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ANOMOEODUS (NEOPTERYGII, PYCNODONTIFORMES) IN THE TURONIAN MARLY LIMESTONE OF THE '*AZILÉ SERIES*', OF THE SURROUNDINGS OF OWENDO, GABON

SUMMARY

The author provides the first report of the presence of pycnodonts in the Turonian limestone of the "Azilé series", for the Owendo port region (Gabon). These were found in association with a rich malaco-fauna, echinoderms, bryozoans and plants that were characteristic of coastal marine environments with a rocky seabed. The findings on which this indication is based are predominantly the dental apparatus. These demonstrate the characteristic random disposition of the anterior teeth, which are, moreover, typically very small and semi-spherical, as seen exclusively for the genus *Anomoeodus*. Although the author does not consider there is a need to establish a new species, the materials described show some peculiar characteristics that together form a complex of anatomical characters that are here designated provisionally as 'species A'. These are: absence of diastemas in the pre-articular series (in contrast to the large diastemas of the vomerine series); a low number of pre-articular batteries (four); and a small number of elements in each pre-articular battery. These pycnodonts of the port of Owendo, which lies almost on the equator, represent today the southernmost report of the genus *Anomoeodus*, which, however, still remains limited geographically to the northern hemisphere.

RIASSUNTO

L'autore segnala per la prima volta la presenza di picnodonti nei calcari turoniani della "Serie di Azilé", della regione del porto di Owendo, Gabon, in associazione con una ricca malaco-fauna, echinodermi, briozoi e vegetali, caratteristica di un ambiente marino costiero con fondo roccioso. I reperti

sui quali è basata la segnalazione sono in prevalenza apparati dentari, che dimostrano la caratteristica disposizione casuale dei denti anteriori i quali, peraltro, risultano tipicamente minuti e semisferici, come accade esclusivamente nel genere *Anomoeodus*. Nonostante l'autore non ritenga di erigere una nuova specie, i materiali descritti mostrano alcune caratteristiche peculiari che, nel loro assieme, configurano un complesso di caratteri anatomici che l'autore designa provvisoriamente come "Specie A"; essi sono: assenza di diastemi nelle serie pre-articolari (in contrasto con ampi diastemi nelle serie vomerine), basso numero di batterie pre-articolari (quattro) ed esiguo numero di elementi in ciascuna batteria pre-articolare. Quella del porto di Owendo, quasi a ridosso dell'equatore, rappresenta ad oggi la più meridionale delle segnalazioni del genere *Anomoeodus,* il quale permane comunque geograficamente limitato all'emisfero boreale.

INTRODUCTION

The so-called Gabon Coastal Basin is part of a series of coastal basins that were active in the Mesozoic and the Cenozoic of West Africa. These were not only equatorial, as they also extended into tropical areas that spread almost uninterruptedly from southern Morocco to South Africa. Many mainly carbonate formations have been identified in the complex of the sediments deposited in these basins during the Middle and Upper Cretaceous, the palaeontological content of which has been described in countless specialised studies.

There are also fish remains among these coastal paleo-fauna, although the presence of pycnodonts is particularly sporadic. Indeed, the remains of pycnodonts were described for the Maastrichtian and the Palaeocene of Niger (Arambourg & Joleaud, 1943; Capetta, 1972), for Santoniano di Vonso in the Congo (Dartevelle & Casier, 1959), for the Palaeocene of Cabinda, Angola (Longbottom, 1984), and for the Upper Cretaceous of the Popenguine Cliffs, in Senegal (Capasso, 2019).

In Gabon, the first Cretaceous fauna from these sediments that are typical of the tele-Mesozoic coastal basins have only recently been collected and described: Musavu Moussavou & Mougola (2016) described a gastropod and bivalve malacofauna contained within the Turonian limestone of the port area of Owendo, while Musavu Moussavou (2017) described fossil oysters from the Turonian limestone around Libreville. Collections carried out during the second half of the last century in the port area of Owendo by the French palaeontophile Joël Vinot, of Mandelieu la Napoule, demonstrated the presence of pycnodonts in the same carbonate formation of the Turonian age for which Musavu Moussavou & Mougola (2016) described their aforementioned malacofauna.

GEOLOGICAL FRAMEWORK

The present study describes the remains of pycnodonts (i.e., teeth and cranial bone fragments) collected in the so-called "Series of Azilé" (Hourcq and Hausknecht, 1954). This series is attributed to the Turonian and is about 650 m thick (Hudeley and Belmonte, 1970), and it includes both carbonate and siliciclastic facies. In the region of the port of Owendo, this series emerges mainly with limestone, marl and dolomite. It has been studied in detail in two particular locations where natural sections are exposed: the so-called section of the SGEPP (because it is right next to the *Société Gabonaise d'Entreposage des Produits Pétroliers*); and the section of Port à Bois (Mbina Mounguengui, 1998). These were the two locations where Musavu Moussavou and Mougola (2016) collected a rich fossil malacofauna that was associated with the fossil remains of algae, bryozoans, echinoderms, foraminifera, ostracods and vegetation. It should be noted that to date, no vertebrate fossils have been reported. Therefore, the pycnodonts presented here are the first indications of fossil fish for the Azilé series.

MATERIALS

The remains of the pycnodonts that are the object of the present study consist of the following findings, all of which belong to the Public Collection of Fossil Fishes of Luigi Capasso (CLC) of Chieti (Abruzzo, Italy). The relevant national interest of this collection - pursuant to Law 1089/39, and its following modifications - was acknowledged by the Ministry for Cultural and Environmental Heritage through the Ministerial Decree of 11 October, 1999. Moreover, this CLC public collection also corresponds to the requisites of the Law on the accessibility of finds, as defined in Article 30 of Law N° 42/2004. The materials in question are as follows:

CLC N° S-1180a – Pre-articular right, almost complete, with four (incomplete) dental series of the splenic dentition, on a matrix (Figure 1A).

CLC N° S-1180b – Pre-articular left fragment with four teeth of the lateral series, on a matrix.

CLC N° S-1180c - Three sequential splenic teeth.

CLC N° S-1180d - A splenic tooth on a matrix.

CLC N° S-1172 - A right incisor (pre-maxillary) on a matrix (Figure 1C).

CLC N° S-1179 - Almost complete vomerine dentition (Figure 1B).

CLC N° S-1186 - Four single teeth, one of which is on a matrix.

All the materials listed here were collected in the Turonian marly limestone of the Azilé series, in the port area of Owendo, about 15 km south of Libreville, about halfway between Owendo Railway Station and Owendo

Port, in a small natural section that was exposed along the Boulevard de l'Indipendance, immediately in front of the Sobraga Brewery.

DESCRIPTION

Although not all of the listed materials are univocally classifiable, most of them can be determined as teeth and fragments of cranial bones from the genus *Anomoeodeus*.
Class: Osteitti
Subclass: Actinopterigi
Superorder: Neopterigi
Order: Pycnodontiformes Berg, 1937
Family: Pycnodontidae Agassiz, 1833
Genus: *Anomoeodus* Forir, 1887
Anomoeodus sp. A
(Figure 1)

The most complete specimens show all of the typical characteristics of the genus *Anomoeodus* (Pyato-Ariza and Wenza, 2002). The pre-articular teeth have an elongated lozenge shape and a sigmoidal profile, and are sinuous, sometimes with the form of a 'drop', with the apex pointing towards the symphysis region; and they are assembled in batteries (i.e., series), in each of which the individual elements are positioned obliquely. For all of the specimens where the teeth are still in sequence, the free spaces between the teeth (i.e., the diastemas) are very small in the pre-articular series, so that the single series have a tight appearance (Figure 1A). On the contrary, the diastemas are relatively much wider for the only vomerine dentition specimen (Figure 1B).

The arrangement of the individual teeth within the dental batteries of the pre-articular show one fundamental feature: while the posterior teeth are arranged in regular series, the anterior teeth are arranged randomly, without any order. Also, the general morphology of the pre-articular teeth varies a lot according to the topographic position within the single batteries: only the rear teeth, which are larger, have the characteristic elongated lozenge morphology and sigmoidal profile. Instead, the front teeth, which are randomly arranged, are semi-spherical, with an almost perfectly circular profile, and are small (Figure 1A).

In all of these specimens, the dental batteries appear to be at most only four for the pre-articular, while in the vomerine dentition, there were certainly five rows. The occlusal surface is concave in the teeth of the para-median row, and convex for those of the outermost row. The outer margin of the pre-articular bone is smooth, thin, and sometimes has sharp edges (Figure 1A).

The vomerine dentition consists of five series: the median series with

teeth with a hexagonal profile; the lateral series with teeth with a trapezoid profile; and the outer teeth with a reniform profile (Figure 1B). In the most complete of these specimens, there is a maximum number of teeth for each series of eight, although this low number is probably because the specimens are incomplete. Interestingly, the only example of an incisor tooth, which certainly comes from the right dentition, is a large scalpelliform tooth, with a cutting edge (Figure 1C).

Fig. 1A. Remains of *Anomoeodus sp. A*, from the Turonian marly limestone of the port of Owendo (Gabon). (A) Partial right pre-articular (CLC N° S-1180a). (B) Vomerine dentition (CLC N° S-1179). (C) Incisor tooth of the right dentition (CLC N° S-1172).

Fig. 1B

Fig. 1C

The numerous isolated teeth are all pre-articular teeth. Some of them are large, lozenge-shaped, with a sigmoidal profile (i.e., those that come from the back of the pre-articular dental series), while others are small and semispherical (i.e., those that come from the front of the pre-articular dental series).

\All these characteristics are typical of the genus *Anomoeodus* (characters #43, #44, #45, #46 and #51 of the systematic scheme proposed by Poyato-Ariza and Wenza, 2002). However, the number of pre-articular dental series is low, on the basis that Poyato-Ariza and Wenza (2002) considered a variability of a minimum of five to a maximum of six prearticular dental batteries for each side as characteristic of the genus *Anomoeodus*. This might be a typical characteristic of the Turonian specimens of Gabon, and might indicate the need to establish a new species. However, the author prefers not to enter into this aspect, even if other authors – some even recently – have considered it appropriate to establish new species of the genus *Anomoeodus* based on a few specimens, as mainly dental remains (*Anomoeodus paucise-riale* Kriwet, 2002). Moreover, this latter species is characterised by only four dental batteries for the pre-articular and by the presence of only seven dental elements for each series. This differs substantially, however, both in terms of the shape and the arrangement of the individual teeth, and the absence in the present specimens of diastemas.

Therefore, according to the usual prudence for the establishment of new palaeontological species based mainly on dental remains, it is preferable here not to continue with the generic attribution of the exhibits described here. The author limits himself here to the defining of the anatomical peculiarities that characterise these Gabon specimens, and that form a morphological set that will temporarily be referred to as "species A". These specimens thus await new possible and more complete specimens, and more extensive palaeontological data.

These Owendo specimens have a complex of anatomical characteristics that are at the same time peculiar and typical, and that shape what is called here "species A". These include: absence of diastemas in the pre-articular series (in contrast to large diastemas in the vomerine series); a low number of pre-articular batteries (four); and a small number of elements in each pre-articular battery.

DISCUSSION

The genus *Anomoeodus* was established by Forir (1887) on the basis of the isolated pre-articular dentition, to which the name of *Pycnodus subclavatus* was attributed. To date, more than 30 species of pycnodonts have been described in this genus, which appears well characterised and easily recognizable through the typical way in which the teeth are arranged in the pre-articular bone: elongated and large teeth arranged in regular rows posteriorly, and small circular teeth arranged in a disorderly fashion in the anterior region of the single pre-articular bone.

The genus *Anomoeodus* is ubiquitous, although it is predominantly limited to the Upper Mesozoic. The most complete specimens come from the Lower Cretaceous in Spain (Kriwet, 1999), from the Upper Cretaceous in England (Woodward, 1917; Kriwet, 2002), from various locations in France (Cornuel, 1877), and from Bohemia (Fritsch, 1878). This last, however, represents the first and oldest configuration of a pre-articular attributable to the genus *Anomoeodus* (Figure 2). The genus *Anomoeodus* has also been well demonstrated for the Maastrichtian of Belgium and Holland (Leriche, 1929), for the Upper Cretaceous of Kansas (Shimada and Everhart, 2009), Texas (McKinzie, 2002) and Arkansas (Hussakof, 1947) in the USA, and for Sweden (Bazzi *et al*., 2015).

From the stratigraphic point of view, and according to Kriwet (2002), *Anomoeodus* appeared in Kimmeridgiano (Upper Jurassic) and survived until the Eocene, although recently Kriwet himself has questioned some of the post-Mesozoic dating of the *Anomoeodus* findings in the literature.

The current indications certainly serve to enrich the knowledge of the fauna contained in the limestone of the "Azilé series", for which, to date, there have

been no traces of vertebrates. On the basis of the study of the malacofaunas that are abundantly present in the limestone of the Azilé series that are outcropping in the port area of Owendo, Musavu Moussavou and Mougola (2016) reconstructed the palaeoenvironmental conditions that were interpreted as marine coasts of high energy, with a prevalently rocky seabed. In this environment, the habitat of medium-sized durivorous pycnodonts is also perfectly placed, for which there should also be those of the genus *Anomoeodus*.

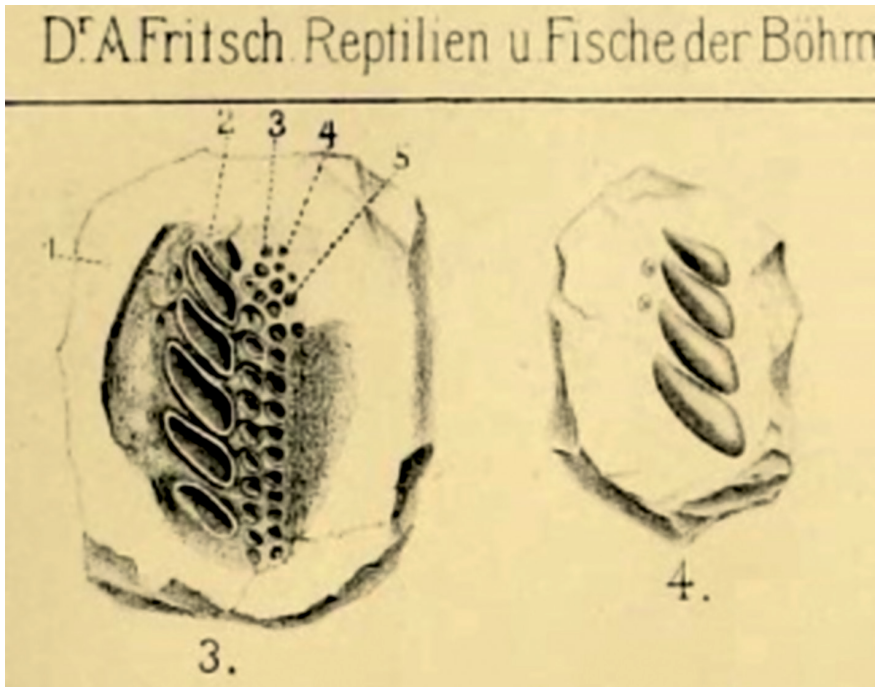

Fig. 2. The first illustration of pre-articular dentition of *Anomoeodus*: *Pycnodus cretaceous* Agassiz from the Cretaceous of Bohemia (from Fritsch, 1878, Table 2, Figures 3, 4).

CONCLUSIONS

The presence of the remains of *Anomoeodus* spp. in the Turonian limestone of the region of the port of Owendo is confirmation of the ubiquity of this pycnodont that was particularly characteristic of the Middle and Upper Cretaceous. The *Anomoeodus* specimens reported here, however, are at present indicative of the southernmost reaches of a genus that has previously only been reported in boreal locations.

At the taxonomic level, the *Anomoeodus* specimens described here have

anatomical peculiarities that define what the author tentatively names as "species A", and which can be summarised in the following three characters: absence of diastemas in the pre-articular series (in contrast to large diastemas in the vomerine series); a low number of pre-articular batteries (four); and a small number of elements in each prearticular battery.

At the palaeo-ecological level, the presence of pycnodont remains in association with bivalves and cliff gasteropods reinforces the reconstructions according to which the Turonian series of the Azilé limestone was deposited in a coastal environment of high energy (i.e., coastal cliffs).

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