

First historical record of *Carcharhinus brachyurus* (Chondrichthyes, Carcharhiniformes) in the Mediterranean Sea

P. N. PSOMADAKIS¹, M. VACCHI², S. DI MUCCIO¹ & M. SARÀ³

¹Istituto Centrale per la Ricerca Applicata al Mare (ICRAM), Roma, Italy, ²ICRAM c/o Museo Nazionale dell'Antartide, University of Genoa, Genova, Italy, and ³Museo Zoologico, Dipartimento di Biologia Animale, University of Palermo, Palermo, Italy

(Received 2 February 2008; accepted 19 May 2008)

Abstract

The dried jaws of two specimens of *Carcharhinus brachyurus* were found in the collections of the Zoological Museum of the University of Palermo. Both pieces belong to the great Doderlein collection of fishes from Sicily assembled during the end of the nineteenth century (1862–1892) and are labelled as *Carcarias (Prionodon) lamia* and *Carcharias lamia*, respectively. These findings represent the first historical evidence of the presence of *C. brachyurus* in the Mediterranean Sea and add the southern Tyrrhenian to the species distribution within the Mediterranean. Moreover, sexual dimorphism in tooth morphology is documented for the first time in Mediterranean specimens. Some meristic and morphological data concerning the dentition are given, and a critical analysis of the presence of the species in the Mediterranean is presented.

Keywords: *Carcharhinus brachyurus*, historical record, Mediterranean, southern Tyrrhenian Sea

Introduction

The copper shark *Carcharhinus brachyurus* (Günther, 1870) is an inshore to offshore warm-temperate species occurring worldwide from the surfline to at least 100 m depth (Compagno 1984). Apparently migratory, this shark species was initially included in the Mediterranean Sea by Garrick (1982) on the basis of re-examination of old museological material coming from Nice and from a rather enigmatic locality 'Constantinopel near Trieste' of the northern Adriatic Sea. However, due to its uncertain origin, the latter record is to be considered doubtful (see Lipej et al. 2004). Subsequent records confirmed the presence of the copper shark in the Mediterranean Sea: Sicilian Channel (Cigala Fulgosi 1983; Fowler & Earll 1994); Alboran Sea, cited by the synonym of *C. acarenatus* (Moreno 1982; Moreno & Hoyos 1983); Rhodes (Fowler & Earll 1994); northern Tyrrhenian Sea (Vacchi et al. 1996); Ligurian Sea (Orsi Relini 1998); Algerian coast (Hemida et al. 2002); Balearic Islands (Morey

& Massuti 2003). The report of a 164 cm total length mature male of *C. brachyurus* from Palermo (Zava et al. 2006) needs confirmation due to the unclear taxonomic procedures used to diagnose the specimen to the specific level.

In this paper is reported the finding, among the collections of the Zoological Museum of the University of Palermo (MZP), of the dried jaws of two specimens of *C. brachyurus*, respectively labelled as *Carcarias (Prionodon) lamia* and *Carcharias lamia*, which belong to the great Doderlein ichthyological collection assembled during the end of the nineteenth century (1862–1892). Although used in the past to identify some not well-defined carcharhinid species, *Carcharias (Prionodon) lamia* Risso must be considered an invalid name, since any valid species is recognizable under this nomenclature (Tortonese, 1950). Furthermore, the evidence of a more ancient presence of *C. brachyurus* in the Mediterranean Sea is revealed and the southern Tyrrhenian Sea is added to the copper shark Mediterranean distribution, therefore filling the gap between the southern and

*Correspondence: Peter Nick Psomadakis, Istituto Centrale per la Ricerca Applicata al Mare (ICRAM), Via di Casalotti 300, I-00166 Roma, Italy. Email: peterpsomadakis@inwind.it

northern records of the species in the central sector of the Mediterranean Sea. Sexual dimorphism in the copper shark teeth is documented for the first time in Mediterranean specimens.

Material and methods

Two dried jaws of *C. brachyurus* originally labelled as *Carcharias (Prionodon) lamia* (Risso), Palermo – catalogue no. AN/93 (Plate I) and *Carcharias lamia*, Palermo – catalogue no. AN/80 (Plate II), were found among the collections of the MZP. These two museological pieces had the old labels covered with more recent ones erroneously labelled as *Prionace glauca*. According to Sarà and Sarà (1990), the locality indication of Palermo given by Doderlein for samples within its collection, is to be intended as the broad stretch of sea that goes from Isola delle Femmine to Trabia (see Figure 1).

The jaws were examined and diagnosed to the specific level on the basis of Garrick (1982) and Compagno (1984). Morphometric measurements performed on the jaws were made as follows: DUJP= dried upper jaw perimeter (measured from the corner and along the functional teeth bases); DLJP= dried lower jaw perimeter; VO= vertical opening (from symphysis to symphysis); HO= horizontal opening (transversally from corner to corner). The following tooth parameters, were also

taken: ULH= largest upper lateral tooth total height (from highest point of root to crown apex); ULW= largest upper lateral tooth width (from side to side in the widest point); LLH= largest lower lateral tooth height; LLW= largest lower lateral tooth width. All tooth parameters were measured on functional teeth of the outer row. Jaws and tooth measurements used in this paper were adapted from Mollet et al. (1996) and are shown in Figure 2. With the exception of the jaw perimeter values (measured with a rounded measuring string), all other parameters were recorded with a clock-calliper to the nearest millimetre.

Results

The identification of the Palermo specimens, based exclusively on the analysis of the jaws, was made possible thanks to the distinctive dentition morphology of the species (Garrick 1982). As pointed out by the latter author, *C. brachyurus* is one of the few carcharhinid species which can, with virtual certainty, be identified by upper tooth shape alone. The dental formulae and the basic jaws morphometry of the two Sicilian samples fall within the range indicated by Garrick (1982) and are summarized in Table I.

The shape of the teeth can be described as follows: upper teeth have a wide concave base with a central notch; cusps are moderately broad, oblique, strongly

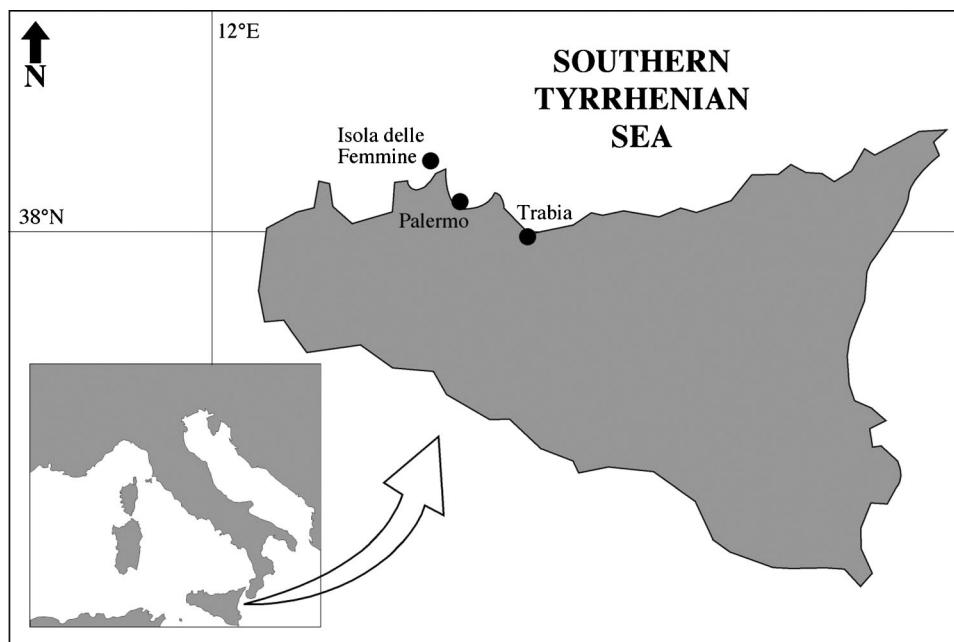


Figure 1. Map of the Italian Peninsula showing in detail Sicily and the stretch of sea from Isola delle Femmine to Trabia which is to be identified with the indication of Palermo given by Doderlein for museological pieces (included the jaws of *Carcharhinus brachyurus* studied in this paper) belonging to the great collection of fishes from Sicily that carries his name.

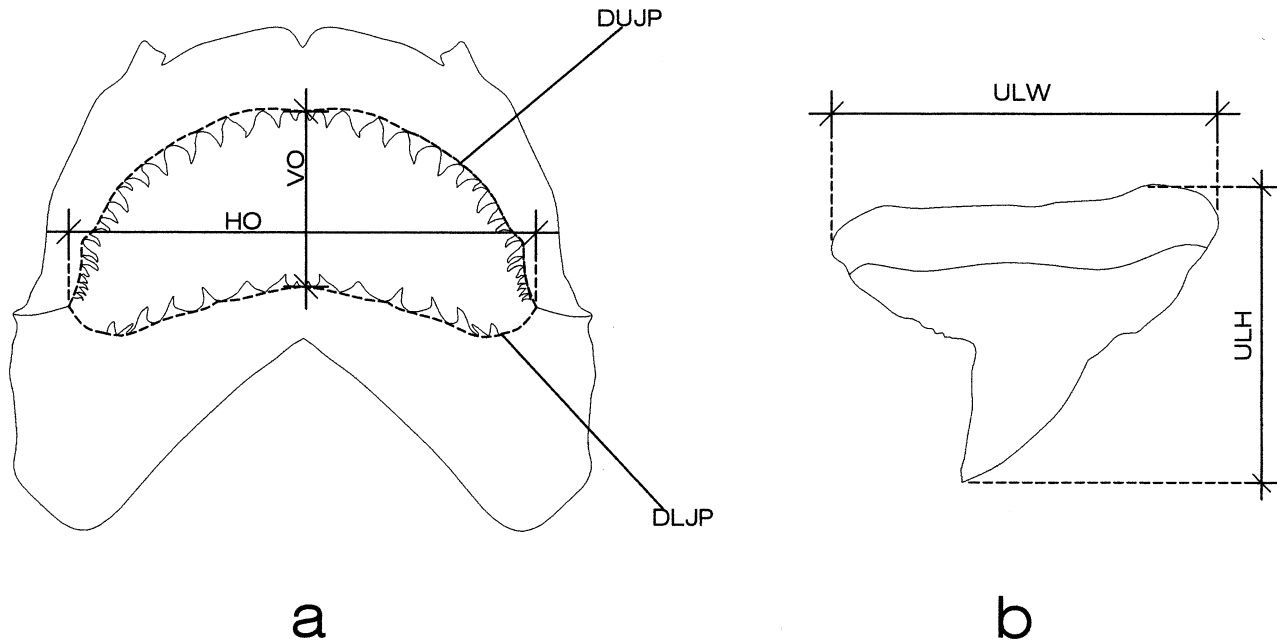


Figure 2. Measurements taken on the jaws (a) and teeth (b) of the museological samples of *Carcharhinus brachyurus* from Palermo (see text for abbreviations).

notched on the distal blade and weakly notched on the mesial blade, with slightly coarser serrations on the shoulders; lower teeth have a wide base only slightly concave with very narrow cusps, almost straight with very fine serration barely perceivable. Reserve teeth are three or four per series, while functional teeth are one or two per series either in the upper or lower jaw. In the lower jaws of both samples, functional teeth appear to be more or less recurved into the jaws, and to a certain degree also in the upper jaws of AN/80.

In the AN/93 specimen, the lateral teeth of the upper jaws (see Plate I, b) appear more narrow and 'hooked' compared with the upper jaw teeth of the AN/80 specimen. According to Bass et al. (1973) and to Garrick (1982), this is the main distinguishing character in male specimens of the species. The

latter authors also state that this difference is not apparent in immature specimens, where the teeth are similar to those of adult females.

Moreover, on the basis of biometrical relationships given by Garrick (1982), the total lengths (TL) of the two copper sharks collected in Palermo waters can be estimated as follows: AN/93 specimen = 236 cm and AN/80 specimen = 287 cm. Records of the copper shark within the Mediterranean are summarized in Table II, Figure 3.

Discussion

The copper shark is apparently rare in the Mediterranean (Garrick 1982). According to Morey and Massuti (2003), only 35 individuals of the species have been reported to date in the Mediterranean. In our opinion this is an underestimate and a more realistic figure of the copper shark records in the Mediterranean must be incremented to at least 50 individuals considering both *C. brachyurus* and its junior synonym *Carcharhinus acarenatus* (see Table II). It is still not clear if *C. brachyurus* is an occasional visitor from the Atlantic or whether the Mediterranean has its own, although small, population. Starting from 1980, an increasing number of specimens of this species have been reported in the Mediterranean (see Table II). Nowadays, there is a tendency to explain the findings of unusual fishes with the physical changing conditions occurring in the latter sea (see

Table I. Basic jaws and tooth morphometry in millimeters (mm) of the two museological samples of *Carcharhinus brachyurus* presented in this study (see text for abbreviations).

Parameter	AN/80 ♀	AN/93 ♂
DUJP	405	367
DLJP	380	338
HO	203	189
VO	38	46
ULH	13	13
ULW	17	12
LLH	10	9
LLW	14	13
Dental formula	15-2-15/14-1-14	16-3-16/14-2-14

Table II. Records of *Carcharhinus brachyurus* in the Mediterranean Sea in chronological order. Measurements of estimated TL in brackets. *Doubtful record (see text); +data not available or not furnished by the author/s; ¹reported as *Carcharhinus acarenatus* by the author.

Area	Year	Specimens	Gear and depth	Reference
1. Palermo (Southern Tyrrhenian)	Ante 1878	1 male (236 cm TL) 1 female (287 cm TL)	+	Present paper
2. Nice (Ligurian Sea)	1881–1898	1 female 80 cm TL 5 embryos 40–46.5 cm TL	+	Garrick (1982)
3. North Adriatic*	1 September 1906	1 female 123 cm TL	+	Garrick (1982)
4. Camogli (Ligurian Sea)	16 December 1906	(250 cm TL)	+	Orsi Relini (1998)
5. Tuscany (Northern Tyrrhenian)	June 1980	260 cm TL female containing 14 embryos 40–50 cm TL	Fixed-net, set at 6–15 m depth	Vacchi et al. (1996)
6. Mazara del Vallo (Sicilian Channel)	12 August 1981	185 cm TL female	+	Cigala Fulgosi (1983)
7. Chafarinas Islands (Alboran Sea)	August 1980–82	4 females 150–235 cm TL 7 males 150–250 cm TL	Pelagic longline, set 4–6 miles from the coastline	Moreno (1982) ¹
8. Alhucemas banks (Alboran Sea)	1981	7 gravid females and many newborn individuals	Longline	Muñoz-Chápuli (1984)
9. Faliraki (Rhodes)	August 1990	60 cm TL	Bottom-net, set ~500 m offshore	Fowler and Earll (1994)
10. Mazara del Vallo (Sicilian Channel)	Contemporary	1 female and 5 males 185–276 cm TL	+	Fowler and Earll (1994)
11. Algerian coasts	1996–2002, mainly summer	3 females 162–193 cm TL 17 males 180–303 cm TL	Trawl and longline	Hemida et al. (2002)
12. Cabrera Archipelago (Balearic Islands)	20 March 2000	220 cm TL female	Pelagic longline	Morey and Massutí (2003)

Psomadakis et al. 2006). However, the dried jaws studied in this paper together with the ones found in the Museum of the Institute of Zoology of the University of Genoa (Orsi Relini 1998) seem to indicate an inadequate knowledge of old ichthyological collections. Further investigations, could reveal a more extensive ancient presence of the copper shark in the Mediterranean waters. This idea is in part confirmed by Doderlein (1878), who includes

Prionodon lamia Risso in the set of infrequent fishes found in Sicilian waters. The latter author enumerates one stuffed specimen (104 cm post-orbital to pre-caudal), five dried jaws and one brain in alcohol that were preserved in the collections of the MZP, and points out that the species common name is lamia and that this shark is locally known as ‘mancia-luvaru’ (‘luvaru’ is the vernacular name for the common pandora *Pagellus erythrinus* and mancia-luvaru means

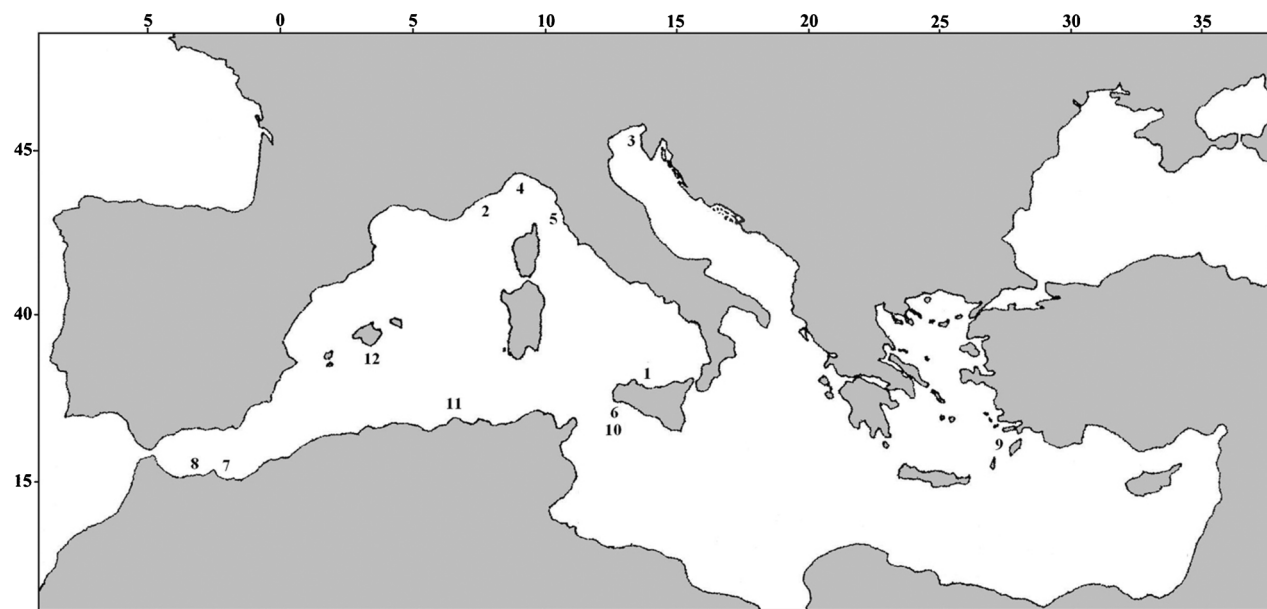


Figure 3. Records of *Carcharhinus brachyurus* in the Mediterranean Sea according to Table II.

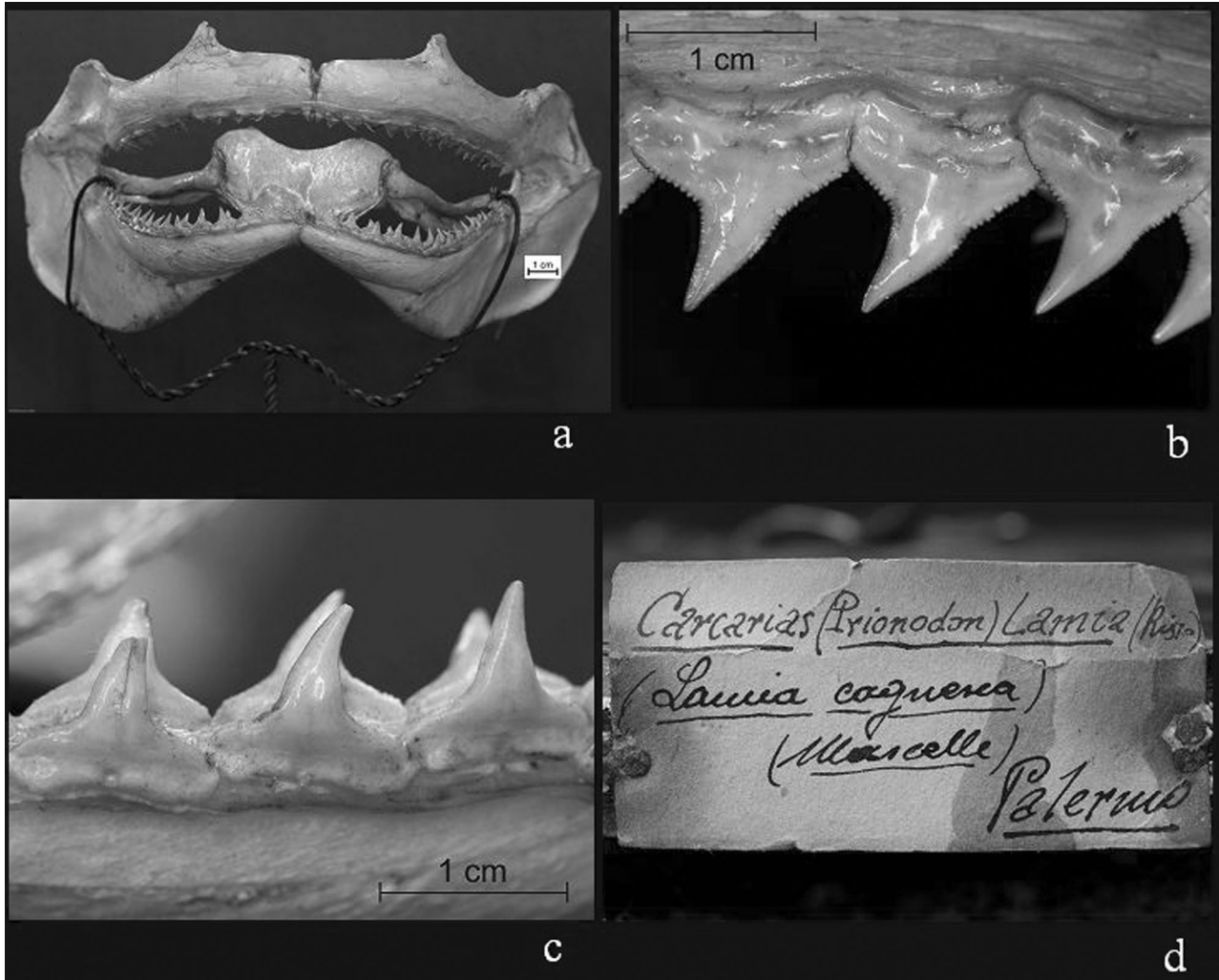


Plate I. *Carcharhinus brachyurus* (AN/93) – Palermo, male 236 cm TL (estimated). a, complete set of jaws (scale bar 1 cm); b, teeth upper jaw; c, teeth lower jaw; d, original label.

common pandora eater). Unfortunately, of this abundant material associated to *P. lamia*, the two dried jaws object of this paper, are the only pieces still preserved in the above mentioned museum. However, Doderlein’s work, published in 1878, attests a more ancient presence of *C. brachyurus* in the Mediterranean, since the oldest report of this species in the latter sea, is represented by a 46.5 cm TL male embryo, catalogue no. NMV 39352 (old number) France, Nice, 1881, Steindachner, held in the Naturhistorisches Museum of Vienna (NMV) (Garrick 1982). According to Dr E. Mikschi (NMV), the 46.5 cm male embryo mentioned above and the 80 cm TL female (catalogue no. NMV 39364, old number) specimens cited in Garrick (1982) are presently missing in NMV systematic collections (see Lipej et al. 2004).

The obvious sexual dimorphism found in tooth morphology of the two Palermo specimens of *C.*

brachyurus attest their condition of mature adults. This condition is also confirmed by the estimated total lengths of the two specimens, 236 cm (AN/93) and 287 cm (AN/80) respectively, which fall within the size maturity range indicated by Compagno (1984). Moreover, the striking difference in height (ULH) to width (ULW) ratios found in the upper lateral teeth of the two examined samples (see Table I) is probably related to the above-mentioned dimorphism, but may also reflect the different position of the teeth used for our measurements (fourth lateral in AN/93 and sixth lateral in AN/80). Sexual dimorphism in the copper shark teeth has so far been documented in specimens from South Africa (Bass et al. 1973) and from the eastern Atlantic and New Zealand (Garrick 1982), but never from the Mediterranean.

Within the Mediterranean, *C. brachyurus* has been principally found in the waters adjacent to the Straits

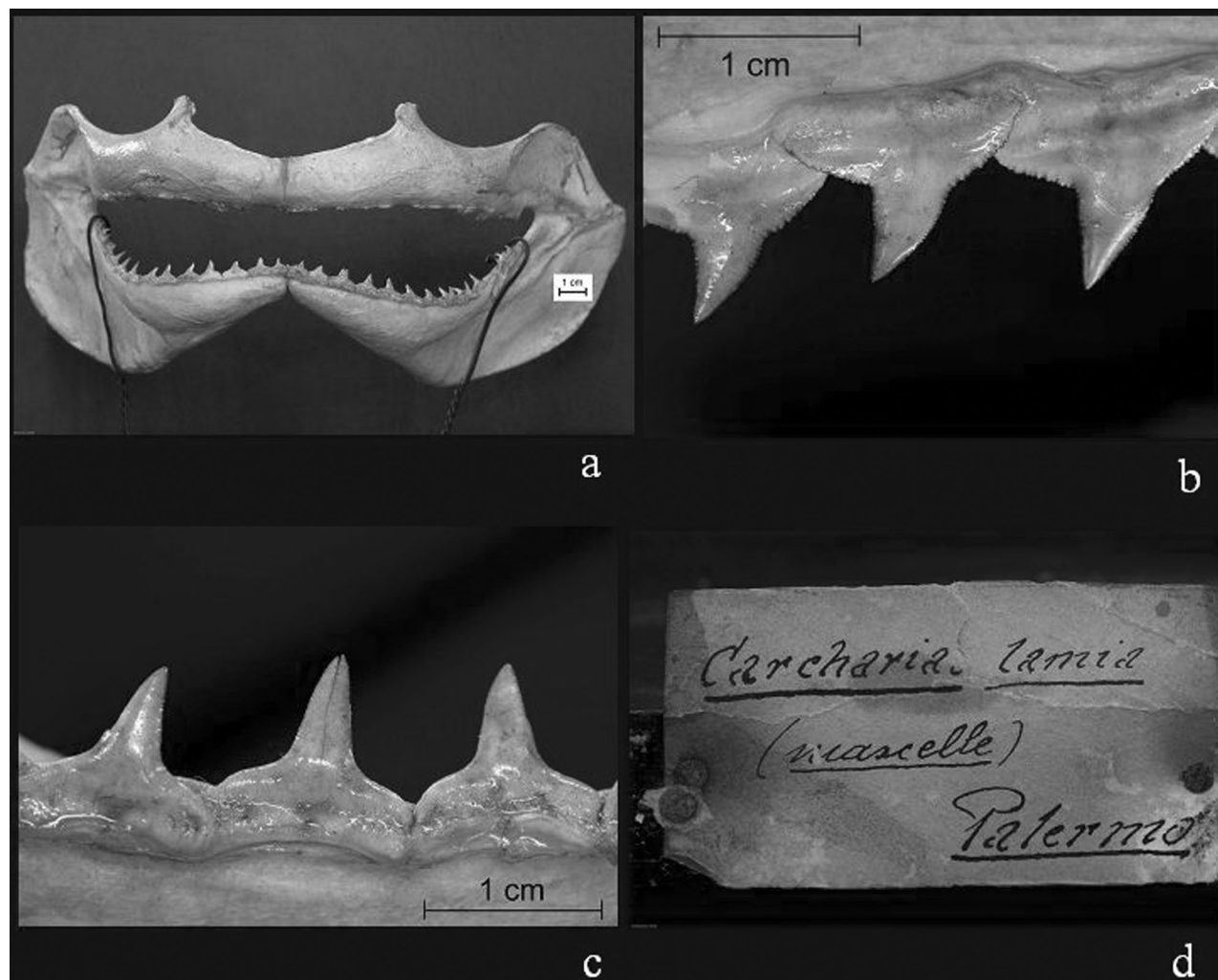


Plate II. *Carcharhinus brachyurus* (AN/80) – Palermo, female 287 cm TL (estimated). a, complete set of jaws (scale bar 1 cm); b, teeth upper jaw; c, teeth lower jaw; d, original label.

of Gibraltar and along the Algerian coast and to some extent in the central Mediterranean (Sicilian Channel), with occasional captures coming from the northern parts of the latter sea (see Figure 3). With the exception of one isolated report from Rhodes (Fowler & Earll 1994), the species seems to be absent from the eastern parts of the Mediterranean and this distribution pattern seems more favourable to the hypothesis of the transit of Atlantic individuals of *C. brachyurus* entering the Mediterranean through the Straits of Gibraltar, rather than the existence of a self sustained Mediterranean population of the species. This hypothesis is supported by investigations conducted in the eastern Atlantic and western Mediterranean where catches of the species resulted concentrated along Gibraltar's northern and southern Atlantic borders as well as directly within the straits (Moreno 1982) and adjacent Alboran Sea (Muñoz-Chàpuli 1984). A similar trend can be

found along the Algerian coast, where captures of the species are more numerous in the western area rather than in the eastern area (Hemida et al. 2002).

Worldwide populations of *C. brachyurus* appear disjoint with probably little genetic interchange between them (Duffy & Gordon, 2003). In particular, South African populations are geographically separated and apparently divergent on the basis of breeding seasonality (Walter & Ebert 1991; Cliff & Dudley 1992). The finding of tooth sexual dimorphism, together with similar dental formulae (see Morey & Massutí 2003) and breeding seasonality between Mediterranean and Atlantic specimens, may contribute to support the 'vagrancy' explanation. Moreover, the consistent finding of single individuals among Mediterranean catches of the species, appears in contrast with the copper shark habits, which tend to live in packs (Cliff & Dudley 1992). At present, data available for Mediterranean

specimens do not allow assessment of important population parameters such as size, biomass and structure of this shark species and it is impossible to evaluate the incidence of the Atlantic population in the Mediterranean. The latter may represent a reproductive zone for these sharks given the presence of pregnant females recorded off Morocco (Muñoz-Chàpuli 1984), Italy (Vacchi et al. 1995) and neonatal specimens taken off Morocco (Muñoz-Chàpuli 1984) and at Rhodes (Fowler & Earll 1994). Clearly, copper shark records within the Mediterranean are sporadically reported either because the species is easily misidentified with other sympatric carcharhinids or because its low density makes it difficult to sample. In order to gain a more complete picture of the species distribution and abundance in the Mediterranean, a more capillary sampling within Mediterranean Maritime districts should be undertaken and old museological materials preserved in naturalistic museums and other institutions should be re-examined on the basis of the huge progress in taxonomy and systematics which this group of sharks has received in the last 60 years.

Acknowledgements

We are grateful to Dr A. Milazzo, Dr E. Bellia and Dr W. Faletta all from the Department of Animal Zoology, University of Palermo for their technical support. The latter researcher dramatically lost his life in an incident. Walter was a good friend and exceptional zoologist, we will miss him and dedicate this article to his memory.

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