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NEW ICHTHYOSAURIAN (AMNIOTA, ?DIAPSIDA) REMAINS IN THE TRIASSIC OF FRIULI (NE ITALY)

NUOVI RESTI DI ITTIOSAURI (AMNIOTA, ?DIAPSIDA)
NEL TRIASSICO DEL FRIULI (ITALIA NORD-ORIENTALE)

Riassunto breve - Vengono descritti alcuni nuovi resti di ittiosauri rinvenuti in formazioni del Triassico medio del Friuli settentrionale (Provincia di Udine). *Mixosaurus* è riportato dalla Formazione di Dont (Anisico, Pelsonico) dei dintorni di Sauris, mentre una vertebra di un taxon indeterminato di dimensioni medie proviene dalle "Torbidity d'Aupa" (Anisico, Illirico) della Val Aupa (Moggio Udinese). L'esemplare delle "Torbidity d'Aupa" è la prima segnalazione di ittiosauri in una unità litostratigrafica che finora ha fornito solo resti di rettili costieri (sauroterigi basali e *Tanystropheus*) e terrestri (arcosauri).

Parole chiave: Diapsida, Ichthyosauria, *Mixosaurus*, Triassico, Formazione di Dont, "Torbidity d'Aupa", Friuli settentrionale.

Abstract - This paper reports new ichthyosaurian remains found in the Middle Triassic of northern Friuli (Udine Province, Friuli Venezia Giulia, NE Italy). *Mixosaurus* is reported from the Dont Formation (Anisian, Pelsonian) of Chiaranda Creek near the town of Sauris. A single, isolated vertebra of a medium-sized, indeterminate taxon comes from the "torbidity d'Aupa" (Anisian, Illyrian) of the Aupa Valley (Moggio Udinese Municipality). The latter specimen is the first report of an ichthyosaur in the "torbidity d'Aupa" where only coastal (basal sauropterygian and *Tanystropheus*) and terrestrial (archosaur) amniotes were found to date.

Key words: Diapsida, Ichthyosauria, *Mixosaurus*, Triassic, Formazione di Dont, "Torbidity d'Aupa", Northern Friuli.

Introduction

Several remains of reptiles (skeletal and ichnological) have been reported from the Triassic of northern Friuli, namely from the Anisian (RIEPPPEL & DALLA VECCHIA 2001; DALLA VECCHIA 2004b; 2006c), Ladinian (DALLA VECCHIA 1994; 2000b; RIEPPPEL & DALLA VECCHIA 2001), Carnian (ZUCCHI STOLFA 1975; PINNA & ZUCCHI STOLFA 1979; PINNA 1990; DALLA VECCHIA 1994; 1996; 2000b; 2006a; 2008b; RIEPPPEL & DALLA VECCHIA 2001; DALLA VECCHIA & AVANZINI 2002; RIEPPPEL & NOSOTTI 2002; AVANZINI et al. 2007) and Norian (CALZAVARA et al. 1981; WILD 1984; PINNA 1988; DALLA VECCHIA et al. 1989; DALLA VECCHIA 1995; 1998; 2000a; 2002; 2004a; 2006b; BIZZARINI & MUSCIO 1995; MUSCIO 1997; DALLA VECCHIA & MIETTO 1998; RENESTO et al. 2002; RENESTO & DALLA VECCHIA 2000; 2005; 2007).

Ichthyosaurian remains are reported from the upper Anisian (Pelsonian) Dont Formation of the Ambruseit Creek near Piedim (*Mixosaurus* sp.) and the Pian delle Streghe locality of Mount Bivera (?*Cymbospondylus*) (RIEPPPEL & DALLA VECCHIA 2001), the upper Anisian (Pelsonian) pelagic limestone near Pian di Cocés (*Tholodus schmidi*; DALLA VECCHIA 2004b), the upper

Anisian (Illyrian) Bivera Formation of the Pian delle Streghe locality (?*Shastasaurus*) (RIEPPPEL & DALLA VECCHIA 2001) and the upper Ladinian (Longobardian) "calcarei del Clapsavon" of Clap di Val (?*Cymbospondylus*) (RIEPPPEL & DALLA VECCHIA 2001). As *Shastasaurus* has an exclusively Upper Triassic distribution (see MCGOWEN & MOTANI 2003) it is very unlikely that the vertebral centrum from the Bivera Formation of Pian delle Streghe really belong to that genus.

Ichthyosaurs were amniotes returned to an aquatic lifestyle and highly specialized, which populated the seas from the Olenekian (early Triassic) up to the Cenomanian (Late Cretaceous). They were once included in the subclass Euryapsida (amniotes characterized by the presence of the sole supratemporal fenestra in the skull) with Plesiosauroidea, Nothosauroidea, Pachypleurosauroidea and Placodontia (see CALLAWAY 1997a). Successive revision (see CALLAWAY 1997a) and recently the result of some cladistic analyses have suggested that they are diapsids with the infratemporal fenestra lost secondarily (BROCHU 2001; BENTON 2006).

Here two further remains belonging to the Ichthyosauria are described (MFSN 19644 and MFSN 37561), coming both from Anisian units that already yielded vertebrate remains in the past.

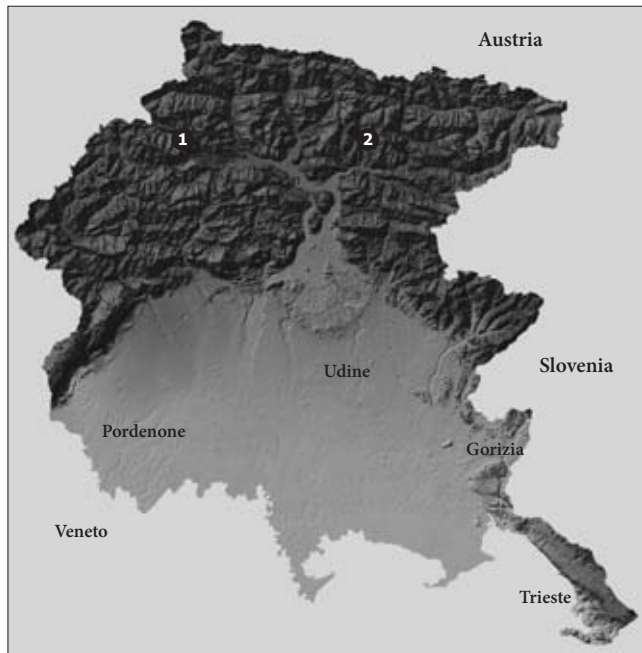


Fig. 1 - Location of the finding sites. 1 = Chiaranda Creek, Sauris; 2 = Aupa valley, Moggio Udinese.
- Posizione delle località di rinvenimento. 1 = Rio Chiaranda, Sauris; 2 = Val Aupa, Moggio Udinese.

Acronyms: MFSN = Museo Friulano di Storia Naturale, Udine; MPUP = Museo di Paleontologia dell'Università di Padova.

Geological and stratigraphical notes

The specimen MFSN 19644 was collected by Pierluigi Fassetta in the debris along the valley of the Chiaranda Creek in the territory of the Sauris municipality (Udine Province; fig. 1). It is preserved in a small block of black limestone with small ammonoids; bones are contained in a set of sub-millimetric laminae, originating from the undisturbed deposition of carbonate mud. Only the lower Triassic Werfen Formation is exposed along the lower-middle part of the valley according to the Geological Map of the Carnic Alps (VENTURINI et al. 2001). Only this formation is exposed in the whole basin of the creek according to the geological map by SELLI 1963. However, lithology and fossils suggest as much more probable the provenance from the Dont Formation (Pelsonian, upper Anisian), which may be present in the valley with small outcrops that cannot be reported in the map. In fact, that thin basinal unit composed of well-bedded black shale and limestone crops out in the close Pian delle Streghe locality, at the base of the NE flank of the Mount Bivera (RIEPPPEL & DALLA VECCHIA 2001).

MFSN 37561 comes from the “torbiditi d'Aupa”, an informal lithostratigraphic unit dated to the late Anisian (Illyrian; DALLA VECCHIA 2006c) cropping out along the Aupa valley, mainly in the banks and bed of the Aupa

torrent close to the village of Saps (Moggio Udinese municipality, Udine Province; fig. 1). DALLA VECCHIA 2006c reports the presence of six distinct fossiliferous sites with vertebrate remains in the “torbiditi d'Aupa” along the Aupa Valley (n. 1 to 6). Most of the specimens described in DALLA VECCHIA 2006c come from site 6, composed of dark siltstone with small carbonate clasts, levels with plant fragments and bivalves, and a thin and often convolute lamination (DALLA VECCHIA 2006c). A fossil-bearing bed not listed by DALLA VECCHIA 2006c because it was discovered later, occurred in the bed of the Aupa Torrent just upstream from the confluence of the Fus Creek. It was destroyed by public works during 2008 and is considered here as the site 7. The specimen here described was collected in a further site (site 8), also occurring on the bed of Aupa Torrent about midway between site 6 and 7. The specimen was included in a hard carbonate nodule inside a yellowish pelite bed. It is the only vertebrate remain found in that bed.

Systematic Paleontology

Phylum Chordata

Subclass Diapsida

Infraclass Ichthyopterygia OWEN, 1840

Order Ichthyosauria BLAINVILLE, 1835

Suborder Mixosauria MOTANI, 1999

Family Mixosauridae BAUR, 1887

Genus *Mixosaurus* (BASSANI, 1886)

Mixosaurus sp.

(Figs. 2-3)

Description: MFSN 19644 is a small portion of a disarticulated skeleton (fig. 2). In particular, some dorsal ribs are preserved, with a thin, long and weakly curved shaft. The proximal articular part is preserved only in one rib and has a single articular head (fig. 2). Most of the other bones represent gastral “ribs” (gastralia) that have a characteristic V-shape with a small apophysis on the vertex (figs. 2-3). The two branches of the V form an angle of 85°. Originally the gastrals were closely spaced to form a “plastron” protecting the ventral part of the trunk. The small apophysis overlapped the preceding element, as can be seen in two gastrals still articulated (fig. 3, right upper corner).

Discussion: *Mixosaurus* is a small-sized ichthyosaur (adult specimens of *M. cornalianus*, *M. atavus*, *M. fraasi* and *M. kuhnschnyderi* are about 1000 mm long) like the reptile under examination. Like MFSN 19644, all ribs in *Mixosaurus* have a single head, excluding the last two or three dorsal ribs and the first two or three caudal ribs (CALLAWAY 1997).

Ichthyosaurs usually have well-developed gastralia covering most of the ventral region of the trunk (see

McGOWEN & MOTANI 2003, fig. 68). *Mixosaurus* has particularly large gastral “ribs” forming a tightly knit plastron (CALLAWAY 1997b). The comparison between the gastralia of the Friulian specimen and those well-preserved in a *Mixosaurus cornalianus* specimen from the Grenzbitumenzone/Besano Formation (Anisian/Ladinian boundary) of Tessin Canton (Switzerland) exposed at the Museo di Paleontologia dell’Università di Padova (MPUP 27546; DALLA VECCHIA 1997) shows the strict resemblance between the gastralia of the two specimens.

Furthermore, *Mixosaurus* has already been reported from the Dont Formation of northern Friuli. Part of a vertebral column was found along the Ambruseit Creek (Piedim, Arta Terme municipality) (RIEPPPEL & DALLA VECCHIA 2001).

Genus indet.
(Figs. 4-5)

Description: The specimen MFSN 37561 was preserved in a carbonate matrix, thus it was freed nearly completely by chemical methods, using diluted formic acid.

It is a single, complete vertebral centrum, nearly discoidal, hour-glass shaped, only slightly deformed and uncrushed. It is 26.95 mm antero-posteriorly long at maximum; it is 49.93 mm wide (along the anterior articular facet) and is 55.80 mm high (along the anterior articular facet). Its outline is sub-hexagonal in antero-posterior view and the articular facets are deeply amphicoelous. It is probably nothocordal, although a very thin film of limestone is still covering the piercing. The zone for the attachment of the pedicels of the neural arch and the neural channel are still covered by limestone, showing clearly that the neural arch was not fused to the centrum. A small bone fragment near the neural channel could belong to the pedicels of the neural arch (fig. 5a), although the latter was not evidently associated with the centrum (R. Rigo, pers. comm.). Distinct diapophysis and parapophysis project from the left lateral sides. They are both elliptical (with main axis dorsoposteriorly to ventroanteriorly elongated) and of a similar size. The parapophysis occurs in the ventroanterior corner of the lateral facet, whereas the diapophysis is placed centrally. The situation in the right side is different: the parapophysis and the diapophysis

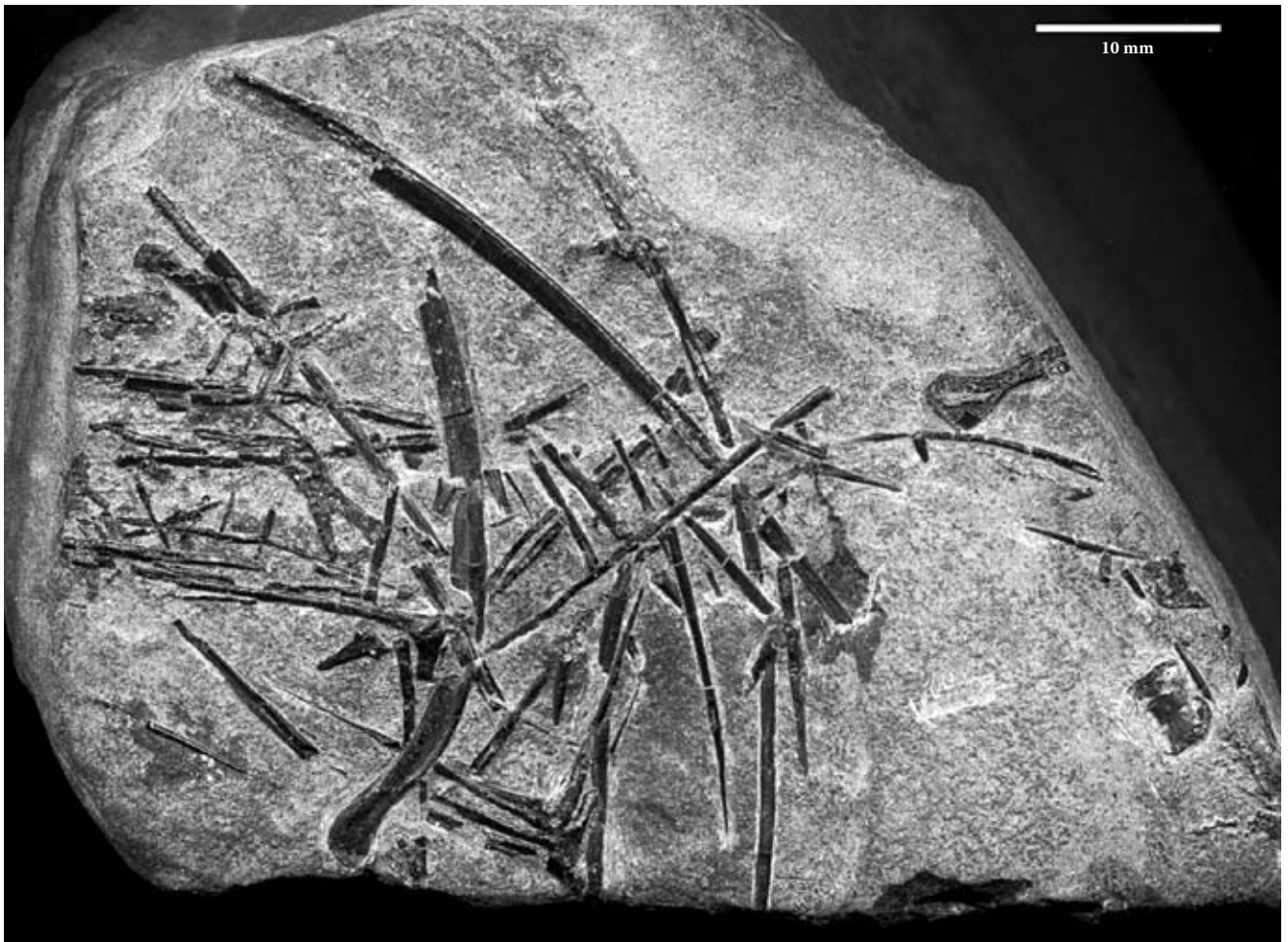


Fig. 2 - The specimen MFSN 19644, *Mixosaurus* sp. Scale bar = 10 mm.
- L'esemplare MFSN 19644, *Mixosaurus* sp. Scala di riferimento = 10 mm.

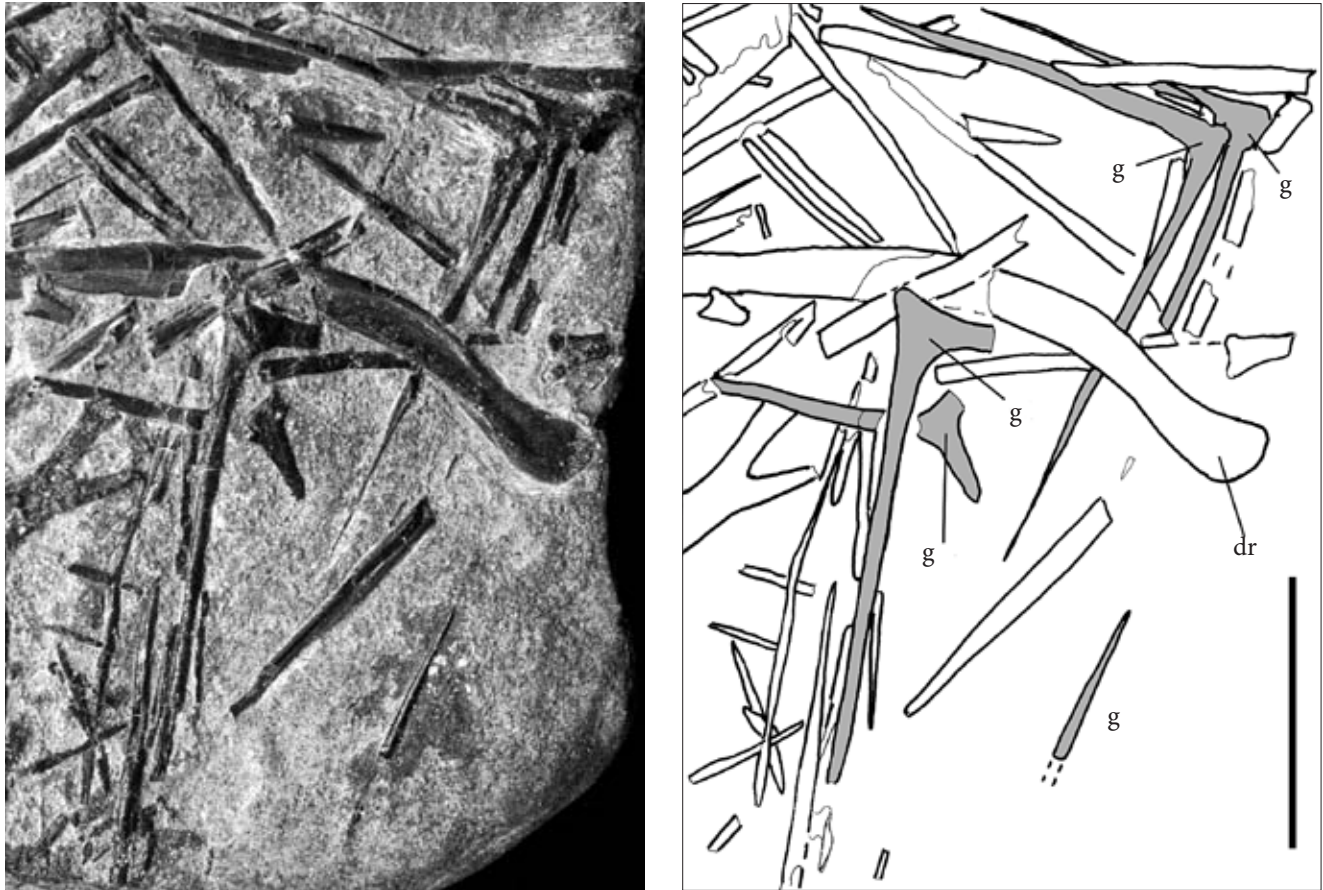


Fig. 3 - The specimen MFSN 19644. Close-up of the gastralia. Left: photograph; right, drawing with the gastralia emphasized in dark grey. Abbreviations: dr = dorsal rib, g = gastral "rib". Scale bar = 10 mm.

- *Lesemplare MFSN 19644. Particolare dei gastrali. Sinistra: fotografia; destra: disegno con i gastrali evidenziati in colore grigio scuro. Abbreviazioni: dr = costola dorsale, g = "rib" gastrale. Scala di riferimento = 10 mm.*

are united forming a ridge running transversally in the ventral half of the centrum.

D i s c u s s i o n : The glass-hour morphology of the bone and all the visible structures support without doubt the identification as a vertebral centrum of an ichthyosaur (see MCGOWEN & MOTANI 2003).

Ichthyosaurians appeared during the latest part of the early Triassic (upper Olenekian; MCGOWEN & MOTANI, 2003), and spread practically worldwide during the Anisian (CALLAWAY & MASSARE 1989; SANDER & MAZIN 1993; HAGDORN & RIEPPEL 1999; RIEPPEL & HAGDORN 1997; MCGOWEN & MOTANI 2003). Thus, their presence in the "torbiditi d'Aupa" is compatible with their stratigraphic and paleogeographic distribution.

The absence of coossification between the neural arch and the centrum is general among ichthyosaurs and is not indicative of immaturity. The shape of the centrum, the presence of distinct diapophysis and parapophysis (at least on the left side) and their position indicate that the centrum is from the posterior part of the dorsal segment of the vertebral column (MCGOWEN & MOTANI 2003). Unfortunately, such vertebrae are not diagnostic to the genus level. If it belonged to the

genus *Cymbospondylus*, which has at least 55 presacral vertebrae (MCGOWEN & MOTANI 2003), the length of the sole presacral vertebral column would be roughly 1.5 m. Taking as reference the reconstruction of *Cymbospondylus piscosus* (Anisian, Nevada, USA) in MCGOWEN & MOTANI (2003, fig. 68C) and based on the size of the preserved centrum, the estimated total body length would be around four meters. Therefore, the specimen MFSN 37561 belongs to a medium-sized ichthyosaur. This excludes the attribution to small-sized Middle Triassic taxa like *Mixosaurus* species, *Parvinator wapitiensis* and *Tholodus schmidi* (MCGOWEN & MOTANI 2003; DALLA VECCHIA 2004b). Medium to large-sized species found in the upper Anisian and basal Ladinian are: *Cymbospondylus* spp. (Anisian, Nevada and Switzerland), *Phantomasaurus neubigi* (upper Anisian, Germany), *Besanosaurus leptorhynchus* (Anisian/Ladinian boundary, Italy), *Mikadocephalus gracilirostris* (Anisian/Ladinian boundary, Switzerland), *Wimanius odontopalatus* (Anisian/Ladinian boundary, Switzerland) and *Pessosaurus polaris* (Ladinian, Spitsbergen) (MCGOWEN & MOTANI 2003). The ichthyosaur of the "torbiditi d'Aupa" could belong to one of those species or to a still unknown species.

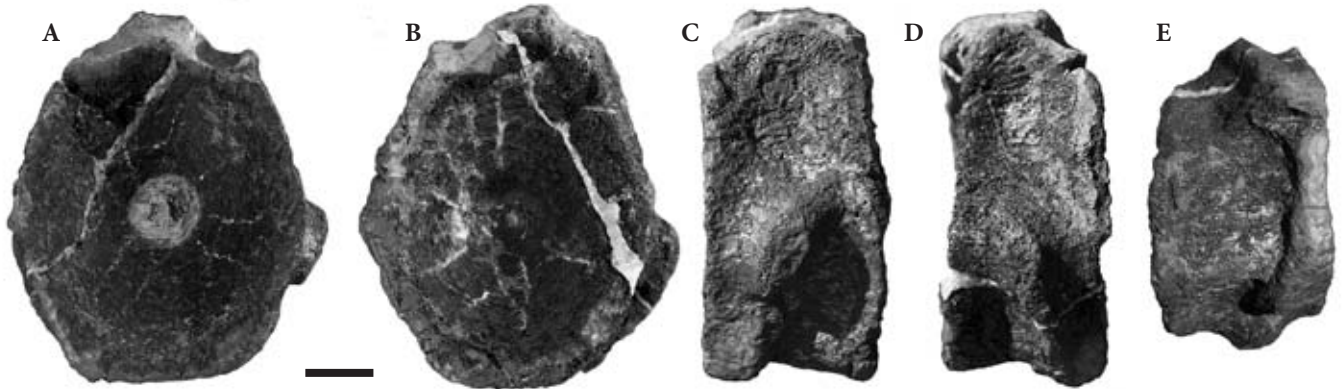


Fig. 4 - The specimen MFSN 37561, posterior dorsal vertebra of a medium-sized ichthyosaur. A) Anterior view, B) posterior view, C) left lateral view, D) right lateral view and E) ventral view. Scale bar = 10 mm.

- *Lesemplare MFSN 37561, vertebra dorsale posteriore di un ittiosauro di medie dimensioni. A) Vista anteriore, B) vista posteriore, C) vista laterale sinistra, D) vista laterale destra; E) vista ventrale. Scala di riferimento = 10 mm.*

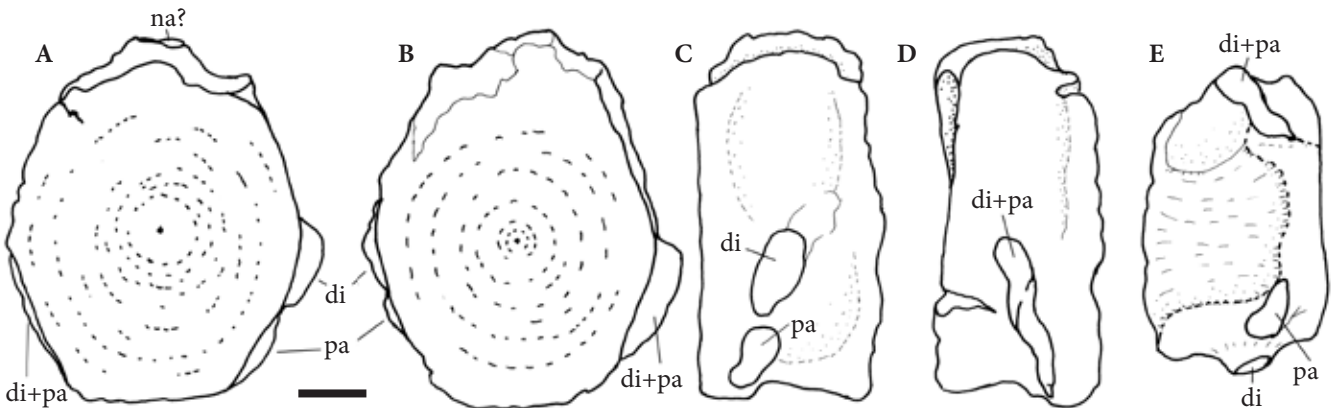


Fig. 5 - The specimen MFSN 37561, posterior dorsal vertebra of a medium-sized ichthyosaur, drawings. A) Anterior view, B) posterior view, C) left lateral view, D) right lateral view and E) ventral view. Abbreviations: di = diapophysis; na = neural arch, pa = parapophysis. Scale bar = 10 mm.

- *Lesemplare MFSN 37561, vertebra dorsale posteriore di un ittiosauro di medie dimensioni, disegni. A) Vista anteriore, B) vista posteriore, C) vista laterale sinistra, D) vista laterale destra; E) vista ventrale. Abbreviazioni: di = diapofisi; na = arco neurale, pa = parapofisi. Scala di riferimento = 10 mm.*

Conclusions

Ichthyosaur remains are rare in Italy and every new specimen is important. Their remains are relatively frequent only in the Besano Formation (Anisian/Ladinian boundary) of Mt. S. Giorgio, Lombardy (TINTORI et al. 2005b), which extends also in Switzerland where it is known as Grenzbitumenzone.

A partial skeleton referred to *Cymbospondylus* was found in the Livinallongo Fm. (Ladinian, Middle Triassic) of Mount Seceda, Alto Adige/Südtirol (KUHN-SCHNYDER 1980). Isolated vertebrae come from the Anisian of Bergamo province (*Cymbospondylus* sp.; RIEPPEL & DALLA VECCHIA 2001) and the upper Carnian (Dürrenstein Fm.) of Dolomites (*Shonisaurus*; DALLA VECCHIA & AVANZINI 2002). A complete Jurassic ichthyosaur was found in the Calcari Diasprigni (Kimmeridgian) of Genga locality, Marche Region (TINTORI et al. 2005a). An isolated tooth from the Lower Jurassic of Mount Traunig at the border between Friuli and Slovenia was reported

as "*Ichthyosaurus* sp." by SELLI (1953). Some remains of Cretaceous ichthyosaurs (referred to *Platypterygius* sp.) come from the Complesso Caotico Alloctono of northern Apennines (Provinces of Bologna and Modena; DALLA VECCHIA et al. 2005 and references therein).

The specimen from the Chiaranda Creek suggests that the small ichthyosaur *Mixosaurus* might be widespread in the basinal deposits of the Dont Formation, which were deposited under conditions of oxygen depletion and preserve also fish and ammonoid remains (DALLA VECCHIA 2008a). This is not surprising, this genus being common worldwide in the Middle Triassic pelagic facies (CALLAWAY & MASSARE 1989; SANDER & MAZIN 1993; MCGOWEN & MOTANI 2003).

The depositional environment of the "torbiditi d'Aupa" was considered as deep marine by several authors (e.g., JADOUL & NICORA 1979; FARABEGOLI et al. 1985; NICORA & RIZZI 1998). DALLA VECCHIA 2006c suggested on the base of the tetrapod assemblage that deltaic environments prograded into the basin at the top

of the regressive cycles from the close “Dorsale Paleocarnica” (Paleocarnic land) occurring just to the north (see FARABEGOLI et al. 1985). The vertebrate-bearing level would correspond to a regressive event (DALLA VECCHIA 2008a). In fact, following an approximate order of frequency, the tetrapods found in the fossiliferous sites of the “torbiditi d’Aupa” along the Aupa valley belong to the large protosauroid *Tanystropheus*, to one or more crurotarsal archosaurs (probably “rauisuchian”), to a large-sized nothosauroid sauropterygian and to a cyamodontoid placodont (DALLA VECCHIA 2006c; 2008a).

The nothosauroids and the placodonts are coastal marine amniotes; *Tanystropheus* was also a coastal amniote that different authors consider both marine or, less frequently, terrestrial (see RENESTO 2005; DALLA VECCHIA 2006c; NOSOTTI 2007). The archosaur might be terrestrial, as most of the Triassic archosaurs, but an aquatic lifestyle cannot be excluded on the basis of the preserved bones. Anyway, none of the tetrapod remains found to date belonged to a pelagic form well adapted to swim and live in the open sea.

As noted by DALLA VECCHIA 2006c, the association globally resembles that of the central part of the Grenzbittumenzone/Besano Formation (Anisian/Ladinian boundary) of Switzerland and Italy (RÖHL et al. 2001), the main difference being the absence of the small pachypleurosaurians sauropterygians and the ichthyosaurs, as well as the rarity of the ammonoids. This would suggest a sedimentary environment with a lesser pelagic influence for the Aupa basin during the intervals of vertebrate deposition (DALLA VECCHIA 2006c).

The report of an ichthyosaurian remain would appear contrasting this interpretation. However, the ichthyosaurian vertebra is not associated with the typical fauna of sites 1 to 6 and 7 and cannot be used to affirm that ichthyosaurs were part of that faunal assemblage. It comes from a distinct site where it is the only vertebrate found to date and most probably from a stratigraphic level distinct from those yielding *Tanystropheus*, sauropterygians and archosaurians, as is also suggested by the different lithology. Therefore, that site could reflect more open conditions with respect to sites 1 to 6 and 7, related to sea level oscillations.

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