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PLIOCENE ELASMOBRANCHS IN THE COLLECTION OF THE "MUSEO CIVICO GIUSEPPE SCARABELLI" OF IMOLA

(Pisces Chondrichthyes Neoselachii)

Abstract

Seven elasmobranch species, *Carcharias acutissima*, *Isurus oxyrinchus*, *I. xiphodon*, *Carcharodon carcharias*, *Carcharhinus* aff. *plumbeus*, *Carcharhinus* sp., *Scymnodon* cf. *ringens*, and an indeterminate Myliobatidae, are recognised by the revision of the elasmobranch teeth collection of the "Museo Civico Giuseppe Scarabelli" of Imola (Bologna). The presence of the family Myliobatidae is confirmed by a fragmentary caudal spine not assigned at generic level. The present study provides a relevant contribution to the understanding of the Pliocene elasmobranch diversity of Romagna region.

Riassunto

[*Elasmobranchi pliocenici nella collezione del "Museo Civico Giuseppe Scarabelli" di Imola*]
Sette specie di elasmobranchi, *Carcharias acutissima*, *Isurus oxyrinchus*, *I. xiphodon*, *Carcharodon carcharias*, *Carcharhinus* aff. *plumbeus*, *Carcharhinus* sp., *Scymnodon* cf. *ringens* e un Myliobatidae non determinabile, sono stati identificati nell'ambito della revisione della collezione ad ittiodontoliti conservata presso il "Museo Civico Giuseppe Scarabelli" di Imola (Bologna). La presenza della famiglia Myliobatidae è confermata sulla base di un piccolo frammento di spina caudale non identificabile a livello tassonomico generico. Il presente studio fornisce un ulteriore contributo alla conoscenza della diversità della fauna pliocenica ad elasmobranchi della Romagna.

Key words: Teeth, Sharks, Elasmobranch, fish fauna, Pliocene, Mediterranean, Romagna, Italy.

Introduction

Elasmobranchs are poorly represented in the Neogene deposits of Romagna Region. SCARABELLI (1851a, b) first recorded shark teeth from the Miocene sediments cropping out near the Casola Valsenio (Ravenna), and Imola (Bologna) villages. Several elasmobranch teeth were also reported from the Neogene deposits cropping out in the Lamone and Santerno valley (SANGIORGI, 1899; TOLDO, 1905). More recently, SORBINI (1982) reported the presence of the living blue shark *Prionace* cf. *glauca* as well as of an indeterminate species of the family Rajidae in the lower-middle Pliocene deposits of the Marecchia River section (Poggio Berni, Forlì), while CIGALA FULGOSI (1988) confirmed the presence of *Alopias superciliosus* in the Pliocene marly clays cropping out along the Rio Gambellaro flanks (Imola). Finally, several bathyal shark teeth assigned to the extra-Mediterranean *Scymnodon* cf. *ringens*, *Deania* cf. *calcea*, and *Pristiophorus* sp. and to the Mediterranean *Centrophorus* cf. *granulosus* have been recently recorded in the middle Pliocene sediments of the Rio Merli, Rio Co di Sasso, Rio Cugno, and Rio dei Ronchi sections (MARSILI & TABANELLI, in press).
The aim of this work is to provide a detailed description of the shark teeth housed in the "Museo Civico Giuseppe Scarabelli" of Imola, collected during the second half of XIX century from the Pliocene clays and marly clays cropping out near the Croara, Rivola, and Tombarelle villages as well as along the Rio Gambellaro flanks (see also DE STEFANO, 1911). Although such material was firstly described by DE STEFANO (1911), an updated taxonomic study is required as a consequence of the recent increase in the knowledge on the elasmobranch systematic and paleontology.

Material and methods

34 teeth were studied (Tab. 1). The specimens are housed in the "Museo Civico Giuseppe Scarabelli" of Imola (MCGS). Most of the teeth are well preserved, with the exception of a few specimens that are only represented by fragmentary crowns and a caudal spine.
Morphological and tooth terminology mostly follows that of ARAMBOUR (1927), GARRICK (1967), LEDOUX (1970), HERMAN et al. (1989); MORENO & MORÓN (1992), and PURDY et al. (2001). The taxonomy of the fossil and living species mostly follow that of NELSON (1994), DE CARVALHO (1996), MCEACHRAN et al. (1996), and PURDY et al. (2001).

Table n. 1 – List of taxa recognised in the elasmobranch teeth collection of the «Museo Civico Giuseppe Scarabelli».

List of taxa			Synonym (see De Stefano, 1911)
Family	n catalogue	Valid species	
Odontaspididae	7902	*Carcharias acutissima*	*Odontaspis contortidens*
	7903	*Carcharias acutissima*	*Odontaspis ferox*
Lamnidae	7879	*Isurus oxyrinchus*	*Oxyrhina* sp.
	7880	*Isurus oxyrinchus*	*Oxyrhina Spallanzani*
	7906	*Isurus oxyrinchus*	*Oxyrhina Spallanzani*
	7907	*Isurus oxyrinchus*	*Oxyrhina Spallanzani*
	7908	*Isurus oxyrinchus*	*Oxyrhina Spallanzani*
	7910	*Isurus oxyrinchus*	*Oxyrhina Spallanzani*
	7911	*Isurus oxyrinchus*	*Oxyrhina Spallanzani*
	7904	*Isurus xiphodon*	*Oxyrhina hastalis*
	7905	*Isurus xiphodon*	*Oxyrhina hastalis*
	7869	*Carcharodon carcharias*	*Carcharodon Rondeleti*
	7870	*Carcharodon carcharias*	*Carcharodon Rondeleti*
	7872	*Carcharodon carcharias*	*Carcharodon Rondeleti*
	7873	*Carcharodon carcharias*	*Carcharodon Rondeleti*
	7874	*Carcharodon carcharias*	*Carcharodon Rondeleti*
	7875	*Carcharodon carcharias*	*Carcharodon Rondeleti*
	7876	*Carcharodon carcharias*	*Carcharodon Rondeleti*
	7877	*Carcharodon carcharias*	*Carcharodon Rondeleti*
	7878	*Carcharodon carcharias*	*Carcharodon Rondeleti*
	7880	*Carcharodon carcharias*	*Carcharodon Rondeleti*
	7896	*Carcharodon carcharias*	*Carcharodon Rondeleti*
	7897	*Carcharodon carcharias*	*Carcharodon Rondeleti*
	7898	*Carcharodon carcharias*	*Carcharodon Rondeleti*
	7899	*Carcharodon carcharias*	*Carcharodon Rondeleti*
	7900	*Carcharodon carcharias*	*Carcharodon Rondeleti*
	7901	*Carcharodon carcharias*	*Carcharodon Rondeleti*
Carcharhinidae	7912	*Carcharhinus* aff. *plumbeus*	*Carcharias [Prionodon] glaucus*
	7912	*Carcharhinus* sp.	*Carcharias [Prionodon] glaucus*
Dalatiidae	7913	*Scymnodon* cf. *ringens*	*Scymnus lichia*
Myliobatidae	7914	Myliobatidae indet.	*Myliobatis* sp.
Sparidae	7917	*Diplodus* sp.	*Sargus* sp.
	7918	Sparidae indet. morphotype 1	cfr. *Chrysophrys Agassizzi*
	7919	Sparidae indet. morphotype 1	cfr. *Chrysophrys Agassizzi*
	7920	Sparidae indet. morphotype 1	cfr. *Chrysophrys Agassizzi*
	7920	Sparidae indet. morphotype 2	*Chrysophrys* sp.
	7921	Sparidae indet. morphotype 2	*Chrysophrys* sp.

Geological setting

The Romagna Apennines are part of the northeast-verging Northern Apennine arc (VAI, 1989; ROVERI et al., 2003), characterized by an early Miocene to Pleistocene siliciclastic succession (RICCI LUCCHI et al., 1982; VAI, 1989; ROVERI et al., 2003). This succession represents the infill of a foredeep basin system actively migrating to northeast since the Oligocene (RICCI LUCCHI, 1986). The material studied herein comes from the laminated marly clay mostly belonging to the Argille-Azzurre Formation that characterized the Plio-Pleistocene regressive trend of the sedimentary evolution of the northern Romagna Apenninic foredeep (RICCI LUCCHI et al., 1982; AMOROSI et al., 1998).

As documented above, the teeth were collected in the last decades of the XIX century from the Pliocene clay and marly clays cropping out near Rivola, Tombarelle, and Croara villages as well as along the Rio Gambalaro flanks, in the Santerno and Senio valley (Fig. 1). Such deposits might be assigned to the middle Pliocene, mainly to the *G. punticulata* or *G. bononiensis* Zone (RICCI LUCCHI et al., 1982; VIAGGI, 1989; Prof. Vai pers. com., 2007). Moreover, the marly clay cropping out near Tombarelle village should be referred to the lower Pleistocene (Dr Tabanelli pers. com., 2007). However, the poor knowledge about the exact geographical location of the teeth studied herein does not allow a more detailed stratigraphic assignment to the material studied, which is herein referred to a generic Pliocene.

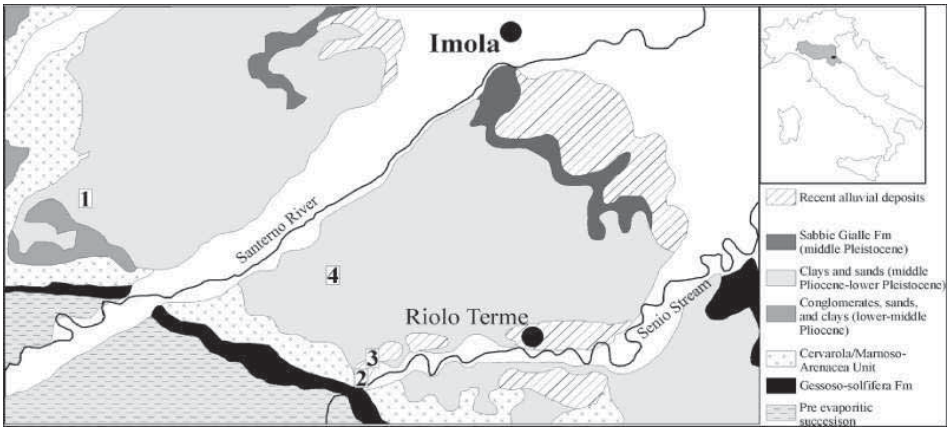

Fig. 1 - Simplified geological sketch map of the studied area. 1, Croara; 2, Rivola; 3, Tombarelle; 4, Rio Gambellaro. Figure modified from CERRINA FERRONI et al. (2002).

Systematic

Order **Lamniformes** Berg, 1958
Family **Odontaspididae** Müller & Henle, 1839
Genus *Carcharias* Rafinesque, 1810
Carcharias acutissima Agassiz, 1843 (Fig. 2 A-D)

1911 *Odontaspis contortidens* Agassiz - DE STEFANO, p. 394, pl. 10, fig. 8-10.
1911 *Odontaspis ferox* Risso - DE STEFANO, p. 394, pl. 10, fig. 11-13.
Synonymy see also MARSILI (2007a) and MARSILI et al. (2007).

Material: Four teeth. MCGS 7902, one fragmentary tooth; MCGS 7903, three fragmentary teeth.
Remarks: The teeth lack the lateral cusplets and the root. A flattened and irregularly striated lingual face of the crown supports the assignment of the specimens to the fossil taxon *Carcharias acutissima* (see e.g. ARAMBOURG, 1927; LANDINI, 1977; PURDY et al., 2001; MARSILI et al., 2007). Because of the presence of such irregular and thin striae on the lingual face of the crown, MCGS 7903 (see also DE STEFANO, 1911, p. 394, pl. 10, fig. 11-13), must be included into *C. acutissima*.
C. acutissima is considered by several authors as junior synonym of the living *C. taurus*, as a consequence of their strong tooth morphologic affinity (see e.g. ARAMBOURG, 1927; CAPPETTA & CAVALLO, 2006). However, even if in agreement with such hypothesis, *C. acutissima* is herein considered as a valid species separated from *C. taurus*, until a much more detailed taxonomic revision of the European Neogene fossil morphotype of the genus *Carcharias* will be produced.
Stratigraphic distribution: *C. acutissima* is a worldwide species, characterized by a continuous stratigraphic record. This fossil shark first occurred in the Oligocene (see e.g. DE ALESSANDRI, 1895; LERICHE, 1910; CAPPETTA, 1987; NOLF, 1988; REINECKE et al., 2001), but only during the Neogene it become one of the most representative elements of the global fossil elasmobranch assemblages (see e.g. CAPPETTA, 1987; PURDY et al., 2001; MAS & FIOL, 2002; ANTUNES & BALBINO, 2003; MARSILI, 2007a; MARSILI et al., 2007).

Family **Lamnidae** Müller & Henle, 1838
Genus *Isurus* Rafinesque, 1810
Isurus oxyrinchus Rafinesque, 1810 (Fig. 3 A-F)

1911 *Oxyrhina Spallanzani* Bonaparte - DE STEFANO, p. 396, pl. 10, fig. 16-19, 22-23.
Synonymy see also MARSILI (2007a) and MARSILI et al. (2007).

Material: Seven teeth. MCGS 7879, incomplete lower tooth; MCGS 7880, upper

anterior tooth; MCGS 7906, lower anterior tooth; MCGS 7907, lower anterior tooth; MCGS 7908, upper antero-lateral tooth; MCGS 7910, upper anterior tooth; MCGS 7911, lower anterior tooth.

Remarks: The upper and lower anterior teeth are characterized by a sigmoid, flexuous, narrow, and distally bended cusps, with smooth cutting edges and labially recurved tips. Moreover, on labial view, the roundness of the crown foot obscures the definition of the mesial and distal cutting edges (PURDY et al., 2001). Such characters justify the assignment of the specimens to the living *Isurus oxyrinchus* (see also GARRICK, 1967; MORENO & MORÒN, 1992; PURDY et al., 2001).

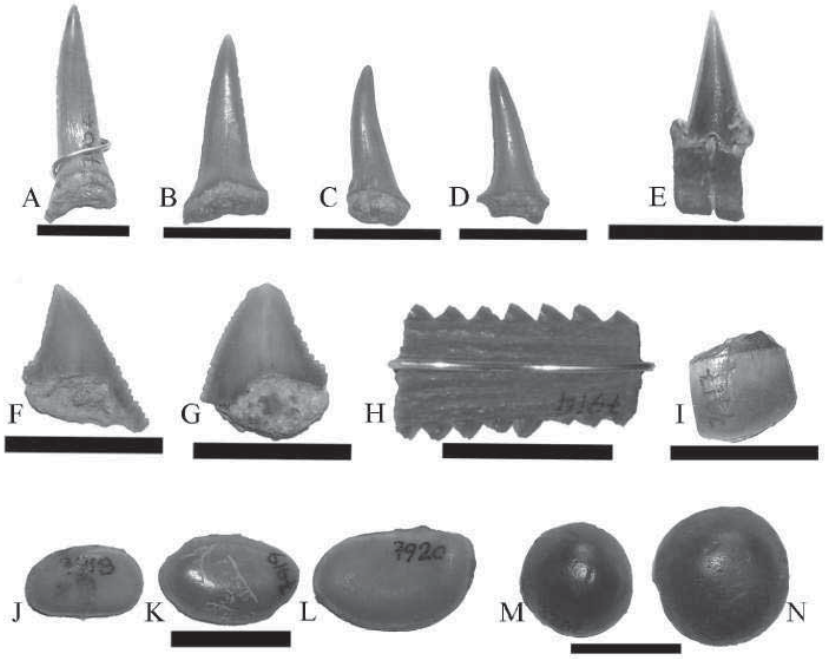

Fig. 2 - **A-D** – *Carcharias acutissima* Agassiz, 1843; antero-lateral teeth, lingual view (**A** – MCGS 7902; **C-D** – MCGS 7903); **E** – *Scymnodon* cf. *ringens* (Bocage & Capello, 1864); lower antero-lateral tooth, lingual view (MCGS 7913); **F** – *Carcharhinus* aff. *plumbeus* (Nardo, 1827); upper antero-lateral tooth, lingual view (MCGS 7912); **G** – *Carcharhinus* sp.; upper antero-lateral tooth, lingual view (MCGS 7912); **H** – Myliobatidae indet.; caudal spine, ventral view (MCGS 7914); **I** – *Diplodus* sp.; incisor, labial view (MCGS 7917); **J-L** – Sparidae morphotype 1; molars, apical view (**J** – MCGS 7918; **k** – MCGS 7919; **L** – MCGS 7920); **M-N** – Sparidae morphotype 2; molars, apical view (**M** – MCGS 7920; **N** – MCGS 7921). Scale bars: 1 cm.

More flexuous and sigmoid upper and lower anterior teeth, characterized by a labially recurved tip of the cusp and a distal cutting edge that never reaches the crown-base, exclude the possible assignment to *I. paucus* (GARRICK, 1967; MORENO & MORÒN, 1992). Moreover, *I. oxyrinchus* differs from *I. hastalis* and *I. xiphodon* in that the upper and lower teeth are characterized by a narrower and slender cusps (LANDINI, 1977; PURDY et al., 2001; MARSILI, 2007a)

Stratigraphic distribution: *I. oxyrinchus* represents one of the most relevant shark species in the Neogene elasmobranch assemblages, characterized by a very wide geographic distribution and continuous stratigraphic record (see e.g. Cappetta, 1987; MARSILI, 2007a; MARSILI et al., 2007).

Isurus xiphodon (Agassiz, 1838) (Fig. 3 G-H)

1911 *Oxyrhina hastalis* Agassiz - DE STEFANO, p. 395, pl. 10, fig. 14-15.
Synonymy see also MARSILI (2007a).

Material: Two teeth. MCGS 7904, upper anterior tooth; MCGS 7905, upper antero-lateral tooth.

Remarks: *I. xiphodon* is characterized by broad and triangular upper anterior and lateral teeth, lower teeth with erect crown, and lower anterior teeth with short, massive root lobes. Moreover, juvenile teeth are like those of adults in form (PURDY et al., 2001). Although the aim of this work goes beyond the debate about the taxonomic validity of *I. xiphodon* (see e.g. PURDY et al., 2001; WARD & BONAVIA, 2001), very broad triangular cusps support the assignment of the specimens to this fossil taxon, herein considered as a valid species separated from the fossil *I. hastalis*.

Stratigraphic distribution: The Miocene record of *I. xiphodon* include the Mediterranean (DE ALESSANDRI, 1897; SEGUENZA, 1900; MENESINI, 1968; 1974), Portugal (ZBYSZEWSKI & MOITINHO D'ALMEIDA, 1950; ANTUNES & BALBINO, 2003), Belgium (DE CEUSTER, 1976; NOLF, 1988), Holland (VAN DEN BOSCH et al., 1975), Venezuela (AGUILLERA & RODRIGUES DE AGUILLERA, 2004) and Japan (YABE & HIRAYAMA, 1998). During the Pliocene *I. xiphodon* was widely recorded in the Mediterranean Basin (see also MARSILI, 2007a), as well as in Belgium (NOLF, 1988), Venezuela (AGUILLERA & RODRIGUES DE AGUILLERA, 2004), and North America (PURDY et al., 2001).

Genus *Carcharodon* Müller & Henle, 1838
Carcharodon carcharias (Linnaeus, 1758) (Fig. 3 I-R)

1911 *Carcharodon Rondeleti* Müller & Henle - DE STEFANO, p. 392, pl. 10, fig. 1-7.
Synonymy see also MARSILI (2007a).

Material: 16 teeth. MCGS 7869, upper anterior tooth; MCGS 7870, upper anterior tooth; MCGS 7871, upper anterior tooth; MCGS 7872, upper anterior tooth;

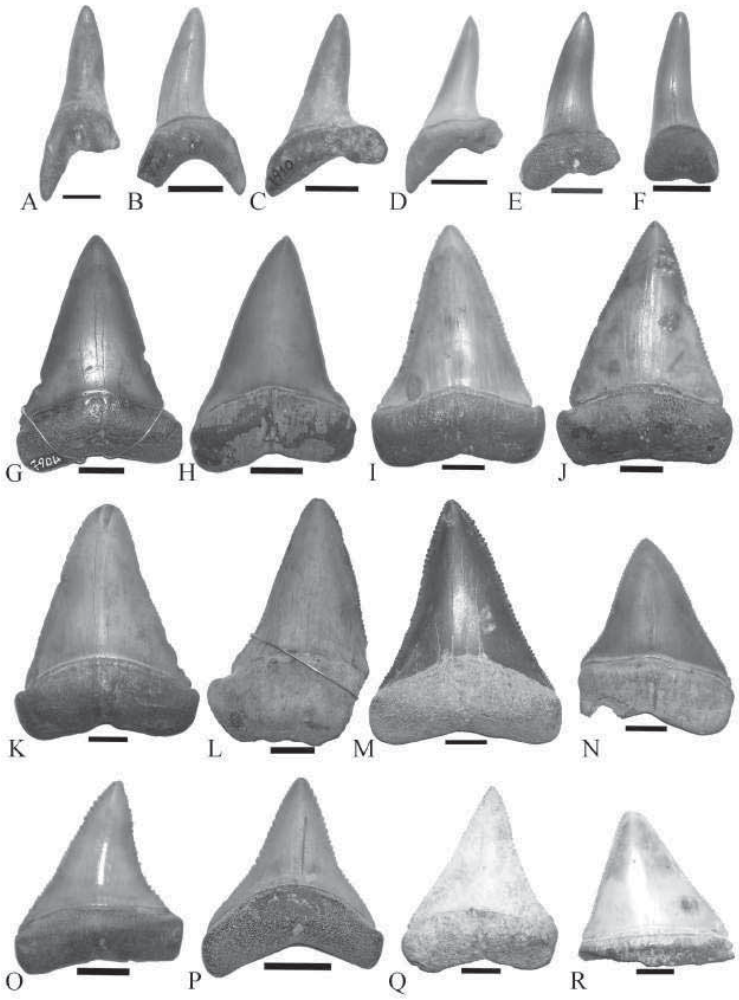

Fig. 3 - **A-F** – *Isurus oxyrinchus* Rafinesque, 1810; **A** – lower anterior tooth, lingual view (MCGS 7906); **B** – lower anterior tooth, lingual view (MCGS 7911); **C** – upper antero-lateral tooth, lingual view (MCGS 7910); **D** – upper anterior tooth, lingual view (MCGS 7880); **E** – upper antero-lateral tooth, lingual view (MCGS 7908); **F** – lower antero-lateral tooth, lingual view (MCGS 7879); **G-H** – *Isurus xiphodon* (Agassiz, 1838); **G** – upper anterior tooth, lingual view (MCGS 7904); **H** – upper antero-lateral tooth, lingual view (MCGS 7905); **I-R** – *Carcharodon carcharias* (Linnaeus, 1758); **I** – upper anterior tooth, lingual view (MCGS 7871); **J** – upper anterior tooth, lingual view (MCGS 7872); **K** – upper anterior tooth, lingual view (MCGS 7898); **L** – lower antero-lateral tooth, lingual view (MCGS 7899); **M** – upper anterior tooth, lingual view (MCGS 7869); **N** – upper lateral tooth, lingual view (MCGS 7900); **O** – upper lateral tooth, lingual view (MCGS 7877); **P** – lower lateral tooth, lingual view (MCGS 7901); **Q** – lower antero-lateral tooth, lingual view (MCGS 7873); **R** – upper lateral tooth, lingual view (MCGS 7874); Scale bars: 1 cm.

MCGS 7873, lower antero-lateral tooth; MCGS 7874, upper lateral tooth; MCGS 7875, incomplete upper anterior tooth; MCGS 7876, lower antero-lateral tooth; MCGS 7877, upper lateral tooth; MCGS 7878, upper lateral tooth; MCGS 7896, upper anterior tooth; MCGS 7897, upper antero-lateral tooth; MCGS 7998, upper anterior tooth; MCGS 7899, lower lateral tooth; MCGS 7900, upper antero-lateral tooth; MCGS 7901, lower lateral tooth.

Remarks: The upper anterior and antero-lateral teeth are broad, triangular and labial-lingually compressed, with linear and serrated cutting-edges. The lower antero-lateral teeth are triangular and more erected than the upper ones, with a concave and serrated cutting edges (see also LANDINI, 1977; CAPPETTA, 1987; PURDY et al., 2001). *C. carcharias* differs from the fossil giant-toothed white shark *C. megalodon* in that the upper and lower teeth are characterized by coarser serrated cutting edges, a more labial-lingual flattened cusps, the absence of a neck in the adult form, and the absence of a torus on the lingual face of the root (see e.g. PURDY et al., 2001).

Stratigraphic distribution: *C. carcharias*, poorly represented during the Miocene, became one of the most relevant shark species in the Plio-Pleistocene elasmobranch fauna, widespread in most marine ecosystems (see e.g. MARSILI, 2007a), in which it represented a top predator on large teleosteans, elasmobranches and marine mammals (COMPAGNO, 1984; BIANUCCI et al. 2000).

Order **Carcharhiniformes** Compagno, 1973
Family **Carcharhinidae** Jordan & Evermann, 1896
Genus *Carcharhinus* Blainville, 1816
Carcharhinus aff. *plumbeus* (Nardo, 1827) (Fig. 2 F)

1911 *Carcharias* (*Prionodon*) *glaucus* Linnaeus - DE STEFANO, p. 397, pl. 10, fig. 26.
Synonymy see also MARSILI (2007a, b).

Material: One tooth. MCGS 7912, incomplete upper antero-lateral tooth.

Remarks: The tooth lacks the root. The cusp is broad, triangular and labial-liangually compressed, with serrated cutting edges. Such characters justified the assignment of the specimen to the living *C. plumbeus* (MARSILI, 2007b). A thinner and labial-lingually compressed cusp differs *C. plumbeus* from *C. leucas*, *C. longimanus* or *C. obscurus* (CAPPETTA & NOLF, 1991; MARSILI, 2007b). Moreover, *C. plumbeus* differs from *C. galapagensis* and *C. altimus* in that the upper teeth are characterized by a less elongated and slender cusps (MARSILI, 2007b). The absence of an hooked tip of the cusps as well as of a shallow notch at the midway along both the cutting edges excludes the possible assignment of the tooth to *C. albimarginatus* (PURDY et al., 2001).

Stratigraphic distribution: The Miocene record of *C. plumbeus* includes North Carolina (PURDY et al., 2001), Portugal (ANTUNES et al., 1999; ANTUNES & BAL-

BINO, 2004), and Libya (D'ERASMO, 1951). During the Pliocene, the geographic distribution of this shark was restricted to the Lee Creek Mine deposits in the North Carolina (PURDY et al., 2001) and to the Mediterranean Basin (MARSILI, 2007b). SCUDDER et al. (1995) also recorded *C. plumbeus* in the Lower Pleistocene deposits of the "Leisey Shell Local Fauna" in Florida.

Carcharhinus sp. (Fig. 2 G)

Material: Two teeth. MCGS 7912, incomplete upper antero-lateral teeth (see DE STEFANO, 1911, p. 397, pl. 10, fig. 24-25).
Remarks: The teeth are strongly incomplete, eroded and devoid of the root. The cusp is broad and triangular, with serrated lateral cutting edge. The absence of a apically convex mesial cutting edge, as well as of a tip of the cusp distally deflected excludes the possible assignment of the specimens to *C. obscurus* (see also PURDY et al., 2001; MARSILI, 2007b). However, the megear state of preservation of the teeth, as well as the wide morphological variability that characterized the dentition of the sharks of the genus *Carcharhinus* (see GARRICK, 1982; MARSILI, 2007b), do not allow a specific assignment of the material studied.
Stratigraphic distribution: *Carcharhinus* first occurred in the Middle Eocene deposits of the Egypt (CAPPETTA, 1987) and North America (CASE, 1981). Moreover, LERICHE (1910) recorded this genus in the Oligocene deposits of Belgium, but it is during the Neogene that *Carcharhinus* becomes one of the most representative genera of the global marine ecosystems (see e.g. UYENO & MATSUSHIMA, 1974; CIGALA FULGOSI, 1986; APPLEGATE, 1986; CAPPETTA, 1987; LONG, 1993; SCUDDER et al., 1995; PURDY, 1998; SÁNCHEZ-VILLAGRA et al., 2000; PURDY et al., 2001; ANTUNES & BALBINO, 2004), including the Mediterranean (LANDINI, 1977; CIGALA FULGOSI, 1986; CAPPETTA & NOLF, 1991; CARNEVALE et al., 2006; MARSILI, 2007b)

Order **Squaliformes** Goodrich, 1909
Family **Dalatiidae** Gray, 1851
Genus *Scymnodon* Bocage & Capello, 1864
Scymnodon cf. *ringens* Bocage & Capello, 1864 (Fig. 2 E)

1911 *Scymnus lichia* Cuvier - DE STEFANO, p. 398, pl. 10, fig. 27-28.
Synonymy see also MARSILI (2007a).

Material: One tooth. MCGS 7913, lower antero-lateral tooth.
Remarks: The cusp is triangular and labio-lingually compressed, with smooth lateral cutting edges. A deep notch separates the cusp from a distal enamel blade. The apron is rectangular and overhangs the upper part of the labial face of the root. The uvula is absent. The root is rectangular. The labial face of the root is characterized by a well developed mesial depression. Several labial foramen are

present around the apron. The lingual face of the root is flat, characterized by a thick longitudinal ridge along the crown-root junction. A deep mesial and central lingual foramen are present on this longitudinal ridge. Such characters justify the assignment of the specimens to the living *S.* cf. *ringens* (see also HERMAN et al., 1989; MARSILI, 2007c). A more erected cusp and a different root and apron morphologies differ *Scymnodon* from the genus *Zameus*, *Centroscymnus*, and *Scymnodalatias* (see also LEDOUX, 1970; HERMAN et al., 1989; ADNET & CAPPETTA, 2001; MARSILI, 2007c; MARSILI & TABANELLI, in press).
Stratigraphic distribution: *S. ringens* is characterized by a continuous Mediterranean fossil record, starting from the lower Pliocene up to the middle Pleistocene (CIGALA FULGOSI, 1986; 1996; MARSILI, 2007c). MARSILI & TABANELLI (in press) recently recorded this Atlantic deep-water shark also in the middle Pliocene deposits cropping out near Rio Cugno (Brisighella, Ravenna district).

Order **Myliobatiformes** Compagno, 1973
Family **Myliobatidae** Bonnaterre, 1838
Myliobatidae indet. (Fig. 2 H)

Material: One incomplete caudal spine (MCGS 7914, see DE STEFANO, 1911, p. 398, pl. 10, fig. 29-30).
Remarks: The specimen is strongly incomplete and eroded (length: 1.5 cm). Caudal spine are very common in the Plio-Pleistocene Mediterranean deposits, commonly assigned by the authors to the fossil taxon *Myliobatis crassus* (see also MARSILI, 2007a). However, because of their poor taxonomic value, such material cannot be assigned at generic level.

Discussion

The review of the elasmobranch teeth collection housed in the "Museo Civico Giuseppe Scarabelli" of Imola (Bologna) provides a further contribution to the understanding of the Pliocene elasmobranch diversity of Romagna region, also confirming some of the main paleoecologic and paleobiogeographic trend that characterized the Mediterranean evolutionary history of this marine vertebrate group across the Plio-Pleistocene.
Seven taxa, *Carcharias acutissima*, *Isurus oxyrinchus*, *I. xiphodon*, *Carcharodon carcharias*, *Carcharhinus* aff. *plumbeus*, *Carcharhinus* sp., and *Scymnodon* cf. *ringens*, included into five genera and four families have been recognised (Tab. 1). A fragmentary caudal spine confirms the presence of the family Myliobatidae in the Pliocene deposits of Romagna region. *C. carcharias* and *I. oxyrinchus* are the most relevant species of the elasmobranch teeth collection, while all the other taxa are represented by very few specimens. Several teleostean teeth, assigned to *Diplodus* sp. (Fig. 2I) as well as to two indeterminate species of the family Sparidae (Fig. 2J-L; Fig. 2M-N), are also included into the reviewed collection (Tab. 1).

Family	List of taxa Species	Present status	Climate	Environment		Depth (m)
Odontaspididae	*Carcharias acutissima*	Mediterranean	subtropical (?)	costal (?)	continental shelf (?)	(?)
Lamnidae	*Isurus oxyrinchus*	Mediterranean	subtropical	pelagic	epipelagic	0 - 152
	Isurus xiphodon	extinct	subtropical (?)	costal-pelagic	continental and insular shelf	(?)
	Carcharodon carcharias	Mediterranean	temperate	costal-pelagic	continental and insular shelf	0 - 1280
Alpiidae	*Alopias superciliosus*	Mediterranean	subtropical	pelagic	epipelagic-costal water	0 - 500
Carcharhinidae	*Carcharhinus* aff. *plumbeus*	Mediterranean	subtropical	costal-pelagic	continental and insular shelf	? - 1800
	Carcharhinus sp.	Mediterranean	subtropical	costal-pelagic	continental and insular shelf	0 - 500
Dalatiidae	*Scymnodon* cf. *ringens*	extra-Mediterranean	deep-water	bathypelagic	continetal slope	200 - 1600
Myliobatidae	Myliobatidae indet.	Mediterranean	subtropical	bentopelagic	shallow costal waters	0 - 300

Table n. 2 – Present status and paleoecological preferences of the shark taxa from the Pliocene deposits of Romagna Region, including *A. superciliosus*.

I. xiphodon and *C. acutissima* represent two relict taxa of the Miocene elasmobranch fauna, widely distributed also during the Plio-Pleistocene into the Mediterranean. *I. xiphodon* was recorded at least until the middle Pliocene, while *C. acutissima* persisted until the upper Pliocene-lower Pleistocene into this basin (MARSILI, 2007a). *I. xiphodon* was a costal-pelagic shark characterized by a feeding ecology near to that of the living white shark *C. carcharis* (PURDY et al., 2001). This shark was mostly abundant in those marine sediments rich in pinniped and/or small cetaceans, on which it commonly fed (see e.g. PURDY et al., 2001; AGUILERAS & RODRIGUES DE AGUILERAS, 2004; MARSILI, 2007a). The presence of *I. xiphodon* in Romagna region confirms the lower-middle Pliocene record of this fossil shark into the Mediterranean Basin (MARSILI, 2007a).
C. aff. *plumbeus* and *Carcharhinus* sp. are two coastal-pelagic sharks (Tab. 2), mostly abundant in the tropical and subtropical waters of the Atlantic and Indo-Pacific Oceans (COMPAGNO, 1984). Moreover, *C.* aff. *plumbeus* is commonly recorded also in the whole Mediterranean (SERENA, 2005).
In the last decades, most of the Pliocene shark teeth included in the genus *Carcharhinus* were assigned by the authors to the "waste-basket" species *C. egertoni*, as a consequence of the poor data available about the tooth morphology and the intraspecific variability of the carcharhinid species (see also LONG, 1993; CAPPETTA & NOLF, 1991; MARSILI, 2007b). Therefore, the presence of *C.* aff. *plumbeus* and *Carcharhinus* sp. in the reviewed collection confirms the Plio-Pleistocene wide diversity and distribution of the genus *Carcharhinus* in the Mediterranean fish fauna (CARNEVALE et al., 2006; MARSILI, 2007b).
Scymnodon cf. *ringens* represents the only bathydemersal shark species of the studied elasmobranch teeth collection (Tab. 2). This shark, not included in the present Mediterranean marine biota, is commonly restricted to the eastern Atlantic continental slope at depth of 200 to 1600 m (COMPAGNO, 1984). The antero-lateral tooth assigned to *S. ringens* increases the Plio-Pleistocene stratigraphic record of this sharks in the Mediterranean region (see also CIGALA FULGOSI, 1986; 1996; MARSILI, 2007c), also supporting the presence of a more middle Pliocene diversified deep-water elasmobranch fauna with a more biogeographic Atlantic affinity than today in Romagna Region (see also MARSILI & TABANELLI, in press).
C. carcharias and *I. oxyrinchus* are two coastal-pelagic sharks (Tab. 2) commonly recorded in the Mediterranean Basin (MOJETTA et al. 1997; DE MADDALENA, 2000; STORAI et al., 2001, MOREY et al., 2003; SERENA, 2005). They are characterized by a very wide stratigraphic record, representing two of the most relevant species of the Plio-Pleistocene Mediterranean elasmobranch assemblages (CAPPETTA, 1987; MARSILI, 2007a; MARSILI et al., 2007). Therefore, their occurrence in the Pliocene Romagna deposits increase the extant knowledge about the geographic distribution of these two living sharks in the Mediterranean region.

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