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MUCCHI - MODENA

A male fish *Bothus podas* (Delaroche, 1809) [Pleuronectiformes: Bothidae] in the Pliocene of the Marecchia river (Italy)

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ABSTRACT – The aim of this paper is a new study of a fossil flatfish discovered in the Pliocene sediments along Marecchia river (Poggio Berni, near Rimini, Eastern Central Italy). L. Sorbini (1988) considered it as member of the Recent genus *Bothus*. Further works on extant fauna provided arguments to specify that this fossil is a male specimen of *Bothus podas* (Delaroche, 1809).

RIASSUNTO – [Un esemplare maschio di *Bothus podas* (Delaroche, 1809) [Pleuronectiformes: Bothidae] del Pliocene del fiume Marecchia (Italia)] – Viene studiato un pleuronettiforme ritrovato nel Pliocene medio-superiore del fiume Marecchia (Poggio Berni, Rimini, Italia centrale) ed attribuito da Sorbini L. (1988) al genere *Bothus*. Recenti studi sulle specie viventi hanno permesso di precisare che si tratta di un esemplare maschio della specie attuale *Bothus podas* (Delaroche, 1809).

RESUMÉ – [Un spécimen mâle de *Bothus podas* (Delaroche, 1809) [Pleuronectiformes: Bothidae] dans le Pliocène de la rivière Marecchia (Italie)] – En 1988, L. Sorbini mentionne la présence d'un poisson plat fossile du genre *Bothus* dans les sédiments pliocènes des rives de la rivière Marecchia (Poggio Berni, Est de Rimini, Italie Centre-orientale). Des travaux récents sur les espèces actuelles ont apporté des arguments permettant d'affirmer que ce fossile correspond à un individu mâle de l'espèce *Bothus podas* (Delaroche, 1809).

INTRODUCTION

In 1988 Sorbini L. presented the diverse ichthyofauna of the Marecchia river, a new fossil locality of Middle-Late Pliocene discovered in the late 1970s due to river erosion. The active collaboration of amateurs and four regular excavation campaigns organized by the "Museo Civico di Storia Naturale di Verona" between 1982 and 1984, resulted in a collection of over 2,000 specimens. This assemblage included a very well preserved flatfish specimen. Sorbini (1988) identified this specimen as a representative of the genus *Bothus*. Further works on recent species provided data to identify precisely the taxonomic status of this fossil.

GEOLOGICAL SETTING

The fossil deposit consists of 15 sapropelitic layers outcropping along the bed of Marecchia river (near Poggio Berni locality, Rimini province) for an extent of about 5 km (Text-fig.1).

The sedimentary succession of the Marecchia valley represents the infilling of an atypical foreland molasse basin (Ricci Lucchi & Ori, 1985) and the Pliocene is represented by deep-water hemipelagic claystones covered by chaotic deposits and sediments. The upper 450 m of the section are characterized by the presence of 15 layers of thick, laminated, often diatomaceous, dark pelites, alternating with biotur-

bated and homogeneous marly-silty clays (Rio *et al.*, 1997). These laminated dark sediments, called sapropels, are indicative of oxygen-deficient bottom waters which allowed the good preservation of ichthyoliths. Biomagnetostratigraphic correlation of the Marecchia section with other sapropel-bearing sections in southern Italy and with astronomical curves permitted to date the fossiliferous sapropels succession from 3.1



Text-fig. 1 - Geographical localization of Marecchia river, Italy.

Ma to 2.2 Ma corresponding to Piacenzian and Gelasian stages (Middle-Late Pliocene) (Rio *et al.*, 1997). The Marecchia fish fauna consists of 37 families and 48 genera almost all referred to living taxa: exceptions are three fossil species dated back to Middle Pliocene and Late Miocene. From a biogeographical point of view, 80% of genera presently live in the Atlantic-Mediterranean biogeographic region and 20% live in Indo-Pacific or Est Atlantic tropical-subtropical areas.

The analysis of the Marecchia fossil fish ecology identifies this ichthyofauna as a marine complex dominated by coastal and open sea forms as well as by epi- and mesopelagic taxa; furthermore a large number of species connected to rather shallow bottoms is also present. In addition to fishes, dolphins and cephalopods, also insects, frogs and terrestrial plant leaves were found in this site, suggesting that the Marecchia depositional basin was not far from the coast where weak currents carried dead littoral and continental organisms toward deeper zones (Sorbini, 1988).

Benthic foraminifera present throughout the section indicate a lower epi-bathial depositional environment with a minimum depth of about 500-700 m and a maximum depth of about 1000-1,200 m, with no indication of any major paleobathymetric changes through the section. Therefore these sediments are considered to have been deposited on the slope of a subsiding basin (Rio *et al.*, 1997). According to Colalongo *et al.* (1982), the laminated organic diatomaceous pelites in which the Marecchia ichthyofauna was preserved correspond to deep-sea stagnation cycles which were associated with phenomena of eutrophication of the water that caused the mass-death in the ichthyofauna.

MATERIAL EXAMINED

Bothus sp., Museo Civico di Storia Naturale di Verona (Verona, Italy), Collection Sabbatini, Marecchia, n. 517.

Comparative Recent material: *Arnoglossus* sp. ANSP-145256 (3). *Arnoglossus imperialis* NMC-600322 (1). *Arnoglossus fisani* AMS-I-3372003 (1), AMS-I-33661001 (2). *Arnoglossus laterna* MNHN-154-1 (4). *Arnoglossus thori* MNHN-1962-62-Banyuls (5). *Bothus lunatus* NMC-682101 (1). *Bothus maculiferus* NMC-680275 (2). *Bothus podas* MNHN-1977-126 (1, male), MNHN-1975-422 (1, male), MNHN-1958-154 (1, female). *Crossorhombus azurea* AMS-I-31484009 (3), AMS-I-22806020 (3). *Engyprosopon blakeri* AMS-I-33663001. (4). *Engyprosopon grandisquama* AMS-I-20771044 (1). *Grammabothus polyphthalmus* NMC-770034(1). *Psettina gigantea* AMS-I-33811001 (3). *Taeniopsetta* sp. ANSP-145354 (1).

All these specimens belong to the Bothidae, X-rays documents have been examined for each of them. Abbreviations: AMS = Australian Museum Sydney

(Sydney, Australia), ANSP = Academy of Natural Sciences (Philadelphia, Pennsylvania (USA), MNHN = Muséum national d'Histoire naturelle (Paris, France), NMC = National Museum of Canada (Natural Sciences) (Ottawa, Canada).

DESCRIPTION

The studied fossil is represented by a unique specimen without counterpart. It is a small flatfish visible by its right side: its standard length is 64 mm, its total length 78 mm, its maximum body height: 38 mm, diameter of each eye is 4.5 mm and the interocular distance is 6 mm. The preservation is good with very little bones and many visible details.

Neurocranium

The neurocranium is triangular in shape with a very high orbito-otic region. The bony sutures are not discernible and few bones can be identified. The traces of each eye are well visible (with very visible traces of the crystalline lens): the upper one is very dorsal and overlaid by broken bony elements from the left frontal, the black trace of the lower one is surrounded by the strong parasphenoid. Such a disposition shows that the skull is asymmetrical and that the two eyes, separated by a wide distance, were present on the left side. The upper eye, the one which has migrated, is the right eye, the lower one being the left eye.

Splanchnocranium

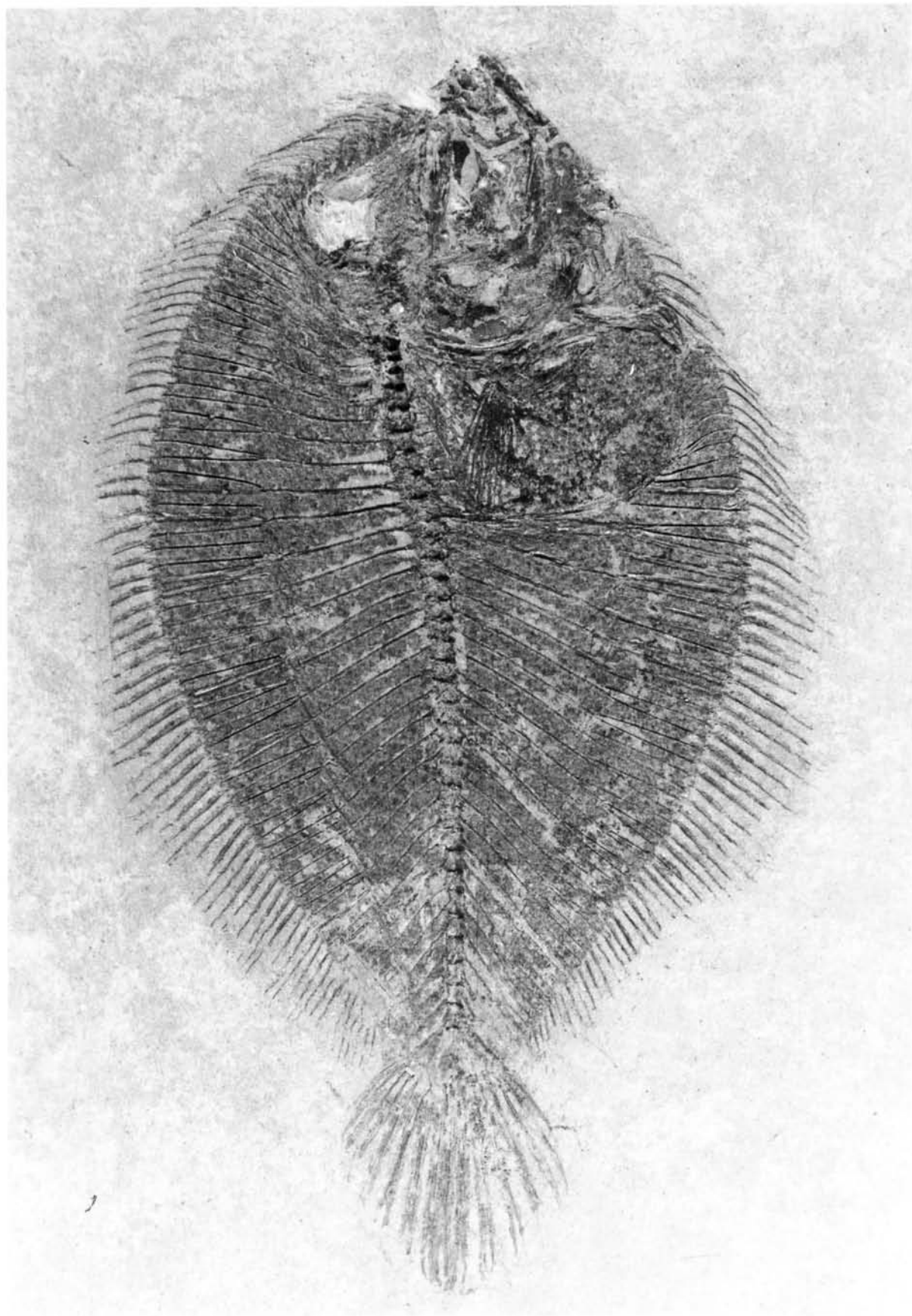
Few elements are really interpretable and the side which they belong to cannot be ascertained. A large triangular quadrate is present, this bone articulates with a robust articulo-angular. The latter is connected with a developed dentary possessing a high coronoid process and bearing little teeth. Maxillae and premaxillae cannot be really identified, an high ascendant process of a premaxillary is well visible on one of these bones. A big boomerang-shaped ectopterygoid is present on either side; one (the left one ?) is smaller than the other. Posteriorly, a large rounded metapterygoid is visible. A few strong branchiostegal rays overlying the urohyal are present

Urohyal

The whole bone is not visible, it is a robust fish-hook bone present ventrally in front of the cleithra. Its dorsal branch is straight whereas the ventral branch is very developed and curved with a pointed tip and is prolonged posteriorly by a large blade.

Opercular bones

Only the opercular bones of the right side are visible. A strong L-shaped preopercle and a large opercle



Text-fig. 2 - *Bothus podas* (Delaroche, 1809) from the Pliocene of Marecchia river, Museo Civico di Storia Naturale di Verona: Collection Sabbatini, Marecchia, n.157, Standard Length = 64 mm.

and an interopercle are present, but their shape cannot be specified. None of these bones seems to be ventrally indented.

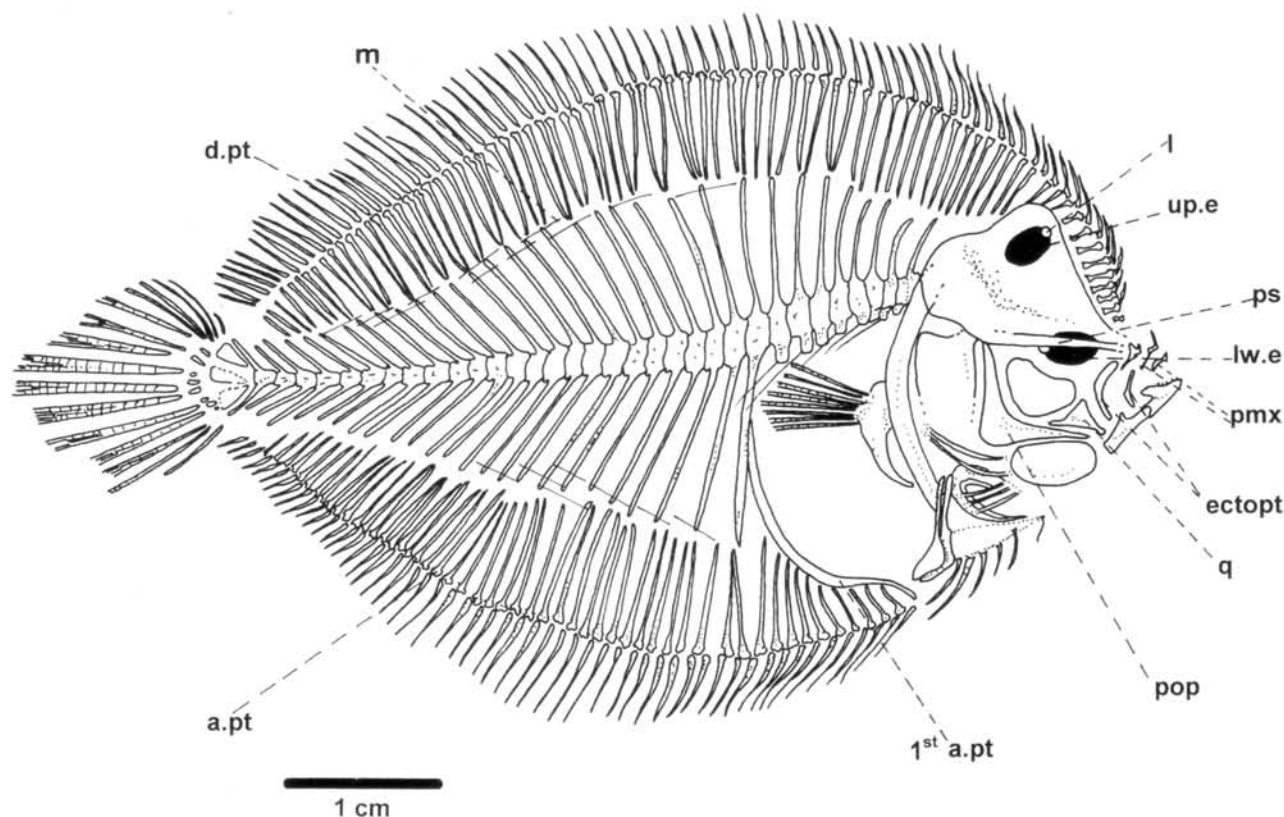
Axial skeleton

The vertebral column is composed of 35-36 vertebrae: 10 precaudal and 25-26 caudal. The centra are strong and square, the posteriormost ones are more slender. Each precaudal vertebra possesses a massive and rectangular postero-ventrally directed haemophysis, the length of which increases progressively. On the five last ones, fine pleural ribs are well visible. The caudal vertebrae possess a long and fine haemal spine. Each of these spines is in contact with a pair of anal pterygiophores. The first one is the strongest, ventrally orientated and supports, on its anterior side, the proximal part of the first anal pterygiophore. Successively, the next haemal spines are smaller, finer and postero-ventrally directed. Each centrum, precaudal and caudal, possesses a neural spine. The presence or the absence of a neural spine on the first precaudal centrum cannot be ascertained. As the two

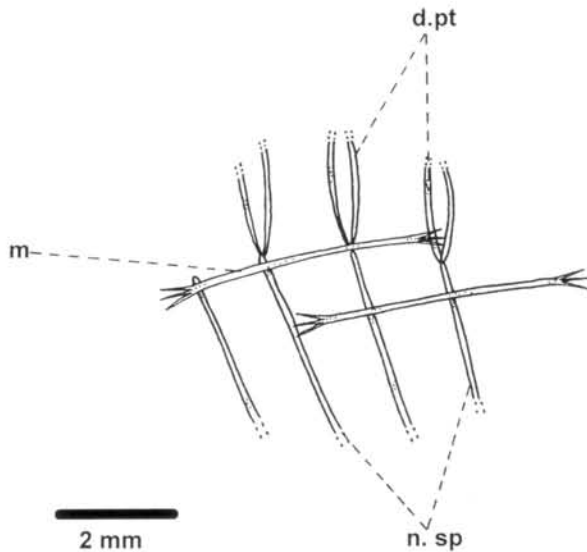
first neural spines have a pointed blade-like shape, the six first neural spines bend towards the occipital region of the neurocranium. The others are longer in the precaudal region but their length decreases progressively in the caudal region. Each neural spine supports two dorsal-fin pterygiophores. At the distal tip of some haemal and neural spines, some myorhabdoi are present. These intermuscular bones existing in two series in the uppermost and lowermost forward flexures (Patterson & Johnson, 1995) are brushlike.

Median fins

The anal and dorsal fins are present all along the edge of the body. The dorsal fin extends over the skull onto the orbito-rostral region and is composed of 82 fin rays. In the supracranial region, each of the dorsal rays is supported by a short and thick spatulate on either extremity pterygiophore. The following ones are in contact with thin and distally spatulate pterygiophores. 57 fin rays are present in the anal fin: the first anal pterygiophore is long, sigmoid and supports the eleven following proximal pterygiophores. Posteriorly,



Text-fig. 3 - Reconstruction of the skeleton of *Bothus podas* (Delaroche, 1809) from the Pliocene of Marecchia river. Scale = 1 cm. Abbreviations: a.pt = anal pterygiophore, ant.exp.p.b. = anterior extension of pelvic bone, b.s. = blind side, br = branchistegal ray, cl = cleithrum, d.pt = dorsal pterygiophore, ectopt = ectopterygoid, e.s. = eyed side, l = crystalline lens, lw.e = lower eye, m = myorhabdoi, n.sp = neural spine, p.f. r. = pelvic fin-ray, pmx = premaxillae, pop = preopercle, ps = parasphenoid, q = quadrate, u = urohyal, up.e = upper eye.



Text-fig. 4 - Myorhabdoid of *Bothus podas* (Delaroche, 1809) from the Pliocene of Marecchia river. Scale = 2 mm. Abbreviations as in Text-fig. 3.

this bone lies on the anterior edge of the first haemal spine. The other pterygiophores are similar in shape and size to their homologues in the dorsal fin.

Pair fins

The right pectoral girdle and fin are can be clearly observed. The cleithrum is strong and the coracoids are large bearing a developed postcleithrum. 10 pectoral fin-rays are present, none of them is elongated.

The tip of the cleithra is in contact with the distal tip of the pelvic bone. Each of them is robust and possesses a strong, curved and postero-ventrally directed process. The right pelvic bone is more slender than its right homologue. This left pelvic bone supports anteriorly a (cartilaginous ?) expansion supporting the anteriormost fin rays. 5-6 rays seem to be present on either pelvic fin.

Caudal endoskeleton and fin

The structure of the caudal endoskeleton cannot be precisely described. The haemal and neural spines of the last visible caudal vertebra (maybe the preural 2) support a triangular plate. The upper one is big in contact with the haemal spine and seems to be hypural five fused with the epural. A similar element is visible on the neural spine, but its shape can hardly be seen; it might be the parhypural. Between those two plates a big triangular hypural is present, but it is impossible to say which it is. All these elements support seventeen caudal fin-rays. The median ones are segmented and are the longest, while the uppermost and lowermost are simple and short. The caudal fin has a pointed shape.

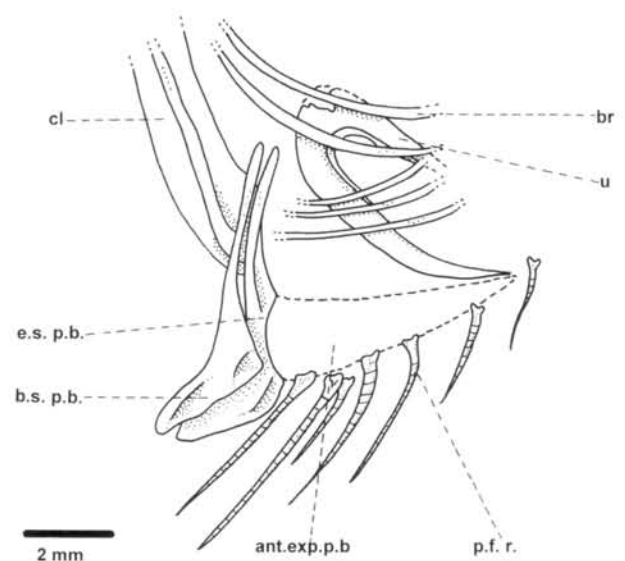
INTERPRETATION

The present fossil shows the following features:

1. Asymmetrical skull
2. Dorsal fin extending onto the head over the orbital region
3. Strong and elongated first pterygiophore of the dorsal fin
4. Fishhook shaped urohyal
5. Postcleithra present
6. Left side expansion of the pelvic fin extending anteriorly and supporting pectoral fin-rays
7. Myorhabdoid present
8. A strong, curved and postero-ventrally directed process on the two pelvic bones
9. Strong and rectangular haemopophysis
10. Not elongated first pectoral fin-ray
11. Wide interorbital space

According to the distribution of the above features within the flatfishes, it is possible to say that the studied fossil belongs to the order Pleuronectiformes [feature 1 (Chapleau, 1993; Cooper & Chapleau, 1998)], to the sub-order Pleuronectoidei [features 2, 3 and 4 (Chapleau, 1993; Chanet, 1995; Cooper & Chapleau, 1998)], and is a member of the bothid family [features 6 (Norman, 1934) and 7 (Hensley, 1977; Patterson & Johnson, 1995; Chanet, 1999)]. Moreover, even if its occurrence has to be studied within flatfishes, feature 8 can be frequently observed within the Bothidae (Chanet, 1999) and feature 9 is only present in the genus *Bothus* (Amaoka, 1969 and B. Chanet, personal observation).

Among the dozen of species gathered in the genus *Bothus* (Norman, 1934), only two present feature 10. All the others show a very long first pectoral fin-ray



Text-fig. 5 - Pelvic region of *Bothus podas* (Delaroche, 1809) from the Pliocene of Marecchia river. Scale = 2 mm. Abbreviations as in Text-fig. 3.

extending backwards (Norman, 1934), sometimes longer than the whole body in *Bothus pantherinus* (Rüppel, 1830) (Norman, 1934, p. 234, fig. 177). These species are: *Bothus podas* (Delaroche, 1809), present in Mediterranean Sea and Atlantic Ocean to the Azores and coasts of Angola (Nielsen, 1986) and *Bothus leopardinus* (Günther, 1862), solely known on the Pacific coasts of Mexico and central America (Norman, 1934). But the interorbital distance (feature 11) is longer (more than the diameter of an eye) in the fossil and in the male specimens of *Bothus podas* (Norman, 1934, p. 225, fig. 169) than in *Bothus leopardinus*, where in both sexes this distance is equal to the diameter of an eye (Norman, 1934, p. 231, fig. 175). Moreover, the study of X-rayed *B. podas* shows that a high neurocranium in the orbito-otic region is only present in the males of this species. Concerning vertebral numbers, Norman (1934) noted that 28-30 caudal vertebrae were present in *B. podas*, whereas the studied fossil only possesses 25-26 caudal vertebrae and the three recent examined specimens show 26-27 caudal vertebrae.

Consequently, the systematic position of this fossil considered before as a *Bothus* sp. by Sorbini (1988) can be specified. The analysis of the present features leads us to the conclusion that it belongs to the Recent bothid species: *Bothus podas* (Delaroche, 1809) and it is a male.

Bothus podas, wide-eyed flounder in English, "rombo di rena" in Italian, "platophrys" in French, is a common little flatfish present in shallow depths (maximum 500 m) on the muddy bottoms. Only European species of the genus, *B. podas* is reported in all the Mediterranean Sea, on the Atlantic coasts of south Europe and along the African coast to Angola (Nielsen, 1986). For the first time a fossil *Bothus podas* is identified, then it is possible to assess that the time of appearance for the genus *Bothus* and the species *Bothus podas* is before the Pliocene. The genus *Bothus* was known as well by fossil otoliths, but Schwarzhans (1997) reviewed this material and concluded that no fossil otolith can be considered as belonging to a *Bothus*. Subsequently, the herein studied fossil appears to be the only fossil representative of the extant species *Bothus podas* (Delaroche, 1809).

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