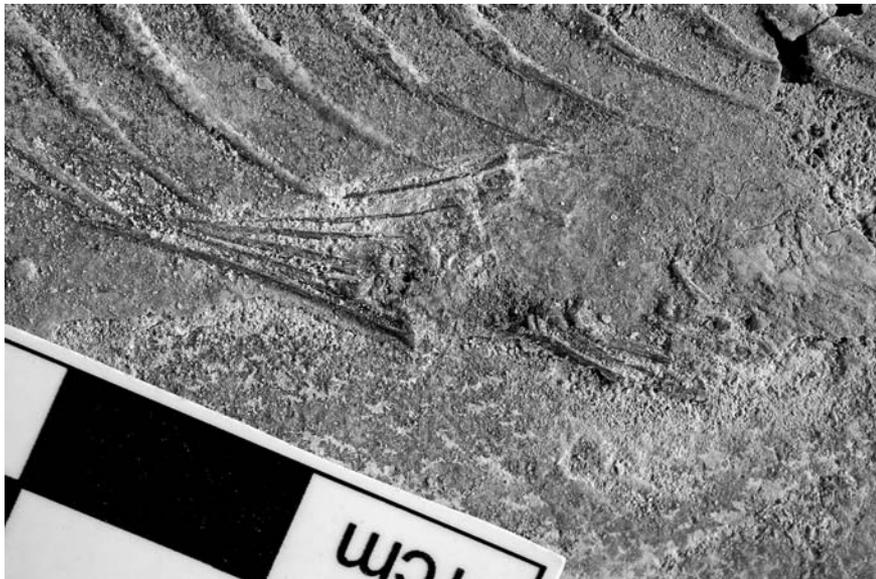


Fig. 17. *Italoalbula pietrarojae* gen. and sp. nov. Region of the anal fin of paratype CLC I-272.

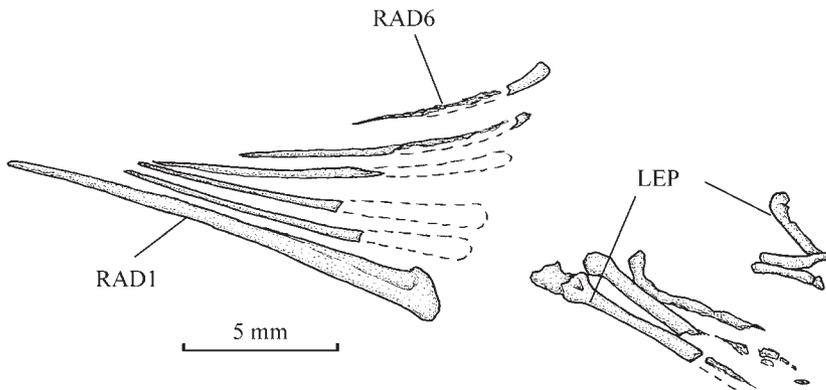


Fig. 18. *Italoalbula pietrarojae* gen. and sp. nov. Anal fin of paratype CLC I-272.

**The caudal skeleton** (Fig. 19, 20)

The caudal skeleton is well visible on both specimens but is a little better preserved on the paratype. The neural and haemal elements involved in the caudal complex are autogenous, included the five visible hypurals (HY1-5). The first preural (PU1) and the two ural (U1, 2) vertebrae are not fused together. PU2, PU1, U1 and U2 progressively decrease in size. U2 is a rather small triangular centrum. The neural spine of PU3 is complete but that of PU2 is slightly shortened. PU1 and U1 are devoid of neural spine but their neural arches are fused together, forming an elongate neural plate. There are three epurals, the middle one being shorter than the two others. The parhypural (PHY) of PU1 and the haemal spines of PU2, 3 and 4 are broader than the preceding ones. PHY is devoid of hypural apophysis. HY1 and 2 are completely fused together, forming a broad ventral hypural plate articulated to U1. The large HY3 and the smaller HY4 are articulated to U2. HY5 is located behind U2. If more posteriorly positioned hypurals are present, they are hidden by the caudal rays. There are three uroneurals (UR1-3). UR1 is the longer of the series. Its anterior extremity is forked. The upper limb of this uroneural reaches the lateral face of PU2 and the lower limb that of PU1. UR2 is unforked and its anterior extremity reaches the boundary between U1 and PU1. UR3 is shorter. On the paratype, UR3 is posteriorly displaced on the caudal rays by an artefact of fossilisation.

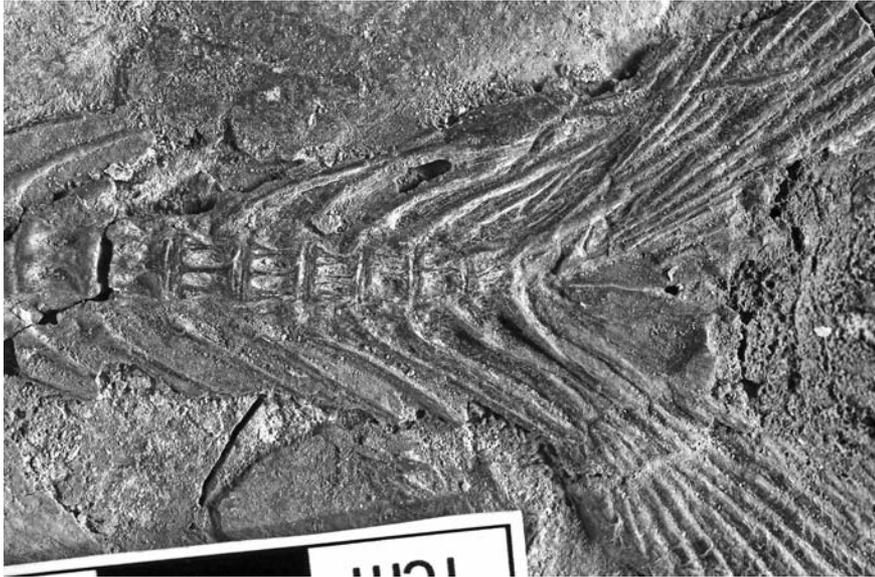


Fig. 19. *Italoalbula pietrarojae* gen. and sp. nov. Tail region of paratype CLC I-272.

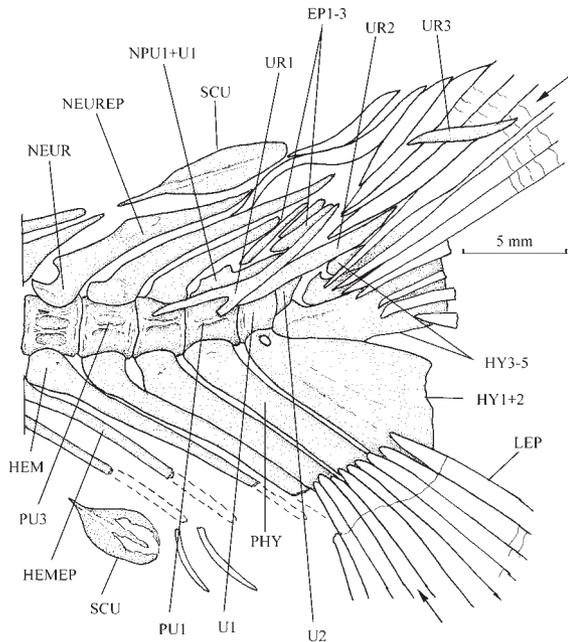


Fig. 20. *Italoalbula pietrarojae* gen. and sp. nov. Caudal skeleton of paratype CLC I-272. The third uroneural is displaced due to the fossilization. The two arrows indicate the most external principal caudal rays.

The caudal fin is deeply forked. There are 19 principal rays, 7 to 10 dorsal and 7 ventral procurrent rays (= basal fulcra). The most external dorsal and ventral principal rays are segmented and pointed. The seventeen other principal rays are segmented and branched. The segmentation follows sigmoid lines. The two longer procurrent rays of each lobe also are segmented. Fringing fulcra are absent.

Well developed dorsal and ventral caudal scutes are present just before the procurrent rays.

### ***The squamation***

The squamation is badly preserved on both specimens but some fragments of cycloid scales are however visible.

## **DISCUSSION**

### ***Italoalbula* within Teleostei**

*Italoalbula pietrarojae* has the maxilla bordering the upper jaw. The skull is medio-parietal. The orbitosphenoid and basisphenoid are preserved. The posterior infraorbitals are large bones. The supratemporal reaches the midline of the skull roof. A gular plate is present. The first epineurals are fused to the neural arches. The pelvic girdle is abdominal. The dorsal and anal fins are devoid of strong spines. PU1, U1 and U2 are autogenous. There are three epurals, three uroneurals and 19 principal caudal rays. All these characters attest that the new Italian fossil fish is a primitive teleost.

*I. pietrarojae* exhibits neural arches on PU1 and U1 that are fused together, forming an elongate plate above these two vertebrae. That is one of the major apomorphies of the orders Elopiformes and Albuliformes (NYBELIN, 1963: Figs 1, 6, 7; FOREY, 1973: Figs 10, 15, 17, 18, 28, 33, 53, 68, 72, 83, 93; among others). *I. pietrarojae* also possesses rostral ossicles, another important apomorphy of these two orders (FOREY, 1973: figs 6, 26, 32, 66, 80, 81; TAVERNE, 1974: Fig. 1). Other teleosts do not share these two apomorphies. The retroarticular fused to the angular is a third specialized character of these two orders (NELSON, 1973) that is shared by the new fish of Pietraraja.

These three features clearly show that *I. pietrarojae* belongs to the superorder Elopomorpha.

### ***Italoalbula* within Elopomorpha**

*Italoalbula pietrarojae* also exhibits a small and slightly inferior mouth, a groove on the premaxilla for the infraorbital sensory canal, a reduced maxilla, only one small supramaxilla, a short triangle-shaped lower jaw, small pointed needle-like tooth on the jaws, a broadened toothed plate on the

parasphenoid, open supraorbital and mandibular sensory canals, the orbitosphenoid lying on the parasphenoid, a small antero-medially directed temporal fossa and an elongate ventral branch of the preopercle. All these characters indicate that the relationships of the new Albian fish are to be found within Albuliformes (FOREY, 1973; FOREY *et al.*, 1996) rather than in Elopiformes that are devoid of such specialized characters.

### ***Italoalbula* within Albuliformes**

The order Albuliformes contains three families, Osmeridae, only occurring in Upper Cretaceous deposits, Albulidae (including Pterothrissinae), a lineage known as fossil but still present today (FOREY, 1973; FOREY *et al.*, 1996; 2003) and Eurokidae, a recently erected family for an Albian fossil fish from Australia (BARTHOLOMAI, 2010). A few fossil taxa left family *incertae sedis*, such as *Branerion* Jordan, 1919, *Paraelops* Da Silva Santos, 1971, *Baugeichthys* Filleul, 2000, *Bullichthys* Mayrinck *et al.*, 2010, *Marathonichthys* Bartholomai, 2013 and *Stewartichthys* Bartholomai, 2013, are also reported to the Albuliformes.

In Osmeridae, the snout is not protruding, the lower jaw is rather elongate, two supramaxillae are present, the anterior extremity of the pterotic largely outpaces the level of the parietal, the branchiostegal rays are very numerous and the two ventral hypurals are completely separated the one from the other (FOREY, 1973: figs 46, 48, 50-55, 57, 59). For all these characters *Italoalbula* differs from the Osmeridae. It is clear that the Italian fish does not belong to this lineage.

In the monogeneric family Eurokidae, the skull is latero-parietal, the snout does not protrude, the lower jaw is elongate, two supramaxillae overlap the maxilla, the jaws exhibit one rank of teeth, the vomer and dermopalatine bear large fangs and the branchiostegal rays are very numerous (BARTHOLOMAI, 2010: figs 1-5). *Italoalbula* can not be reported to such a family.

All the fossil albuliform fishes left family *incertae sedis*, except *Stewartichthys*, have long jaws and one of them, *Maratonichthys*, exhibits a latero-parietal skull (BLUM, 1991; MAISEY and BLUM, 1991; FILLEUL, 2000; MAYRINCK *et al.*, 2010; BARTHOLOMAI, 2013). They strongly differ from *Italoalbula*.

*Stewartichtys* is known by only one specimen reduced to the posterior part of the braincase (BARTHOLOMAI, 2013: figs 6-13). The *dilatator fossa* is extremely atrophied and located on the pterotic. The temporal fossa is surrounded by the pterotic, the parietal, the epiotic and the intercalar. In *Italoalbula*, the *dilatator fossa* is wider and entirely located on the autospheonic and the parietal is not involved in the margin of the temporal fossa. *Stewartichtys* and *Italoalbula* are two different fishes.

Albulidae exhibit a protruding snout, shortened jaws and needle-like teeth. *Italoalbula* shares these apomorphies. The new Italian albuliform fish is thus related to that family.

### ***Italoalbula* and the fossil and recent Albulidae**

*Italoalbula* exhibits many characters that are primitive for the family. There is a gular plate as in *Albula* Scopoli, 1777, *Lebonichthys* Forey, 1973 and *Deltaichthys* Fielitz and Bardack, 1992 (NYBELIN, 1960: Fig. 1; FOREY *et al.*, 2003: Fig. 26; FIELITZ and BARDACK, 1992: Fig. 5). The large posterior infraorbitals cover the cheek as in *Albula*, *Deltaichthys* and *Farinichthys* Gallo and De Figueiredo, 2002 (FOREY, 1973: Fig. 80; FIELITZ and BARDACK, 1992: Fig. 4; GALLO and DE FIGUEIREDO, 2002: Fig. 4). The vomer is toothed as in *Albula* and *Phosphonatator* Cavin *et al.*, 2000 (FOREY, 1973: Fig. 78; CAVIN *et al.*, 2000: 588). The dermobasihyal and the dermobasibranchial are toothed as in *Pterothrissus*, *Deltaichthys* and *Farinichthys* (FOREY, 1973: 135; FIELITZ and BARDACK, 1992: Fig. 7; GALLO and DE FIGUEIREDO, 2002: Fig. 9, 10). The dorsal fin is short as in *Albula* and *Lebonichthys* (FOREY, 1973: Fig. 84, 91; FOREY *et al.*, 2003: Fig. 32; TAVERNE and CAPASSO, 2012: Fig. 15). There are three epurals as in *Pterothrissus* Hilgendorf, 1877 and some species of *Lebonichthys* (MONOD, 1968: Fig. 108; FOREY, 1973: Fig. 68, 90; FUJITA, 1990: Fig. 8; FOREY *et al.*, 2003: Fig. 31 C; TAVERNE and CAPASSO, 2012: Fig. 17). Caudal scutes are present as in *Albula* and some species of *Lebonichthys* (FOREY, 1973: Fig. 83; FOREY *et al.*, 2003: Fig. 31 B, D; TAVERNE and CAPASSO, 2012: Fig. 17).

*Italoalbula* does not possess the advanced characters present in *Albula*, such as the development of a complete bony interorbital septum and the broadening of the last neural spines (FOREY, 1973: Figg. 77, 83).

*Italoalbula* shares a few evolved characters with *Pterothrissus* and *Istieus* Agassiz, 1844, for instance the shortening of the neural spine on PU 2 (MONOD, 1968: Fig. 108; FOREY, 1993: Figg. 68, 72; FUJITA, 1990: Fig. 8) and the reduced number (never more than 10) of branchiostegal rays (FOREY, 1973: 135, Fig. 71). *Italoalbula* and *Pterothrissus* have a triangular expansion on the posterior margin of the upper limb of the cleithrum (FOREY, 1973: Fig. 67).

A detailed comparison between *Italoalbula* and *Phosphonatator* is difficult because that Paleocene albulid fish from Morocco is only known by its braincase. However, the rather posterior position of the lateral ethmoids and the length of the vomer (CAVIN *et al.*, 2000: Figg. 2-4) indicates that *Phosphonatator* has a much elongate snout than *Italoalbula*.

*Italoalbula* exhibits much shorter jaws than in all the other fossil or recent Albulidae. The morphology of the maxilla, the dermethmoid, the parasphenoid and of a few other bones in *Italoalbula* greatly differs from the shape of the same bones in all the known genera of that family. *Italoalbula* also differs from the other Albulidae by its premaxilla not tightly bound to the mesethmoid, by its reduced *dilatator fossa* located on the autosphenotic, by the preservation of three uroneurals and by its fused ventral hypurals. These characters largely justify the peculiar generic status of the new fossil fish from Pietraraja.

## ACKNOWLEDGMENTS

We greatly thank Dr. Silvano Agostini, Superintendent of the Soprintendenza per i Beni Archeologici dell'Abruzzo – Chieti, for allowing us to study the fossil fishes of the Capasso collection. We are grateful to M. Adriano Vandersypen, from the Royal Institute of Natural Sciences of Belgium, and to M. Luciano Lullo, from the University of Chieti, for their technical help. We are also indebted to the anonymous reviewers who have read and commented our text.

## List of abbreviations used in text-figures

AN: angular; ANT: antorbital; ASPH: autosphenotic; BRSTG: branchiostegal rays; BSPH: basisphenoid; C: vertebral centrum; CLT: cleithrum; DBBR: dermobasibranchial; DBHY: dermobasihyal; DETH: dermethmoid (= rostral); DN: dentary; DSPH: dermosphenotic; ECPT: ectopterygoid; EP 1-3: epurals 1 to 3; EPI: epiotic (= epioccipital); EPIN: epineural; FR: frontal; GU: gular plate; HCLT: hypercleithrum (= supracleithrum); HEM: haemal arch; HEMAP: haemapophysis (= parapophysis); HEMEP: haemal spine; HCOR: hypocoracoid (= coracoid *sensu stricto*); HETH: hypoethmoid; HY 1-5: hypurals 1 to 5; HYOM: hyomandibula; IC: intercalar; IOP: interopercle; IORB 1-5: infraorbitals 1 to 5; LEP: fin ray (= lepidotrichia); LETH: lateral ethmoid; MX: maxilla; N PU1+U1: neural arch of preural vertebra 1 and ural vertebra 1; NA: nasal; NEUR: neural arch; NEUREP: neural spine; OP: opercle; OSPH: orbitosphenoid; PA: parietal; PCLT: postcleithrum; PELV: pelvic bones; PHY: parhypural; PMX: premaxilla; POP: preopercle; PS: parasphenoid; PSPH: pleurosphenoid (= pterosphenoid); PT: posttemporal; PTE: pterotic; PU1-3: preural vertebrae 1 to 3; QU: quadrate; RAD (1-13): pterygiophores (= radials) (1 to 13); RART: retroarticular; RI: rib; ROS: rostral ossicles; SCA: hypercoracoid (= scapula); SCU: caudal scute; SETH: suprethmoid; SMX: supramaxilla; SN1-14: supra-neurals 1 to 14; SOC: supraoccipital; SOP: subopercle; SORB: supraorbital; ST: supratemporal (= extrascapular); SY: symplectic; U1-2: ural vertebrae 1 and 2; UR 1-3: uroneurals 1 to 3; VO: vomer. br.: broken; d. f.: *dilatator fossa*; ep.c.: epiphyseal sensory commissure; l.: left; l. l. c: lateral line sensory canal; m. c.: mandibular sensory canal; ot. c.: otic sensory canal; pop. c.: preopercular sensory canal; r.: right; sorb. c.: supraorbital sensory canal; te: teeth; t. f.: temporal (= posttemporal) fossa.

## REFERENCES

- BARTHOLOMAI A., 2010. A new Albian teleost, *Euroka dunravensensis* gen. et sp. nov; and a new family, the Eurokidae from the Eromanga Basin of Queensland, Australia. *Memoirs of the Queensland Museum / Nature*, **55** (1): 69-85.
- BARTHOLOMAI A., 2013. New teleosts (Elopomorpha: Albuliformes) from the Lower Cretaceous (Late Albian) of the Eromanga Basin, Queensland, Australia. *Memoirs of the Queensland Museum/Nature*, **58**: 73-94.
- BLUM S., 1991. *Brannerion* Jordan, 1919. In: MAISEY J. G. (ed.), *Santana Fossils. An illustrated atlas*. T.F.H. editions, Neptune City, U.S.A.: 218-237.
- BRAVI S., 1996. *Ricerche sui livelli ad ittioliti in facies di piattaforma carbonatica dell'Italia Meridionale*. Tesi di dottorato, Università degli Studi di Napoli Federico II: 396 pp.
- CAPASSO L., 2007. *Pietraroja pietre e memorie*. Ed. Paper's World, Teramo: 181 pp.
- CAVIN L., BARDET N., CAPPETTA H., GHEERBRANT E, IAROCHE S.M., SUDRE J., 2000. A new Palaeocene albulid (Teleostei: Elopomorpha) from the Ouled Abdoun phosphatic basin, Morocco. *Geological Magazine*, **137** (5): 583-591.
- COSTA O.G., 1864. Paleontologia del Regno di Napoli. Parte III. *Atti dell'Acad. Pontaniana*, **8**: 1-119.
- D'ERASMO G., 1914. La fauna e l'età dei calcari a ittioliti di Pietraroia. Parte I. *Palaeontographica Italica, Memorie di Paleontologia*, Pisa, **20**: 29-86.
- D'ERASMO G., 1915. La fauna e l'età dei calcari a ittioliti di Pietraroia. Parte II. *Palaeontographica Italica, Memorie di Paleontologia*, Pisa, **21**: 59-111.
- FIELITZ C., BARDACK D., 1992. *Deltaichthys albuloides*, a new and unusually preserved albulid (Teleostei) probably from the Cretaceous of Texas. *Journal of Vertebrate Paleontology*, **12** (2): 133-141.
- FILLEUL A., 2000. *Baugeichthys caeruleus*, gen. et sp. nov., a new albuliform fish from the Hauterivian of the Massif des Bauges (France). *Journal of Vertebrate Paleontology*, **20** (4): 637-644.
- FOREY P.L., 1973. A revision of the elopiform fishes, fossil and recent. *Bulletin of the British Museum (Natural History), Geology, Supplement* **10**: 1-222.
- FOREY P.L., LITTLEWOOD D.T.J., RITCHIE P., MEYER A., 1996. Interrelationships of elopomorph fishes. In: STIASNY M.L.J., PARENTI L. R., JOHNSON G.D. (eds), *Interrelationships of fishes*, Academic Press: 175-191.
- FOREY P.L., YI L., PATTERSON C., DAVIES C.E., 2003. Fossil fishes from the Cenomanian (Upper Cretaceous) of Namoura, Lebanon. *Journal of Systematic Palaeontology*, **1** (4): 227-330.
- FREELS D., 1975. Plattenkalke Becken bei Pietraroja (Prov. Benevento, Sud Italien) als Voraussetzung einer fossillagerstätte Erbildung. *Neues Jahrbuch für Geologie und Paläontologie Abteilung*, **148**: 320-352.
- FUJITA K., 1990. The caudal skeleton of teleostean fishes. Tokai Univ. Press, Tokyo: XIII + 897 pp.
- GALLO V., DE FIGUEIREDO F.J., 2002. *Faugichthys gigas*, a new albulid fish (Teleostei, Elopomorpha) from the Paleocene of the Pernambuco-Paraíba Basin, northeastern Brazil. *Journal of Vertebrate Paleontology*, **22** (4): 747-758.
- MAYRINCK D., BRITO P. M., OTERO O., 2010. A new albuliform (Teleostei: Elopomorpha) from the Lower Cretaceous Santana Formation, Araripe Basin, northeastern Brazil. *Cretaceous Research*, **31**: 227-236.

- MAISEY J.G., BLUM S., 1991. *Paraelops* Da Silva Santos, 1971. In: MAISEY J. G. (ed.), *Santana Fossils. An illustrated atlas*. T.F.H. editions, Neptune City, U.S.A.: 238-247.
- MONOD T., 1968. Le complexe urophore des poissons téléostéens. *Mémoires de l'Institut Fondamental d'Afrique Noire (IFAN)*, **81**: I-VI + 1-705 pp.
- NELSON G., 1973. Relationships of clupeomorphs, with remarks on the structure of the lower jaw in fishes. *Zoological Journal of the Linnean Society*, **53**, Supplement 1: 333-349.
- NYBELIN O., 1960. A gular plate in *Albula vulpes* (L.). *Nature*, **188**: 78.
- NYBELIN O., 1963. Zur Morphologie und Terminologie des Schwanzskelettes der Actinopterygier. *Arkiv für Zoologie*, ser. 2, **15** (35): 485-516.
- SIGNORE M., 2004. Sample excavations in Pietraraja (lower Cretaceous, Southern Italy) in 2001 and notes on the Pietraraja palaeoenvironment. *www.PalArch.nl, Vertebrate paleontology*, **2** (2): 13-21.
- TAVERNE L., 1974. L'ostéologie d'*Elops* Linné C., 1766 (Pisces Elopiformes) et son intérêt phylogénétique. *Académie Royale de Belgique, Mémoires de la Classe des Sciences*, coll. in-8°, 2e sér., **41** (2): 1-96.
- TAVERNE L., CAPASSO L., 2012. Les poissons crétacés de Nardò. 34°. *Nardoelops nybelini* gen. et sp. nov. et *Lebonichthys nardoensis* sp. nov. (Teleostei, Elopomorpha). *Bollettino del Museo Civico di Storia Naturale di Verona, Geologia Paleontologia Preistoria*, **36**: 3-24.
- WOODWARD A.S., 1901. *Catalogue of the fossil fishes in the British Museum (Natural History)*. Part IV. Trustees of the British Museum (Natural History), London: XXX-VIII + 636 pp.