A partial skeleton of *Carcharias cuspidatus* (Agassiz, 1843) (Chondrichthyes, Carchariidae) including embryos from the Oligocene of Germany

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A partial skeleton of a pregnant shark with nine embryos was found in the clay pit of the Grube Unterfeld ("Frauenweiler") locality near Rauenberg (Oligocene, Rupelian; Baden-Württemberg, southern Germany). The shark is identified as *Carcharias cuspidatus* (Agassiz, 1843). The cranium with upper and lower dentition, the majority of the vertebral column, parts of the pectoral fins, the dorsal fins, a pelvic fin, an anal fin and caudal fin, as well as skin patches with dermal denticles of the adult specimen and remains of the embryos are described and illustrated.

Key words: Carchariidae, *Carcharias*, Oligocene, Germany

Ein artikuliertes Teilskelett eines trächtigen Haies mit neun Embryonen wurde in der Tongrube Unterfeld („Frauenweiler") bei Rauenberg (Oligozän, Rupelium; Baden-Württemberg, Süddeutschland) gefunden. Der Hai ist identifiziert worden als *Carcharias cuspidatus* (Agassiz, 1843). Der Schädel mit Unter- und Oberkieferbezahnung, ein Großteil der Wirbelsäule, Reste der Brustflossen, die Rückenflossen, Teile einer Bauchflosse, einer Analflosse und die Schwanzflosse sowie Hautteile mit Hautzähnchen des adulten Exemplars und die Reste der Embryonen werden beschrieben und illustriert.

Schlüsselwörter: Carchariidae, *Carcharias*, Oligozän, Deutschland

Introduction

An articulated skeleton of a pregnant shark was found in the Unterfeld ("Frauenweiler") clay pit near Rauenberg, 13 km South of Heidelberg, Baden Württemberg, South Germany (Fig. 1) together with remains of nine embryonic individuals. Although articulated chondrichthyan remains are rare at this locality, some exiting skeletal parts have been recorded in the recent past. An articulated skeleton of a pregnant shark identified as *Cacharias gustrowensis* (Winkler, 1875) with remains of at least eight embryos was previously found and described from this locality by Hovestadt & Hovestadt-Euler (2010). A summary of the Rauenberg chondrichthyan fauna was given by Hovestadt *et al.* (2010).

The specimen described here was excavated in 1996 by the amateur palaeontologists Klaus Dieter Weiss and the late Manfred Keller from beds that correspond to the so-called "Fischschiefer" (Fish Shales) which belong to the Rupelian stage of the Oligocene.

The specimen consisting of two slabs, part and counterpart, was prepared and reconstructed at the Hessisches Landesmuseum Darmstadt (HLMD). The main part is deposited in the collection of the HLMD under the inventory number HLMD-WT 941 (Pl. 1, figs 1, 1a): the counter part is housed in the palaeontological collection of the Staatliches Museum für Naturkunde, Karlsruhe (SMNK), and has the inventory number SMNK-PAL 6598 (Pl. 2, figs 1, 1a).

The articulated skeletal parts are more or less exposed in dorso-lateral view comprising the cranium with upper and lower jaws, the majority of the vertebral column, parts of the pectoral fins, the first and second dorsal fins, one pelvic fin, an anal fin, the caudal fin, patches of skin and nine embryos. The cranium of the specimen comprises several parts of cartilage including remains of the palatoquadrate and Meckel's cartilage. Over 100 teeth and tooth fragments, as well as an almost complete vertebral column with 153 vertebrae and vertebral fragments of the adult specimen are also preserved. Near the vertebral column there are lots of clustered or scattered smaller vertebrae, teeth, and dermal denticles belonging to embryos. The remains of the embryos comprise the following elements: several larger parts of cartilage including parts of the cranium, 51 teeth and tooth remains some of which are more or less grouped in clusters, 264 vertebrae and vertebral fractions, many of which more or less articulated as partial sections of the original ver-

tebral column and scattered skin patches with numerous dermal denticles more or less aligned in their original pattern.

Specimen HLMD-WT 941 comprises the upper jaw and upper dentition with remains of the cranium (Pl. 1, figs 1, 1a), probable remains of a hyomandibula, the majority of the vertebral column, parts of both pectoral fins and the first and second dorsal fins, a pelvic fin, an anal fin, the caudal fin and remains of embryos. The embryo remains comprise a vertebral column section and scattered teeth (Pl. 4, figs 1-1e2), two vertebral column sections and three groups of scattered vertebrae.
Specimen SMNK-PAL 6598 conversely comprises the lower jaw and lower dentition (Pl. 2, figs 1, 1a), the majority of the vertebral column, probable remains of a hyomandibula, parts of the pectoral fins, the first and second dorsal fins, a pelvic fin, an anal fin, the caudal fin, remains of embryos represented by six clusters of scattered vertebrae, a cluster of associated teeth and a vertebral column part, two additional vertebral column parts, another group of associated teeth and a patch of dermal denticles (Pl. 5, figs 1-1d) and another vertebral column with remains of the cranium that are more or less preserved in their original position and together represent an almost complete embryo.

Geological setting

The Rauenberg locality, also known as the Unterfeld claypit, is situated near the city of Rauenberg (Baden-Württemberg) between Heidelberg and Karlsruhe (Fig. 1).
Previously already several chondrichthyan remains have been discovered at this locality, amongst which several partial skeletons of sharks and rays (Hovestadt *et al.* 2010). The Grube Unterfeld is also type locality of two chondrichthyan species, *Triakis kelleri* Hovestadt & Hovestadt-Euler, 2002 and *Weissobatis micklichi* Hovestadt & Hovestadt-Euler, 1999. The sedimentary layers comprising these remains are known as the "Fish Shales" that are overlain by the Meletta Layers (Fig. 2).
A comprehensive description of the Rauenberg locality including the stratigraphy is given by Maxwell *et al.* (2016). Note that thus far no formal stratigraphic units have been defined.

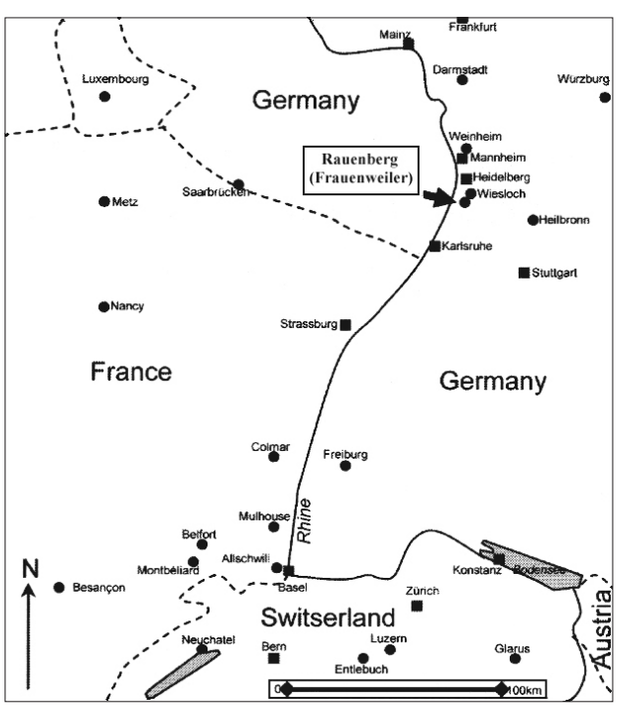

Fig. 1. Locality of Rauenberg (After Hovestadt & Hovestadt-Euler (2010))

Chattian	**Bunte Niederrödener Beds**	
Rupelian	**Gray Layers sequence**	**Cyarena Marls**
		Meletta Layers
		Fish Shales
		Foraminiferal Marls
Latdorfian	**Upper Pechelbronner Layers**	
	Middle Pechelbronner Layers	
	Lower Pechelbronner Layers	

Fig. 2. Stratigraphy of the Rauenberg Site adopted from Micklich & Hildebrand (2005).

Material and Methods

The specimen was recovered in approximately 500 pieces. These were identified and separated into belonging to the main or the counterpart of the specimen. Each of these were transferred onto polyester resin plates according to the method described by (*e.g.*) Lippmann (1987) and Micklich & Drobek (2007). By this method a part and counterpart are created that comprise skeleton parts as either original remains or their imprint. After careful preparation, when both jaws were still isolated pieces, a camera on a stand was used to photograph every single tooth on the pieces with the jaw remains. A selection of the teeth with morphologically different characteristic features was isolated from their original images. Excess matrix material of those pieces that included shark or embryo remains was carefully removed to expose teeth or dermal denticles. Subsequently, these single pieces were mounted together, resulting in a reconstruction of the shark in the two slabs HLMD-WT 941 and SMNK-PAL 6598 as mentioned above, the reconstruction of the complete dentition of the adult specimen (Pl. 3, figs 1-35b) and the reconstruction of the embryo figured on Pl. 4, figs 1-1e2 as well as a second embryo. For tooth position the terminology defined by Bor (2013) is followed.

NOTE: The photographs of the shark were made years ago. Only afterward it was realised several photos are not properly focused and therefore not suitable for publication. As they comprise valuable information those photo-

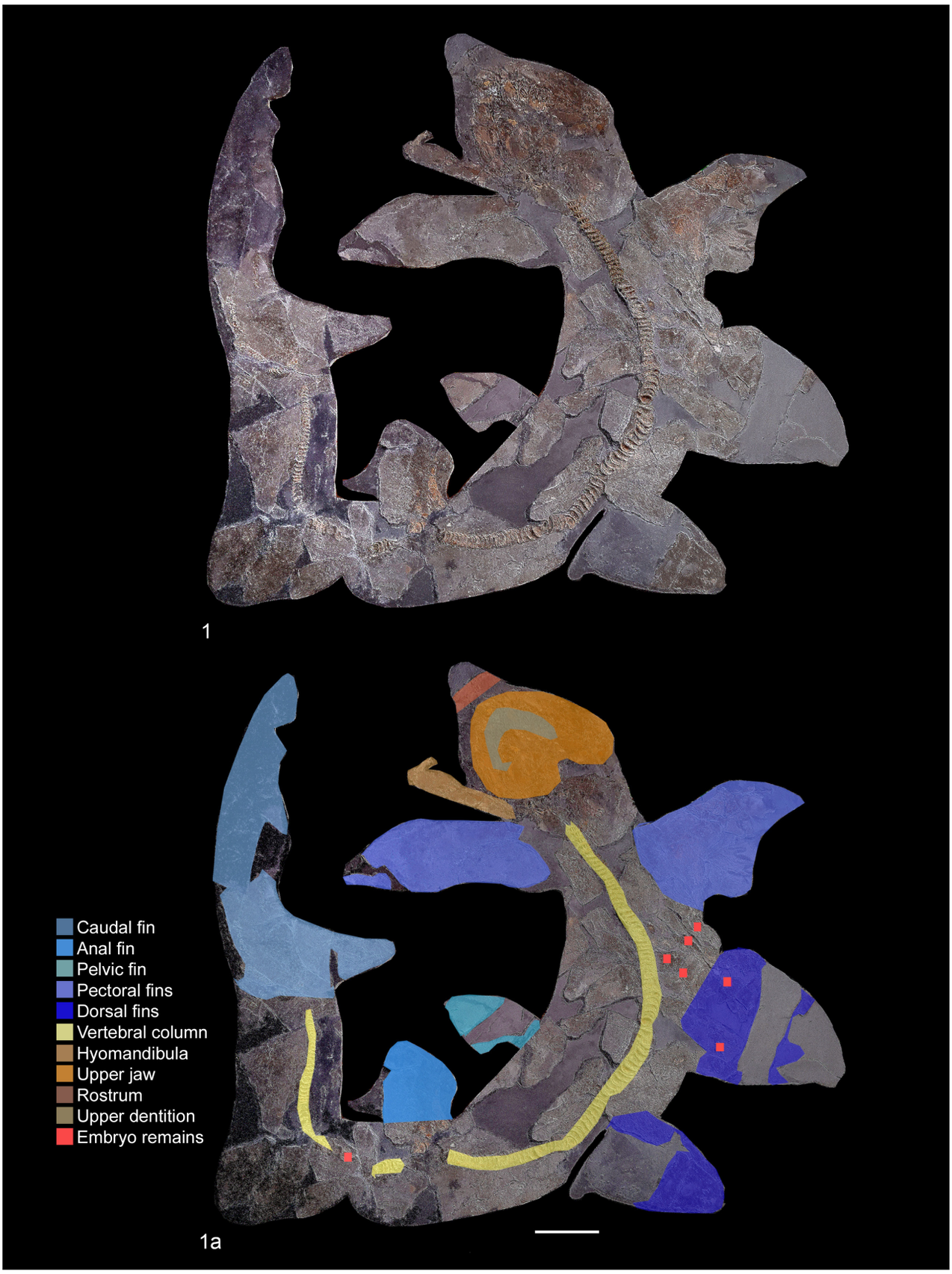

Plate 1. *Carcharias cuspidatus* (Agassiz, 1843). HLMD-WT 941. 1. Main slab; 1a. Main slab with most important remains coloured. Bar: 200 mm.

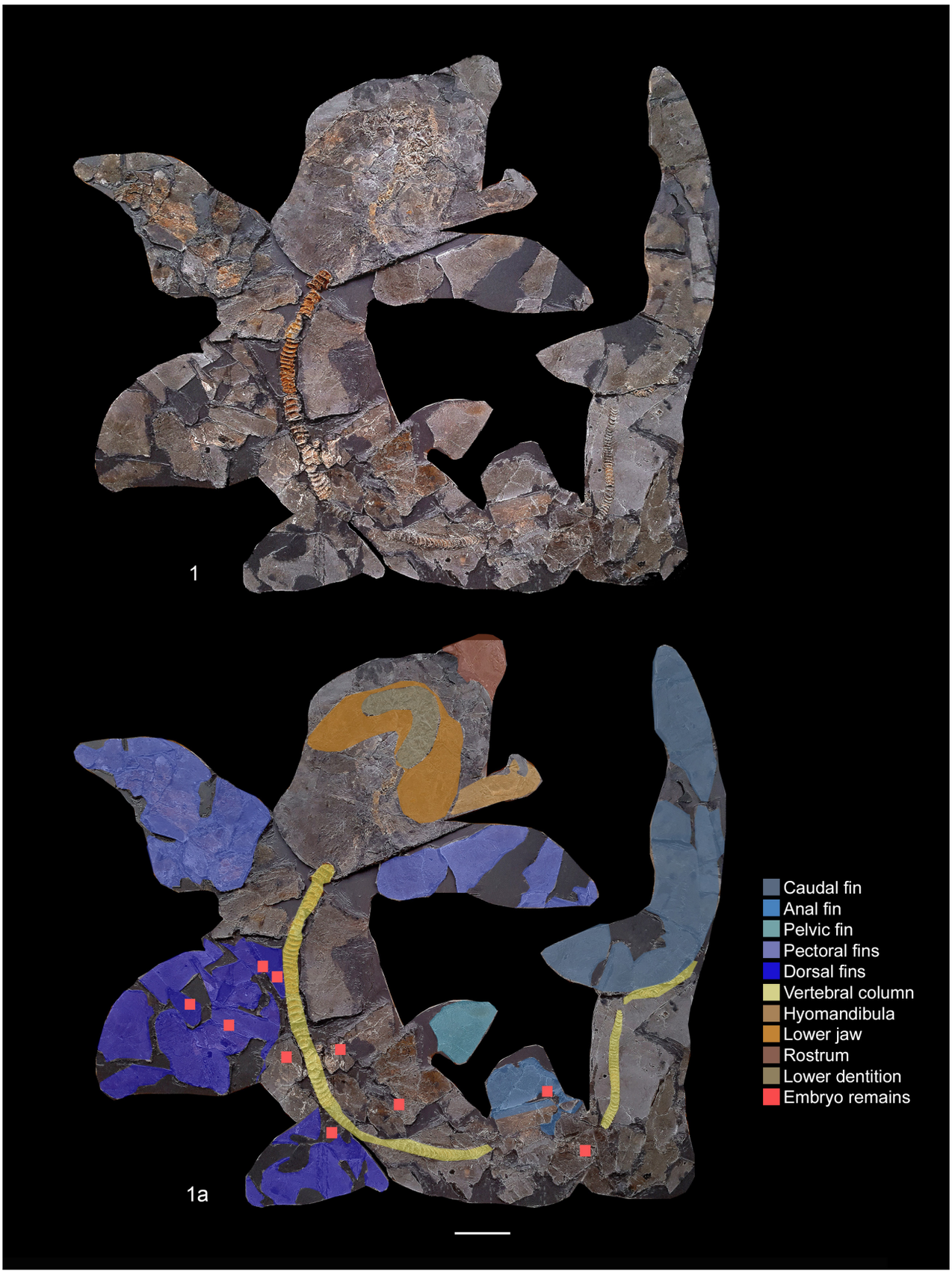

Plate 2. *Carcharias cuspidatus* (Agassiz, 1843). SMNK-PAL 6598. 1. Counter slab; 1a. Counter slab with most important remains coloured. Bar: 200 mm.

graphs are made available as Supplementary Online Materials at www.wtkg.org/tijdschriften/cainozoic-research.

Systematic Palaeontology

Class Chondrichthyes Huxley, 1880
Superorder Galeomorphii Compagno, 1973
Order Lamniformes Garman, 1885
Family Carchariidae Müller & Henle, 1839

According to Ebert *et al.* (2013), the extant Odontaspididae comprise two genera: *Carcharias* Rafinesque, 1810, with the type species *C. taurus* (Rafinesque, 1810) and *Odontaspis* Agassiz, 1838, with the type species *O. ferox* (Risso, 1810). Stone & Shimada (2019) resurrected the Carchariidae Müller & Henle, 1839 which naturally includes the genus *Carcharias*.
After Cappetta (2012) placed *Carcharias cuspidatus* in the genus *Araloselachus* Cappetta, 2012 two extinct genera from Oligocene deposits remained: *Araloselachus* Glickman, 1964 and *Carcharias*.
A comprehensive study of the tooth morphology of Odontaspididae and Carchariidae (Hovestadt, 2021) revealed that *Carcharias cuspidatus* belongs to the Carchariidae and was reassigned as *Carcharias cuspidatus* (Agassiz, 1843).
The general tooth morphology of HLMD-WT 941/ SMNK-PAL 6598 corresponds to the dentition of *C. cuspidatus* as characterised by Hovestadt (2021) and is identified accordingly.

Carcharias cuspidatus (Agassiz, 1843)

The specimen is preserved on two slabs: the main part (HLMD-WT 941) and the counterpart (SMNK-PAL 6598).

Cranium
The compressed cranium comprises the palatoquadrate with the upper jaw, as well as Meckel's cartilage with the lower jaw.

Dentition
HLMD-WT 941 shows the almost complete upper jaw dentition. The tooth morphology can be characterised as follows:
Upper jaw: Three anterior teeth (Pl. 3, figs 1-3) are identified, possessing a high and slender principal cusp. The first anterior tooth is exposed in lingual view. The high and slender crown is estimated to be approximately four times as high as its base, it is wide and slightly curved distally. Both convex cutting edges are first constricted and then extended at the base that might have supported a small cusplet at each side which were most likely lost due to damage. Although less developed, the mesial and distal extensions bear some faint folds in the enameloid. The smooth surface of the principal cusp is convex. The root lobes are equally sized, short and narrow and diverge at an angle of approximately 90°.
The second tooth (Pl. 3, fig. 2) is exposed in labial view. The high and slender crown is approximately three times as high as its base width and upright. The base is one and a half times wider than that of the first tooth. Both convex cutting edges are firstly constricted and then extended at the base that supports a well-developed small cusplet at each side that curves towards the principal cusp. The mesial and distal extensions bear several folds, more or less radiating from the cusplets in all directions. The surface of the principal cusp is slightly convex to almost flat. A central depression is present near the crown base. The mesial root lobe is shorter than the distal one and both diverge at an angle of approximately 60°.
Although difficult to identify, the third tooth (Pl. 3, fig. 3) is considered to belong to the third anterior file and is exposed in labial view. The crown height is almost four times its base width. The surface is slightly convex and smooth. The mesial and distal cutting edges are slightly convex, firstly constricted and then extended at the base supporting a well-developed cusplet at each side. Both mesial and distal root lobes are relatively wide, form a V and diverge at an angle of approximately 120°.
The fourth tooth is an intermediary positioned between anterior and lateral teeth. This results in a smaller tooth with a rather particular shape. In labial view (Pl. 3, fig. 4a) the tooth is mesiodistally compressed with a principal cusp four times its base width and strongly convex. The root lacks root lobes and is also compressed. Cusplets are absent. In lingual view (Pl. 3, fig. 4b) the principal cusp is less convex than in labial view. Both mesial and distal lateral views (Pl. 3, figs 4c, 4d) show the strongly lingually curved principal cusp and the massive root that strongly protrudes lingually.
The fifth tooth also belongs to the intermediate row and is exposed in lingual view (Pl. 3, fig. 5). It consists of a more or less convex, smooth, triangularly shaped principal cusp, that is twice as high as its base is wide, lacking cusplets and having almost straight cutting edges. The root lacks lobes and is labiolingually flattened with the lingual surface sloping from the crown-root junction toward the basal edge.
There are seven lateral teeth (Pl. 3, figs 6-12). The first two are exposed in labial view, the other four in lingual view. The principal cusp of the first two teeth is oblique to slightly curved, whereas the principal cusps of the following four teeth become significantly more curved towards the commissure. Generally the teeth gradually decrease in size towards the commissure. The first four teeth possess a principal cusp that is approximately twice as high as its base is wide, becoming equally high as its base width in the remaining three teeth. The mesial and distal cutting edges are smooth and basally extended, bearing a low, straight to rounded blade. The root lobes are arranged in a V-shape at a very blunt angle of 120 to 140°.
Eight posterior teeth are defined based on their lower crow and lacking a mesial cusplet or blade (Pl. 3, figs 13-20). All teeth are exposed in labial view. In the first tooth (Pl. 3, fig. 13) the principal cusp is significantly distally

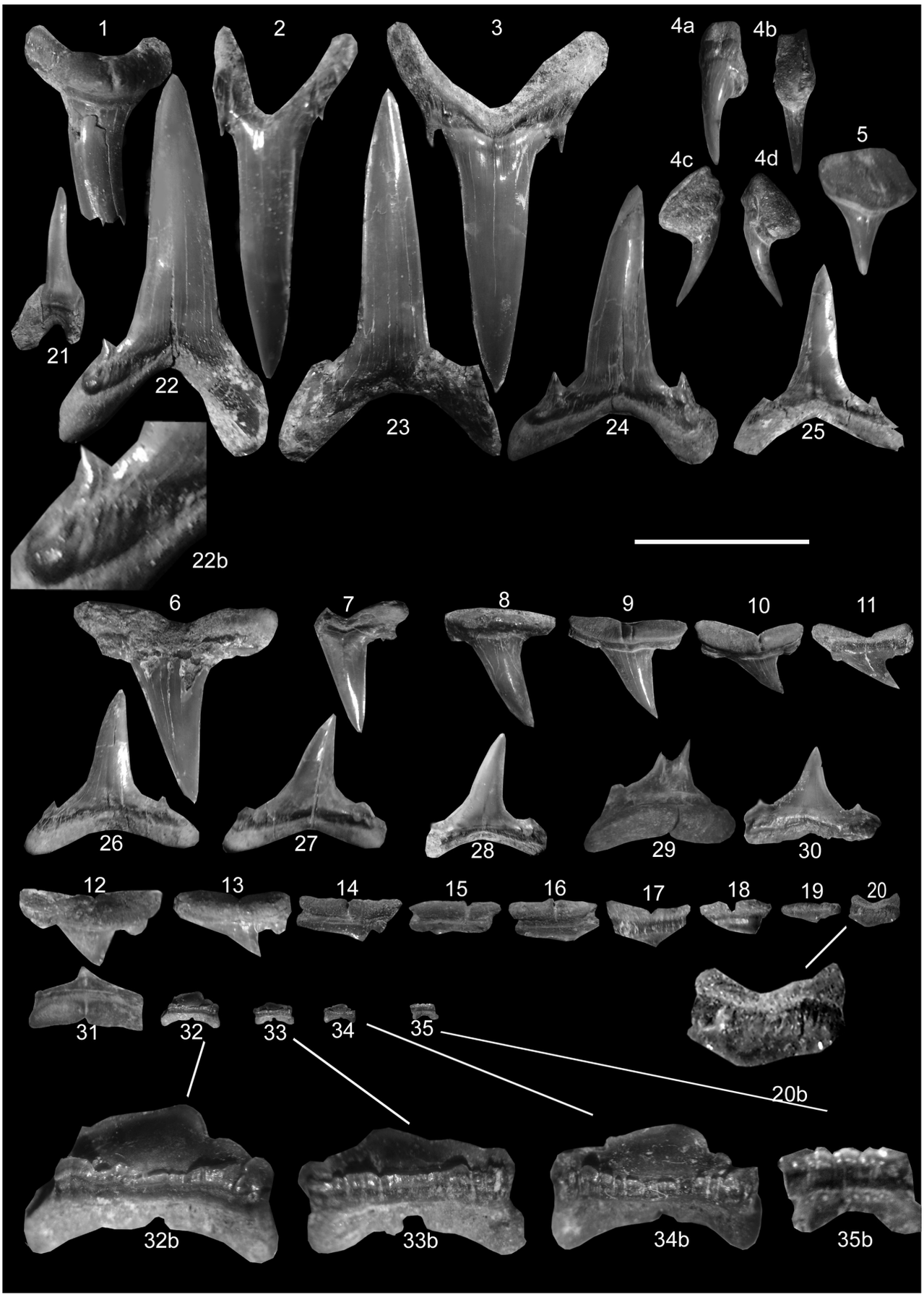
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Plate 3.

inclined, without a mesial cusplet or blade. The second to seventh teeth present a principal cusp that is reduced to a blade or sometimes with an extra distal blade and with a longitudinal depression along the crown base. The crown surface is smooth. The root is divided into two equally wide root lobes by a relatively deep central groove. The eighth tooth (Pl. 3, fig. 20b) presents a longitudinal ridge with vertical folds along the crown base.

SMNK-PAL 6598 shows the almost complete lower jaw dentition and the tooth morphology can be characterised as follows:

Lower jaw: One parasymphyseal tooth and three anterior teeth are identified.

The parasymphyseal tooth is relatively small (Pl. 3, fig. 21), approximately one third of the height of the first anterior tooth, and exposed in labial view. The principal cusp is slender and high, both mesial and distal cutting edges are sigmoidal and the crown base is straight. The labial crown surface is smooth. Cusplets are absent. The root is massive with a broader mesial lobe and a shorter distal one. It has an arched outline, and the lobes diverge at an angle of approximately 45°.

Three anterior teeth are preserved (Pl. 3, figs 22-24). The first anterior tooth (Pl. 3, fig. 22) is exposed in labial view and has a high slightly distally curved principal cusp, constricted at the base, which is three times as high as the crown base. The slightly sigmoidal cutting edges possess mesial and distal basal extensions that bear some shallow folds in the enameloid (Pl. 3, fig. 22b) and support a poorly developed mesial cusplet. The distal cusplet is absent due to damage. The crown base is slightly depressed. Its labial surface is smooth except for some cracks in the enameloid. The root consists of two relatively narrow root lobes that diverge V-shaped at an angle of 70°.

The second anterior tooth (Pl. 3, fig. 23) is exposed in labial view and has a high upright principal cusp, which is constricted at the base and is approximately four times as high as the crown base. The convex cutting edges show mesial and distal basal extensions that bear some shallow folds in the enameloid and support a poorly developed distal cusplet. The mesial cusplet is absent. The crown base is slightly depressed. Its labial surface is smooth except for some cracks in the enameloid. The root consists of two relatively narrow root lobes that diverge V-shaped at an angle of 90°. The mesial root lobe is slightly thicker than the distal one.

The third anterior tooth (Pl. 3, fig. 24), exposed in labial view, possesses a principal cusp that is three times as high as its base width and slightly curved distally. The labial crown surface is smooth presenting some cracks in the enameloid due to external influences. The principal cusp is constricted at the base and the mesial cutting edge is convex; the distal one conversely is concave. Both cutting edges are extended at the base that bears some shallow folds in the enameloid and support well-developed mesial and distal cusplets. The folds more or less radiate from the cusplets. The root has a mesial root lobe that is slightly narrower and longer than the distal one. They diverge in a V-shape at an angle of 120°.

Next to the third tooth six lateral teeth (Pl. 3, figs 25-30) are exposed in labial view. They gradually decrease in size towards the commissure. The principal cusp is slightly inclined distally and gradually lowers closer to the commissure. The mesial and distal cusplets are modified into blades.

Five posterior teeth are present (Pl. 3, figs 31-35) which are exposed in labial view. The principal cusp of each is reduced into a blade presenting a longitudinal ridge with vertical folds along the crown base (Pl. 3, figs 32b, 33b, 34b, 35b), and the crown surface is smooth. The root base is arched.

Dermal denticles

A significant number of skin patches is preserved that include numerous dermal denticles. In both slabs they are arranged more or less in their original pattern. Most of these dermal denticles possess a crown that consists of up to five ridges: a central one with two at each side. They originate at the anterior margin and run parallel to each other exceeding the posterior margin of the crown.

Plate 3.

1-20. *Carcharias cuspidatus* (Agassiz, 1843). HLMD-WT 941.

Upper jaw. 1. first anterior tooth, lingual view; 2. second anterior tooth, labial view; 3. third anterior tooth, labial view; 4. first intermediate tooth, a. labial view, b. lingual view, c. distal lateral view, d. mesial lateral view; 5. second intermediate tooth, labial view; 6. first lateral tooth, labial view; 7. second upper lateral tooth, labial view; 8. third lateral tooth, lingual view; 9. fourth lateral tooth, lingual view; 10. fifth lateral tooth, lingual view; 11. sixth lateral tooth, labial view; 12. seventh lateral tooth, labial view; 13. first posterior tooth, lingual view; 14. second posterior tooth, lingual view; 15. third posterior tooth, lingual view; 16. fourth posterior tooth, lingual view; 17. fifth posterior tooth, labial view; 18. sixth posterior tooth, lingual view; 19. seventh posterior tooth, lingual view; 20. eighth posterior tooth, labial view, b. detail.

21-35. *Carcharias cuspidatus* (Agassiz, 1843). SMNK-PAL 6598.

Lower jaw. 21. parasymphyseal tooth, labial view; 22. first anterior tooth, labial view, b. detail; 23. second anterior tooth, labial view; 24. third anterior tooth, labial view; 25. first lateral tooth, labial view; 26. second lateral tooth, lingual view; 27. third lateral tooth, lingual view; 28. fourth lateral tooth, lingual view; 29. fifth lateral tooth, labial view; 30. sixth lateral tooth, labial view; 31. first posterior tooth, lingual view; 32. second posterior tooth, labial view; b. detail; 33. third posterior tooth, labial view, b. detail; 34. fourth posterior tooth, labial view, b. detail; 35. fifth posterior tooth, labial view, b. detail.

Bar: 20 mm in 1-35; 40 mm in 22b, 60 mm in 20b, 32b, 33b, 34b, 35b.

In occlusal view, the crown is V-shaped at the front from which the ridges originate. They are rounded at the front, rapidly changing into ridges with a relatively sharp edge on top. This type of denticle corresponds with those figured by Reif (1985, pl. 16, fig. H2) which indicates, that they were located above the gill slits and confirms allocation to the genus *Carcharias*.

Vertebrae

Both slabs comprise approximately 106 preserved pre-caudal vertebrae and 47 caudal vertebrae. All are arranged more or less in their original position.

The preservation of the vertebrae is poor but particularly the first two pre-caudal ones show several non-calcified areas, which indicates that they belong to the radial astrospondylic type of vertebrae (White, 1937, pl. 29, fig. k).

Fins

Many parts of the fins were preserved, which allowed a reconstruction of a pair of pectoral fins, both dorsal fins, a pelvic fin, an anal fin, and the caudal fin (Pl. 1, figs 1, 2 & Pl. 2, figs 1, 2). Considering their size and shape, the reconstructed fins resemble those of the species *C. taurus*.

Embryos

Both slabs comprise remains of embryos. Some of these are only represented by associated vertebrae, but others also consist of part of a vertebral column with associated teeth, or even a vertebral column including the cranium. The preservation, however, is often poor. As many of the embryos are only represented by some clusters of vertebrae, it is difficult to determine their exact number. Seven remains of vertebral columns of embryos and approximately 82 single vertebrae (often associated in scattered clusters) are observed, as well as one cluster of associated teeth. Both kinds of clusters of vertebrae and teeth probably result from the decay of the embryos.

HLMD-WT 941 comprises the following remains of embryonic individuals:

One embryo is represented by a large part of the vertebral column terminating in a few detached vertebrae. Near this vertebral column lie five clusters of associated teeth (Pl. 4, figs 1, 1a-1e2). In total there are 15 teeth, some of which are aligned in a row. By careful selection the reconstruction of the partial dentition was possible including the differentiation of both upper and lower teeth. Two upper anterior teeth were identified (Pl. 4, figs 1a3, 1b1), three could be identified as upper lateral teeth (Pl. 4, figs 1d2, 1e1, 1b2). One lower anterior tooth and five lower lateral teeth were identified (Pl. 4, figs 1a2, 1c1, 1a4, 1e2, 1d1, 1a1). One abnormal tooth was found (Pl. 4, fig. 1d1) which might represent a growth abnormality. Another series of vertebrae probably represents remains of a decomposed embryo, two remains of vertebral columns in their original arrangement, and three further clusters of associated vertebrae that probably also result from post-mortem decomposition. SMNK- PAL 6598 shows remains of nine embryos. There are six clusters of associated vertebrae that, once again, probably result from decomposition, as well as a cluster of associated teeth. Remains of another embryo were found that comprise a cluster of teeth, and a skin patch (Pl. 5, figs 1, 1a, 1b, 1c, 1d). Two vertebral column sections are present. In addition, a complete skeleton of another embryo with an estimated TL of 180 mm was found. It consists of the vertebral column and a partial skull. Although the preservation is poor, approximately 65 vertebrae can be identified. Unfortunately, the skull remains are too poor to allow the identification of particular structures.

The six embryos appear to be three individuals only, representing part and counterpart. They are present at the same locations on both slabs HLMD-WT 941 and SMNK- PAL 6598 with similar composition.

Discussion and Conclusions

As both slabs represent the almost complete skeleton of the specimen, the total length from tail fin tip to the tip of the snout (TL) could be measured. This is unique and the first record of a fossil *Carcharias cuspidatus* of which the total length can be identified and that is preserved with almost its complete dentition.

HLMD-WT 941 and SMNK-PAL 6598 together represent a very large shark with a total length of at least 5 m. The teeth of the lectotype and paralectotypes of *C. cuspidatus* have similar sizes and probably had a similar total length (Hovestadt, 2021). For comparison, a sketch is presented (Fig. 3; after Ebert *et al*., 2013) which shows the size of HLMD-WT 941 / SMNK-PAL 6598 versus the size of a full grown *Carcharias taurus* of 3 m.

A synopsis of tooth sizes of both slabs together with their particular positions in upper and lower jaws measured from the apex to the root base is given in Table 1.

Plate 4.

Carcharias cuspidatus (Agassiz, 1843). HLMD-WT 941.

Embryos. 1. Embryonic vertebral column with five clusters of associated embryonic teeth; 1a. cluster with three teeth, 1a1. lower lateral tooth (labial view), 1a2. lower anterior tooth (lingual view), 1a3. upper anterior tooth (labial view), 1a4. isolated tooth, lower lateral tooth (lingual view); 1b. cluster with three teeth, 1b1. upper anterior tooth (lingual view), 1b2. upper lateral tooth (lingual view); 1c. isolated tooth, lower lateral tooth (lingual view); 1d. cluster with two teeth, 1d1. abnormal lower lateral tooth (labial view), 1d2. upper lateral tooth (lingual view); 1e. cluster with two teeth, 1e1. upper lateral tooth (profile view), 1e2, lower lateral tooth (labial view).

Bar: 20 mm in 1; 5 mm in 1a-1e and 1a1-1e2

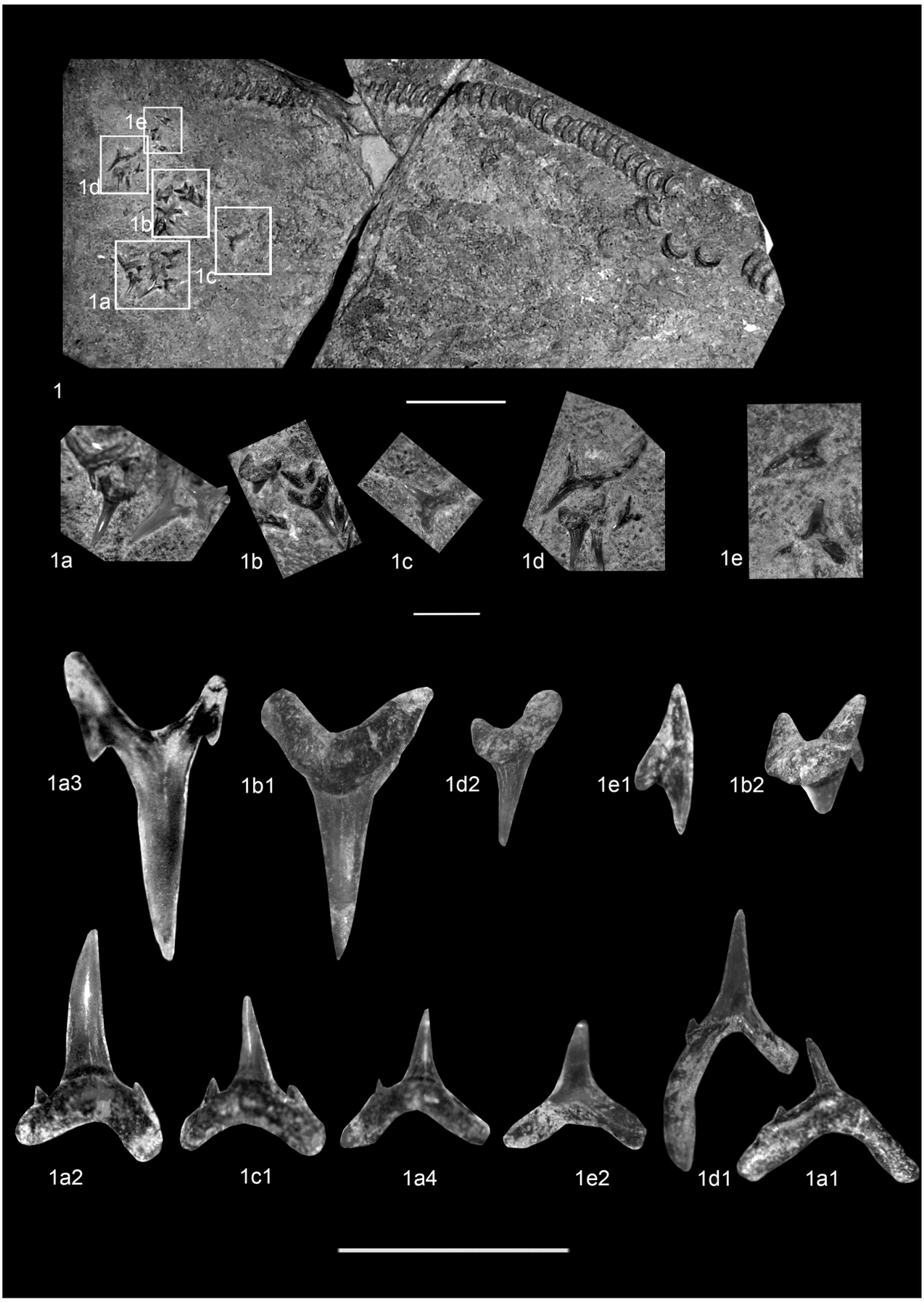
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Plate 4.

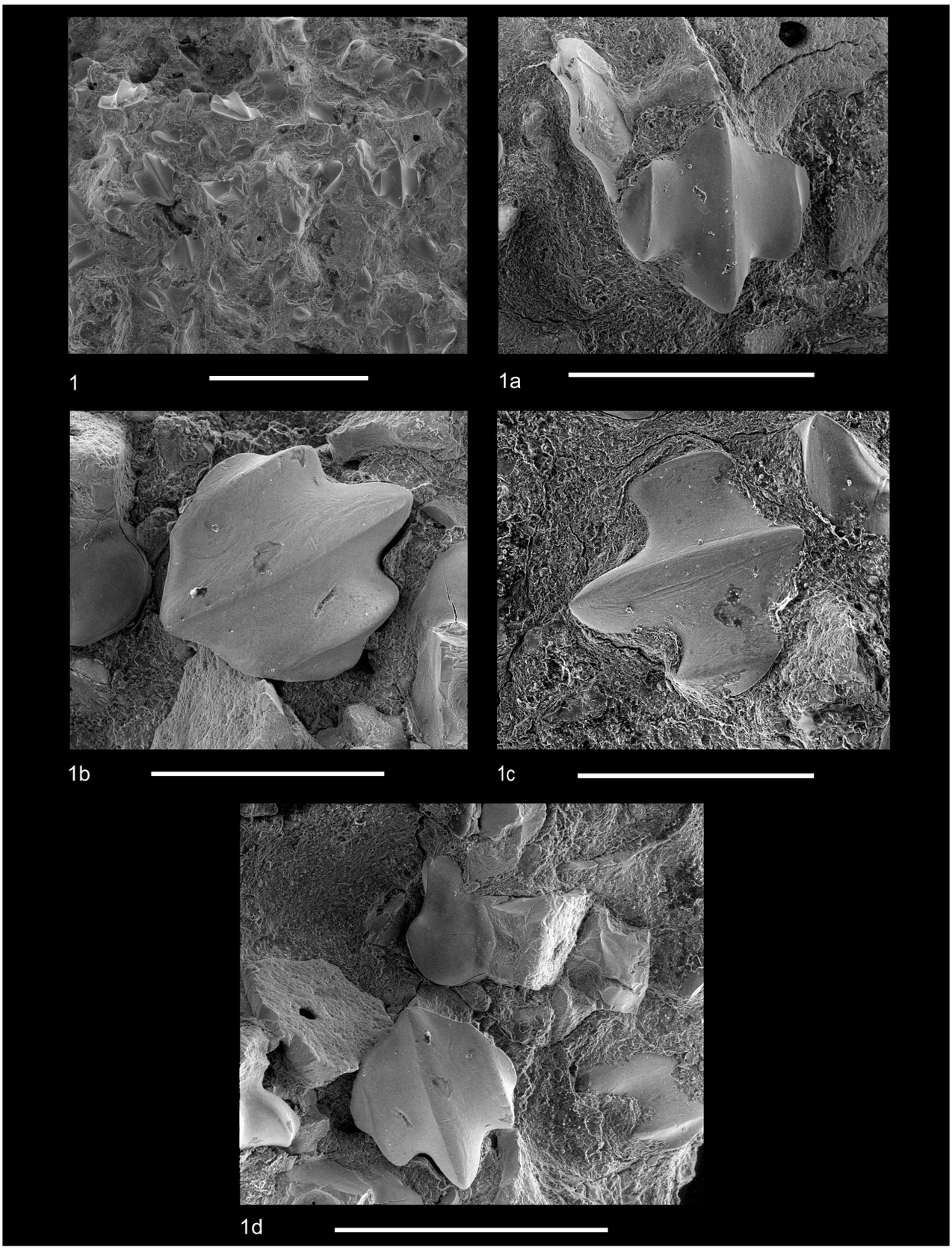

Plate 5. *Carcharias cuspidatus* (Agassiz, 1843).

Embryo details of dermal denticles. 1. group of dermal denticles; 1a. dermal denticle 1; 1b. dermal denticle 2 of 1; 1c. dermal denticle 3; 1d. dermal denticle 4.

Bar: 300 µm in 1, 500 µm in 1a-1d.

UA 1	UA 2	UA 3	UI 1	UI 2	UL 1	UL 2	UL 3	UL 4	UL 5	UL 6	UL 7
30	40	44	16	17	25	16	14	13	9	8	8
	LPS	LA 1	LA 2	LA 3	LL 1	LL 2	LL 3	LL 4	LL 5	LL 6	
	17	44	45	33	24	18	16	16	15	13	

Table 1. Tooth sizes of HLMD-WT 941 and SMNK-PAL 6598 together with their particular positions in upper and lower jaws measured from the apex to the root base (in mm). Total length of the specimen is 5 m. UA=Upper anterior, UI=Upper intermediate, UL=Upper lateral, LPS=Lower parasymphyseal, LA=Lower anterior, LL= Lower lateral.

Although more evidence is needed to establish a possible ontogenetic linear development of tooth height versus total length of a carchariid shark, an example of the second upper anterior tooth in two specimens of *Carcharias taurus* of 2300 mm TL and 1450 mm TL with a tooth height of 26.5 mm versus a height of 14.6 mm seems to confirm this linear development. Table 1 gives the unique opportunity to compare teeth of the same jaw position of other *Carcharias cuspidatus* specimens against this series to estimate a possible total length.

Cannibalism among unborn pups of *Carcharias taurus* is well known, which is demonstrated by larger pups preying on smaller ones (*e.g.*, Compagno, 1984, 2001and Ebert *et al.,* 2013). This might also exist in *C. cuspidatus* and could explain the large number of incomplete embryos.

With seven remains of vertebral columns of embryos and 82 isolated vertebrae (often found associated in small scattered clusters), as well as a cluster of associated teeth, it is difficult to determine the exact number of preserved embryos. However, one is almost complete and with an approximate number of 65 vertebrae this can be assumed to be the number of a complete vertebral column. Therefore, the earlier mentioned 82 isolated vertebrae scattered over both plates, may represent two additional decomposed embryos. This indicates that the total number of embryos may have been nine.

The size of the specimen HLMD-WT 941 / SMNK-PAL 6598 was at least 5 m. This TL, together with the number of embryos (approximately nine), as well as the shape of the fins, corresponds rather well with mature individuals of the extant *C. taurus*.

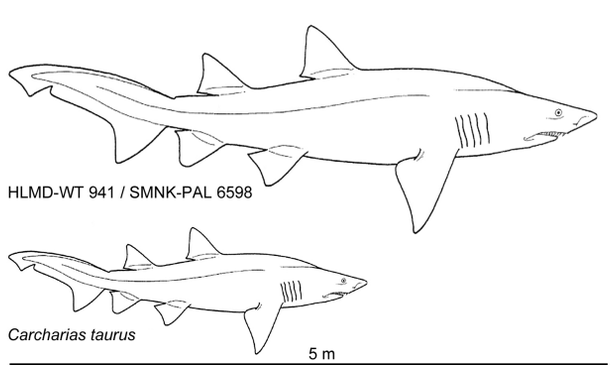

Fig. 3. The size of HLMD-WT 941/SMNK-PAL 6598 versus a full grown *Carcharias taurus* (Rafinesque, 1810).

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