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Elasmobranch and teleost fish remains from the Korytnica Clays (Middle Miocene; Holy Cross Mountains, Poland)

ABSTRACT: The assemblage of the elasmobranch and teleost fish remains from the Middle Miocene (Badenian) Korytnica Clays (Holy Cross Mountains, Central Poland) shows the presence of diverse sharks and rays, as well as teleosteans, some of which have been first recognized in the Paratethys basins. This assemblage is indicative of tropical/subtropical climatic conditions, and mostly of littoral or neritic environment, comparable to that existing in Miocene time in the Vienna Basin.

INTRODUCTION

The world-famous Middle Miocene (Badenian) Korytnica Clays developed on the southern slopes of the Holy Cross Mountains, Central Poland, that contain extremely abundant and diverse invertebrate fossils (*cf.* Bałuk & Radwański 1977) have also yielded a relatively rich fish material. It was obtained during sifting the clay samples, and it comprises such diverse remains as teeth, shagreen, spines, otoliths, vertebrae and bone fragments. The best preserved are elasmobranch teeth, whilst usually the teleost remains are very fragmentary, and they are hardly determinable.

In the Fore-Carpathian Depression to which the Korytnica basin belongs (*cf.* Bałuk & Radwański 1977), the fish remains are known primarily from the detrital (bryozoan-algal) limestones of the type distinguished in the Vienna Basin as *Leithakalk*, and exposed at Pińczów (*cf.* Pawłowska 1960, Radwański 1965). The report on the fish remains from the Korytnica Clays, except for the otoliths (*cf.* Bałuk & Radwański 1977), concerns only single teeth determined by Kowalewski (1930) as *Oxyrhina* sp., *?Lamna cuspidata* Agassiz, and *Sphaerodus cinctus* Münster.

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SYSTEMATIC DESCRIPTION

Class *Chondrichthyes*
Subclass *Elasmobranchii*
Supraorder *Selachii*
Order *Hexanchida*
Family HEXANCHIDAE
Hexanchus primigenius (Agassiz, 1843)
(Pl. 1, Fig. 7)

1910. *Notidanus primigenius*, L. Agassiz, 1843; M. Leriche, p. 257, Pl. 13.
1965. *Notidanus primigenius* Agassiz, 1843; A. Radwański, pp. 268—269, Pl. 1, Figs 1—2.
Material: Two damaged lateral teeth from the lower jaw.

Occurrence: The species is commonly known all over the world (*cf.* Leriche 1910, Radwański 1965), ranging since the Eocene through the Pliocene. In the Fore-Carpathian Depression, it was reported from the Leithakalk facies at Pińczów (Radwański 1965).

Order *Squatinida*
Suborder *Squatinoidei*
Family SQUATINIDAE
Squatina subserrata (Münster, 1846)
(Pl. 1, Fig. 6)

1846. *Sphyrna subserrata*, Münster; G. Münster, p. 21, Pl. 2, Fig. 17.
Material: Eight teeth.

Occurrence: This rare species is known from the Miocene of the Vienna Basin (*cf.* Münster 1846, Schultz 1971a).

Suborder *Rajoidei*
Rajoidei indet.

Remarks: The two of the collected seven caudal spines are recognizable as belonging to the Rajoidei, one of which presumably represents either the genus *Raja* or *Dasyatis*, and the other may correspond to *Raja* or *Dactylobatus*.

Family DASYATIDAE
Dasyatis aff. *probsti* Cappetta, 1970
(Pl. 1, Figs 2—3)

1970. *Dasyatis probstii* nov. sp.; H. Cappetta, p. 91, Pl. 21, Figs 15—23.
Material: 27 teeth, 21 of which belonged to females (4 undamaged, 13 strongly damaged, 4 in fragments), and 6 to males.

Remarks: Differences in the crown sculpture, and in the shape of the root are the diagnostic features (*cf.* Probst 1877, Cappetta 1970) for numerous species within the genus *Dasyatis*. In the investigated material, only 4 undamaged specimens are hardly comparable to those presented by Probst, and by Cappetta from the older Miocene deposits (*"Helvétien inférieur"* of Cappetta, 1970). Since the Korytnica sequence is younger (*cf.* Bałuk & Radwański 1977), the specimens studied are determined only as related to the species established by Cappetta.

Dasyatis aff. *cavernosa* (Probst, 1877)
(Pl. 1, Fig. 1)

1877. *Raja cavernosa* n. sp.; J. Probst, p. 75, Pl. 1, Figs 1—4.
1877. *Raja rugosa* n. sp.; J. Probst, p. 76, Pl. 1, Fig. 6 [*non* Figs 5 and 7—9].
1970. *Dasyatis cavernosa* (Probst); 1877; H. Cappetta, pp. 88, Pl. 22, Figs 1—13.
Material: One tooth.

Remarks: The investigated specimen, belonging to a male, is comparable to those presented by Probst, and by Cappetta, although it may be determined also only as related to the species established by Probst.
Occurrence: Lower Miocene of Switzerland, southern Germany, and southern France (*cf.* Probst 1877, Cappetta 1970).

Family MYLIOBATIDAE
Myliobatis sp. and/or *Rhinoptera* sp.
(Pl. 1, Fig. 4)

Material: 20 dental plates (13 median, 7 lateral ones).

Remarks: Since these are only the isolated dental plates, it cannot be precisely stated whether they belong to the genus *Myliobatis* or *Rhinoptera*, or perhaps to the both.

Family MOBULIDAE
Mobula aff. *loupianensis* Cappetta, 1970
(Pl. 1, Fig. 5)

1970. *Mobula loupianensis* nov. sp.; H. Cappetta, p. 103, Pl. 26, Figs 1—6.
Material: Two teeth.

Remarks: The genus *Mobula* is for the first time reported from the Paratethys basins.
Occurrence: Lower and Middle Miocene of southern France (*cf.* Cappetta 1970).

Order *Carcharhinida*
Family SCYLIORHINIDAE
Scyliorhinus distans (Probst, 1879)
(Pl. 1, Fig. 8)

1879. *Scyllium distans* n. sp.; J. Probst, p. 170, Pl. 3, Figs 23—26.
1970. *Scyliorkinus distans* (Probst), 1879; H. Cappetta, p. 41, Pl. 9, Figs 1—18.
Material: Eleven teeth.

Remarks: The *Scyliorhinus* teeth have hitherto been usually overlooked due to their extremely small size; within the Paratethys basins, they have been reported only from the Vienna Basin (Schultz 1971a).
Occurrence: Lower and Middle Miocene.

Family CARCHARHINIDAE
Carcharhinus priscus (Agassiz, 1843)
(Pl. 2, Figs 1—2)

1970. *Carcharhinus priscus* (Agassiz), 1843; H. Cappetta, p. 54, Pl. 13, Figs 1—20, and Pl. 14, Figs 1—20.
Material: 112 teeth.

Remarks: This is the most common species within the fish-teeth assemblage of the Korytnica Clays.

Occurrence: In Europe, the species is widely distributed, and usually very common; it ranges since the Middle Oligocene through the Upper Miocene.

?*Galeocerdo aduncus* Agassiz, 1843
(Pl. 2, Fig. 7)

1960. *Galeocerdo aduncus* Agassiz, 1843; K. Pawłowska, p. 422, Pl. 2, Figs 14—19.
1970. *Galeocerdo aduncus* Agassiz, 1843; H. Cappetta, p. 50, Pl. 12, Figs 1—21.
Material: One, posterior-lateral tooth.

Remarks: The tooth is partly damaged, and it cannot be assigned to the species with certainty; it might be also attributed to the posterio-lateral part of the upper jaw of any *Sphyrna*.
Occurrence: The species is widely distributed since the Upper Oligocene through Pliocene. In the Fore-Carpathian Depression, it is known from the Leithakalk facies at Pińczów (Kowalewski 1930, Pawłowska 1960, Radwański 1965).

?*Galeorhinus affinis* (Probst, 1878)
(Pl. 2, Fig. 6)

1878. *Galeus affinis* n. sp.; J. Probst, p. 139, Pl. 1, Figs 64—67.
1970. *Galeorhinus affinis* (Probst), 1878; H. Cappetta, p. 65, Pl. 18, Figs 1—13.
Material: Six teeth, and one fragment.

Remarks: The present-day representatives of the genera *Galeorhinus* Blainville, *Paragaleus* Budker, and *Hypoprion* Müller & Henle possess so much similar teeth that their assignation, especially when having isolated and damaged crowns, is almost impossible. In the investigated material, it is not certain whether such teeth represent *Galeorhinus* and/or *Paragaleus*. The illustrated specimen (Pl. 2, Fig. 6) may either come from the upper jaw of *Galeorhinus affinis*, or from the lower jaw of *Paragaleus pulchellus* as indicated below; its attribution to the genus *Hypoprion* should however be also taken into account (*cf.* Bigelow & Schroeder 1948, Fig. 54: *Hypoprion signatus*).
Occurrence: Lower through Upper Miocene of southern France, Spain and Portugal, also of northern Germany (*cf.* Probst 1878, Cappetta 1970) and Middle Miocene (Badenian) of the Vienna Basin (*cf.* Schultz 1971a).

?*Paragaleus pulchellus* (Jonet, 1966)
(Pl. 2, Fig. 5)

1970. *Paragaleus pulchellus* (Jonet), 1966; H. Cappetta, p. 68, Pl. 18, Figs 19—31.
Material: Three teeth.

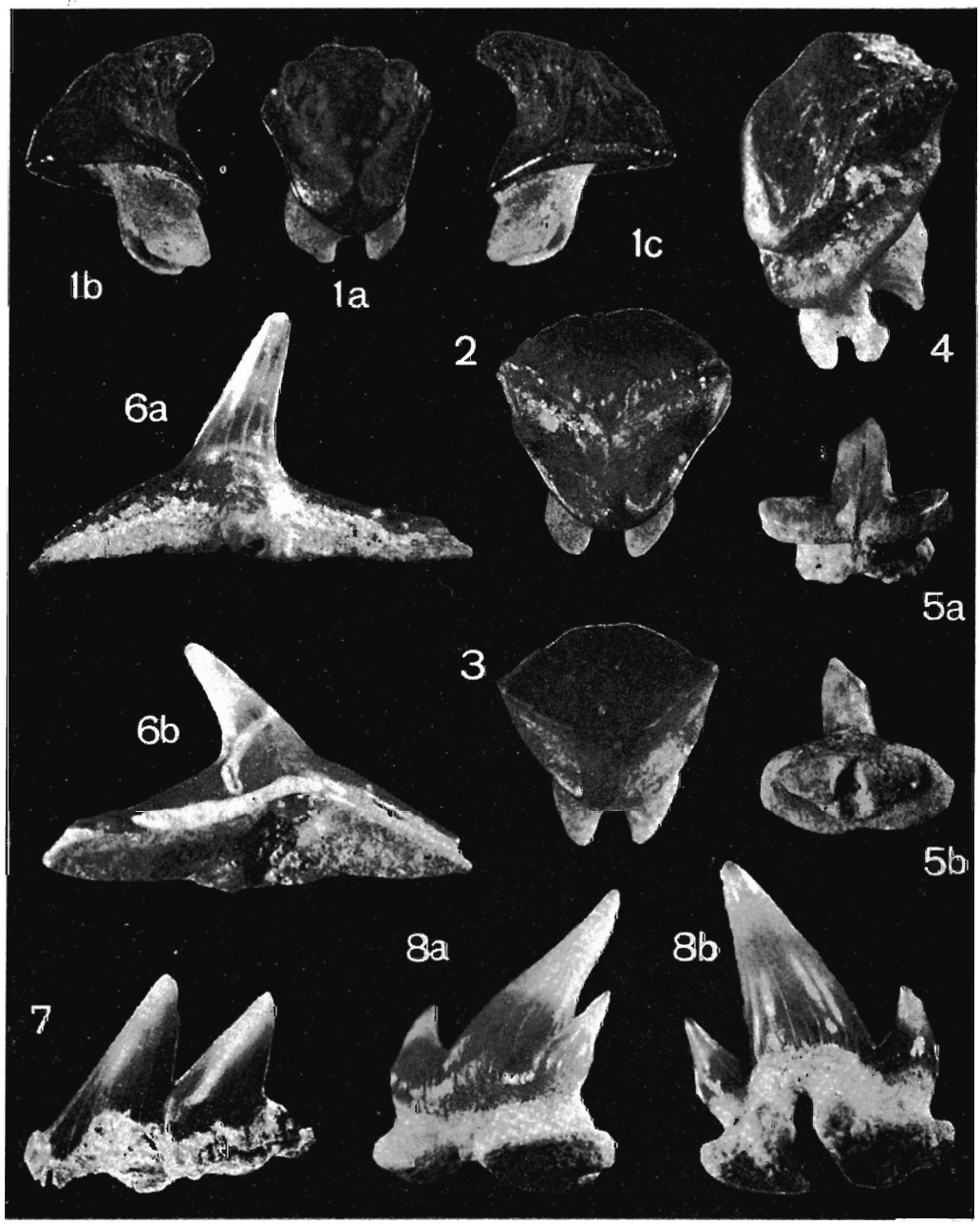
Remarks: See above, as for *Galeorhinus affinis*.
Occurrence: Middle Miocene of Portugal, southern France and Belgium.

Family SPHYRNIDAE
Sphyrna sp.
(Pl. 2, Figs 3—4)

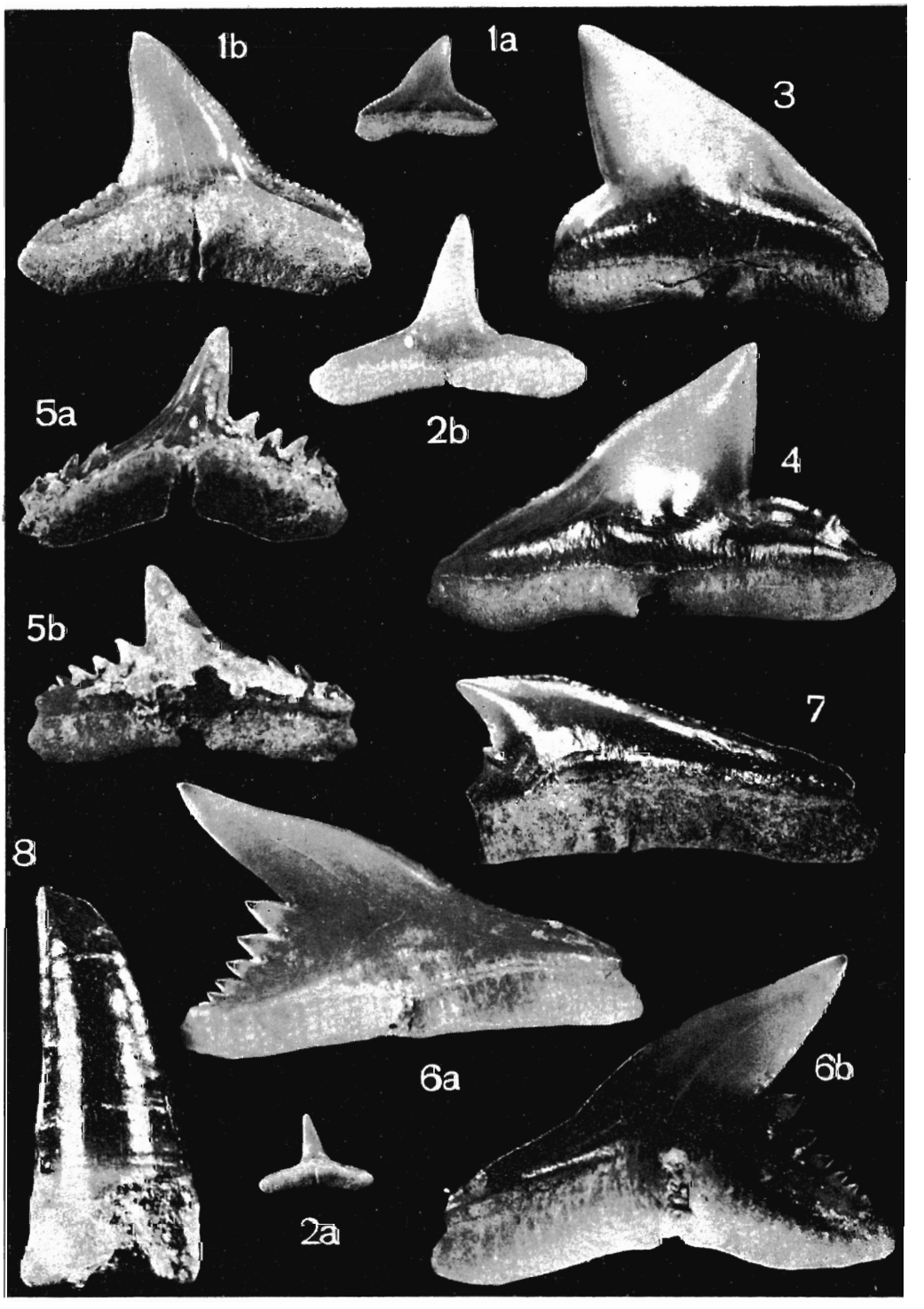
Material: One lateral tooth from the upper jaw, and another one from the lower jaw.

Remarks: The two illustrated specimens are so much similar to the teeth of present-day *Sphyrna zygaena* (Linnaeus, 1758), presented i.a. by Bigelow & Schroeder (1948, p. 437, Fig. 85*A—E*), that their assignation to the genus *Sphyrna* seems to be justified.

Another tooth, which may be assigned to this genus was discussed above, and uncertainly ascribed to Galeocerdo.



1 — *Dasyatis* aff. *cavernosa* (Probst); male specimen; 1*a* upper view, 1*b* and 1*c* side views; × 10.
2 and 3 — *Dasyatis* aff. *probsti* Cappetta; female specimens; upper views, × 10.
4 — *Myliobatis* sp. or *Rhinoptera* sp.; lateral dental plates, side view; × 10.
5 — *Mobula* aff. *loupianensis* Cappetta: 5*a* upper, 5*b* basal view; × 10.
6 — *Squatina subserrata* (Münster); lateral tooth (6*a* inner, 6*b* outer view); × 10.
7 — *Hexanchus primigenius* (Agassiz); fragment of lateral tooth (inner view) from the lower jaw; × 5.
8 — *Scyliorhinus distans* (Probst): 8*a* outer-side, 8*b* inner view; × 10.


1b
1a
3
5a
2b
4
5b
7
8
6a
6b
2a

Order *Odontaspidida*

Family ODONTASPIDIDAE

Odontaspis (Synodontaspis) acutissima (Agassiz, 1844)

1960. *Odontaspis acutissima* Agassiz, 1843; K. Pawłowska, pp. 421—422, Pl. 1, Figs 1—2.
1970. *Odontaspis acutissima* Agassiz, 1844; H. Cappetta, p. 29, Pl. 1, Fig. 1—22, and Pl. 2, Figs 1—16.

Material: Five teeth.

Remarks: The investigated badly preserved specimens, assigned to this species, are of very small size.

Occurrence: The species is widely distributed all over the world, and ranges since the Lower Oligocene through the Upper Miocene (*cf.* Kruckow 1959); it was also reported from the Pliocene of Spain (Bauza 1964). In the Fore-Carpathian Depression, it was formerly observed within the Leithakalk facies at Pińczów (Pawłowska 1960, Radwański 1965).

Family CARCHARODONTIDAE

Procarcharodon megalodon (Agassiz, 1843)

1926. *Carcharodon megalodon*, L. Agassiz, 1843; M. Leriche, p. 412, Pls 25—26.
1960. *Carcharodon megalodon* Agassiz, 1843; K. Pawłowska, p. 422, Pl. 1, Figs 3—4.
1971. *Procarcharodon megalodon megalodon* (Agassiz, 1843); O. Schultz, p. 323, Pl. 3, Fig. 17.

Remarks: The only specimen, collected by K. Kowalewski, and being a damaged crown is housed at the Museum of the Geological Survey of Poland (letter communication of Docent A. Radwański).

Occurrence: This widely distributed species, reported from many areas all over the world, ranges since the Oligocene/Miocene boundary (Egerian stage of the Paratethys basin) through the Pliocene. In the Fore-Carpathian Depression, it is commonly known within the Leithakalk facies at Pińczów (*cf.* Kowalewski 1930, Pawłowska 1960, Radwański 1965).

Family ISURIDAE

?Isurus hastalis (Agassiz, 1843)

Remarks: One small specimen, the root of which is badly preserved, may belong to this very species, commonly distributed all over the world (*cf.* Leriche 1926, Radwański 1965, Cappetta 1970, Schultz 1971a, b), ranging since the Oligocene through the Pliocene. In the Fore-Carpathian Depression, it was reported from the Leithakalk facies at Pińczów (Radwański 1965).

PLATE 2

1 and **2** — *Carcharhinus priscus* (Agassiz): *1* lateral tooth from the upper jaw (*1a* outer view, × 2; *1b* inner view, × 5), *2* tooth from the lower jaw (*2a* inner view, × 2; *2b* outer view, × 5).
3 and *4* — Sphyrna sp.: *3* lateral tooth from the upper jaw, *4* lateral tooth from the lower jaw; both in outer view, × 5.
5 — *?Parageleus pulchellus* (Jonet); lateral tooth (*5a* inner view, *5b* outer view), × 10.
6 — *?Galeorhinus affinis* (Probst); lateral tooth (*6a* outer view, *6b* inner view), × 10.
7 — *?Galeocerdo aduncus* (Agassiz); hind lateral tooth (inner view), × 10.
8 — *Dentex* sp.; × 10.

Class *Osteichthyes*
Subclass *Actinopterygii*
Supraorder *Teleostei*
Teleostei indet.

Remarks: Isolated remains, the investigated material of which comprises 93 vertebral or bone fragments, various tooth fragments, and 3 caudal spines, are hardly determinable, and they can be assigned only generally to the Teleostei.

Order *Mugilida*
Family SPHYRAENIDAE
?*Sphyraena* sp.

Remarks: The only tooth is highly similar to those presented by Jonet (1967, Pl. 1, Figs 1—20) as belonging to the genus *Sphyraena*. In the Paratethys basins, this genus is known from the otolith materials (*cf.* Brzobohaty & Schultz 1977).

Order *Percida*
Family SPARIDAE
Sparus sp.

Remarks: In the investigated material, two large, flat teeth of an oval outline are assigned to the genus *Sparus*. Small, conical teeth (32 specimens in the material studied) may belong to other families. In the Paratethys basins, the genus *Sparus* is represented by the otoliths distinguished as *Sparus doderleini* Brzobohaty & Schultz; other otoliths (*cf.* Brzobohaty & Schultz 1977) indicate however the presence of the genera *Boops* and *Pagrus* whose teeth are most similar to those of *Sparus*. It is therefore possible that the small conical teeth in the Korytnica material may belong either to *Boops*, or to *Pagrus*.

Diplodus sp.

Remarks: The spade-shaped tooth is assigned to the genus *Diplodus* (synonymic with *Sargus*), which is commonly known in the Miocene deposits of Europe, the Fore-Carpathian Depression including, and which is represented both by teeth (*cf.* Pawłowska 1960), and by otoliths (*cf.* Brzobohaty & Schultz 1977).

Dentex sp.

Remarks: In the investigated material (*cf.* Pl. 2, Fig. 8), eight teeth are well comparable to those of the genus *Dentex*, whose presence in the Paratethys basins is also indicated by the otoliths (*cf.* Brzobohaty & Schultz 1977) reported formerly from the Korytnica basin by Friedberg (1924; *cf.* also Kowalewski 1930).

Family LABRIDAE
?LABRIDAE indet.

Remarks: The stick-shaped, slightly arched teeth occur in various families, and in various parts of the mouth; some of the collected specimens (26 teeth) may belong, as indicated above, to the genus *Sparus* of the family Sparidae.

Family SCOMBRIDAE
?*Scomberomorus* sp.

Remarks: Two specimens may belong to the genus *Scomberomorus*, as they are similar to those presented (as *Cybium*) by Jonet (1967, Pl. 1, Figs 21—22 and Pl. 2, Figs 1—25).

Order *Tetrodontida*
Family BALISTIDAE
?*Balistes* sp.

Remarks: The caudal spines occur not only in the Rajoidei, but also in some Teleostei, e.g. in the genus *Balistes* to which two specimens from the investigated material may be attributed.

COMPARATIVE REMARKS

The biological requirements of the investigated genera (Table 1) show that the fish assemblage from the Korytnica Clays may be characterized as typical of tropical/subtropical waters, and mostly of littoral or neritic habitats in which the majority of the fish genera studied led nectic mode of life. A tropical/subtropical character of both the elasmobranch and teleost fish in the Middle Miocene (Badenian) sea of the Fore-Carpathian Depression was formerly recognized by Pawłowska (1960) and Radwański (1965; *cf.* also Bałuk & Radwański 1977).

Table 1

Biological requirements of the investigated fish genera

Genus	Climatic conditions				Bathymetric conditions			Mode of life		
	tropical	subtropical	temperate	boreal-arctic	littoral-neritic	pelagic	bathyal	nectic	benthic	planktic
Hexanchus	+	+	+			+	+	+		
Squatina	+	+	+		+				+	
Dasyatis	+	+	+		+				+	
Myliobatis or	+	+	+		+				+	
Rhinoptera	+	+			+				+	
Mobula	+	+	(+)		+			+		
Scyliorhinus	+	+	+		+		+	+	+	
Carcharhinus	+	+	(+)		+	+		+		
Galeocerdo	+	+			+	+		+		
Galeorhinus	+	+	+		+			+		
Sphyrna	+	+	(+)		+			+		
Odontaspis	+	+	+		+	+		+		
Procarcharodon	+?	+?			+?	+?		+		
Isurus	+	+	+		+	+		+		
Sphyraena	+	+	(+)		+	+		+		
Sparus	+	+	+		+			+		
Diplodus	+	+			+			+		
Dentex	+	+			+			+		
Labrus	+	+	+		+			+		
Scomberomorus	+	+			+	+		+		
Balistes	+	+			+	+		+		

A comparison with the fish assemblage of the Vienna Basin (*cf.* Schultz 1969, 1971a) indicates that some forms are identical in both regions, whilst the others are hitherto observed but in one of these basins. Further investigations on the teeth and the otoliths will certainly demonstrate whether the differences in the composition of fish assemblages result from the fortuitousness of the material available, from the facies conditions, or finally, from paleogeographic setting of these two regions.

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