

BITE MARKS OF THE GIANT CROCODYLIAN *DEINOSUCHUS* ON LATE CRETACEOUS (CAMPANIAN) BONES

DAVID R. SCHWIMMER

Department of Earth and Space Sciences, Columbus State University, Columbus, GA 31907 USA; schwimmer_david@colstate.edu

Abstract—The giant (~10 m) Late Cretaceous eusuchian crocodylians of the genus *Deinosuchus* are shown to have left large, blunt, sometimes penetrating bite marks on a significant number of sea turtle shells, and on several dinosaur specimens. The morphology of crocodylian bite marks is generally well documented, and the identification of bite traces specifically attributable to *Deinosuchus* may be made by reference to their size, age, habitat and prey selection. *Deinosuchus* species, and bite traces referable to the genus, are present on both sides of the Late Cretaceous Interior Seaway, and known only from Campanian deposits in the USA and northern Mexico. The heavily enameled, multi-layered, low-crowned posterior teeth of *Deinosuchus* were adapted specifically for bone-crushing feeding behavior, and the evidence of such is present in both the morphology of preserved bite traces and in characteristic wear patterns on their posterior teeth.

INTRODUCTION

Bite marks on larger Late Cretaceous vertebrate bones may be attributed to several categories of predaceous and or scavenging organisms. On terrestrial bones, the most obvious sources of such bite marks are theropod dinosaurs (Erickson and Olsen, 1996; Carpenter, 2000; Farlow and Holtz, 2002), and on marine vertebrates (or floating terrestrial carcasses), sharks are the most frequently referenced source of bite marks (Schwimmer et al., 1997; Shimada and Everhart, 2004; Shimada and Hooks, 2004; Everhart and Ewell, 2006). However, crocodylians, especially very large or giant species, are another credible source of bite marks on larger terrestrial and marine bones. In the North American Late Cretaceous, specifically the Campanian Stage, the crocodylians most likely to be responsible for bite traces evident on several dinosaur and sea turtle bones are species of *Deinosuchus*, a genus of gigantic eusuchians with heavy, blunt teeth. As used here (and see Brochu, 1997; Schwimmer, 2002), the term “crocodylian” refers to the clade of crocodylomorphs (*sensu* Clark, 1996) which includes all extant mesoeosuchians (i.e. alligators, true crocodiles and gharials) and their monophyletic Mesozoic ancestors.

Discrimination of Spurious *Deinosuchus* Bite Traces

In the discussion to follow, it is recognized that some ostensible bite traces on bones may actually be invertebrate borings and dwelling sites (Kase et al. 1998: but, see Tsujita and Westermann, 2001 for a counter opinion; Roberts et al, 2007; Bader et al., 2009). It is apparent that not all perforations and depressions in fossil bones are necessarily of vertebrate origin. However, those invertebrate traces that might be mistaken for crocodylian tooth marks, especially gastropod borings, are generally more perfectly circular, and rarely bluntly terminated, as compared with plausible crocodylian feeding traces. For example, Figure 1 is a circular perforation in a Late Cretaceous pleurodire turtle costal fragment, which may be compared with the presumably crocodylian traces to be discussed (see Figs. 4-5). The bone perforation in Figure 1 is almost perfectly circular on the external surface, penetrates the bone completely, and tapers evenly through the bone in the manner typical of naticid gastropod borings found commonly in Late Cretaceous to modern clam shells. (This may have been from a moon snail or other gastropod that mistook a dead turtle carapace for an inoceramid clam!) The characteristics of crocodylian bites are discussed below, but, in general, they are usually bluntly terminated, and they do not taper in the rare cases where they penetrate thick bones.

It is also recognized that not all blunt-toothed vertebrate bites in the marine realm are necessarily from crocodylians. Notably, round-toothed mosasaurs of the genus *Globidens* are reported (and I have

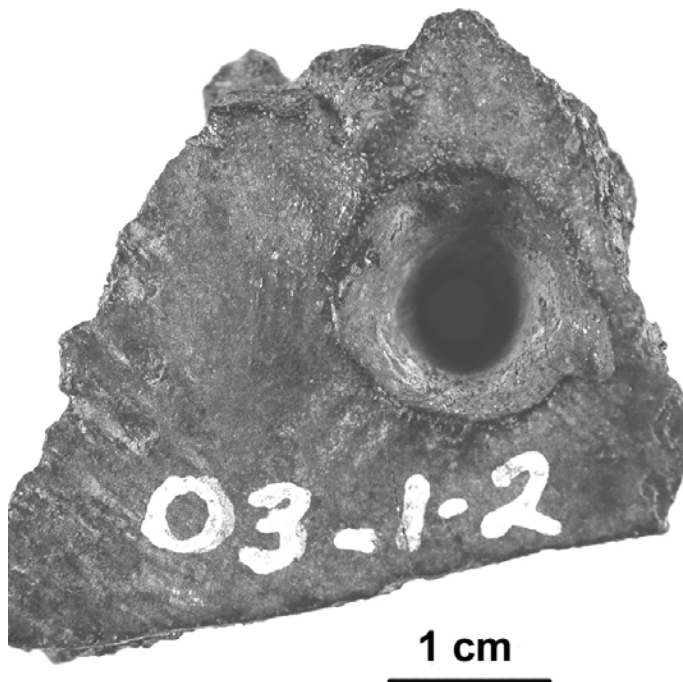


FIGURE 1. Circular perforation of a pleurodire turtle costal fragment, from the uppermost Blufftown Formation (mid-Campanian), Hannahatchee Creek, Stewart County, western Georgia, cataloged as Columbus State University Cretaceous (CSUK) research collections CSUK-03-1-2. This is interpreted as a non-crocodylian trace fossil, probably a gastropod drilling, because it tapers evenly through the bone and has a larger, nearly perfectly circular external opening, and a small internal opening.

observed many of their teeth) to have co-occurred in Campanian deposits with *Deinosuchus* in sites in New Jersey, Alabama (Russell, 1988), and Mississippi (Manning and Dockery, 1992). However, I believe these can be excluded from causing the traces discussed here because the heavy-boned skull and mandible morphology, musculature, and thus, crushing power, of crocodylians (Schwimmer, 2002) is inherently much greater than that of mosasaurs. Crocodylians have extremely powerful jaw adduction due to the leverage of the temporalis muscles located relatively far anterior to the jaw hinge, pulling almost exactly perpendicular to the bite. This optimized muscle position is combined with the enhanced leverage provided by the jaw articulation offset from the line of closure, due to the elongate quadrate (Schwimmer, 2002). Eusuchian crocodylians,

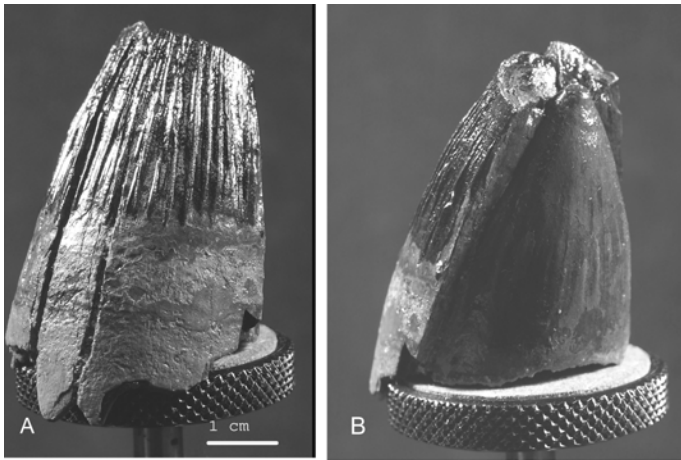


FIGURE 2. Large *Deinosuchus rugosus* (4.0 cm base diameter) posterior tooth from the Blufftown Formation, locality as in Figure 1, CSUK-09-02-02. **A**, External (labial) surface showing deeply infolded enamel on crown; **B**, Reverse (lingual) view, showing exfoliation with exposure of replacement crown.

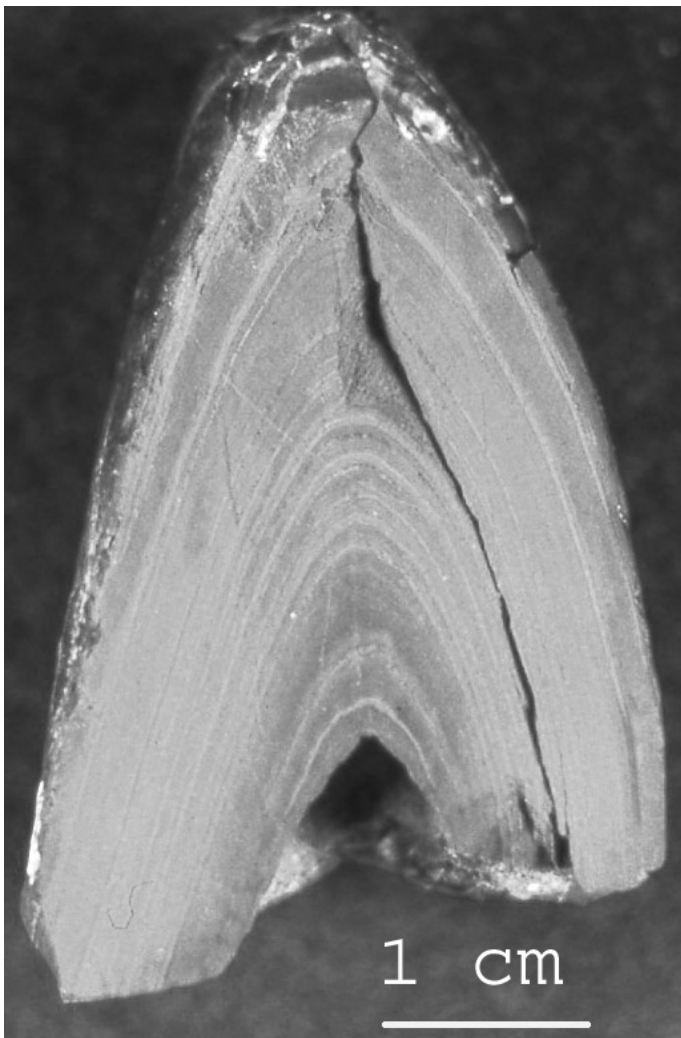


FIGURE 3. Posterior *Deinosuchus rugosus* tooth from the Blufftown Formation, locality as in Figure 1, CSUK-85-02-1, cut to show thick cross-section structure with multiple replacement crowns in place, and relatively small medial nutritive region.

further, have massively braced skulls, with the full-length bony palate acting as an internal buttress to better handle bite pressure on the cantilevered rostrum (Busbey, 1997). In contrast, as lizards, mosasaurs had no internal palate, a lower jaw with a loose dentary/post-dentary suture, and the temporalis located relatively close to the jaw articulation: in short, a relatively weaker bite. In addition, the nearly spherical (=“globidentine”) tooth crowns of *Globidens* (Gilmore, 1912; Martin, 2007) would not create penetrating bite marks but rather would broadly depress or crush bone surfaces if so used. Indeed, no reports of potential *Globidens* traces have been published, and they are generally assumed to have been durophagous molluscivores, probably co-evolving to feed on shelled cephalopods and inoceramid clams. We can therefore exclude them as the source of deep, circular bite marks in bones.

OCCURRENCE AND CHARACTERS OF *DEINOSUCHUS*

The existence of a gigantic crocodylian species in North America (here defined as having body length >10 m) was first recognized by Holland (1909) based on a few vertebrae and huge osteoderms reported from the Judith River Formation in northwestern Montana. Holland named the specimen *Deinosuchus hatcheri* (in honor of J.B. Hatcher). Subsequently, Colbert and Bird (1954) collected gigantic crocodylian remains, most notably skull fragments, from the Campanian Aguja Formation in Big Bend, southwest Texas, and assigned the name *Phobosuchus riograndensis* to the specimen. Whereas Holland’s material was never the basis for a skull- or full-body reconstruction, Colbert and Bird’s specimen was the basis of the famous 2-m long American Museum of Natural History *Phobosuchus* skull reconstruction (Bird, 1985), and this remained the concept of the genus until fairly recently (Schwimmer, 2002). In subsequent discussion, the senior name *Deinosuchus* will be used because it is currently assumed that the Texas, Montana, and eastern USA taxa (discussed below) are at least congeneric, if not conspecific (Baird and Horner, 1979; Schwimmer, 2002).

Less noted, and pre-dating either Holland’s or Colbert and Bird’s reports, large crocodylian teeth and vertebrae were known from the eastern USA Coastal Plain (Emmons, 1856), especially well-represented in the Campanian Black Creek Formation in North Carolina (Miller, 1967, 1968). These were assigned the name *Polyptychodon rugosus* by Emmons (with the generic name later suppressed because it was pre-occupied). Subsequent reports from the eastern USA showed that larger crocodylian teeth, vertebrae and other bones were fairly common in Campanian deposits across the Southeast (Schwimmer and Williams, 1993, 1996) as well as in New Jersey and vicinity (Parris et al., 1987; Gallagher, 1993). Most (but not all) of these eastern crocodylian teeth and bones are smaller than the material from Big Bend and Montana, but still represent very large crocodylians (extrapolated to 8-9 m length

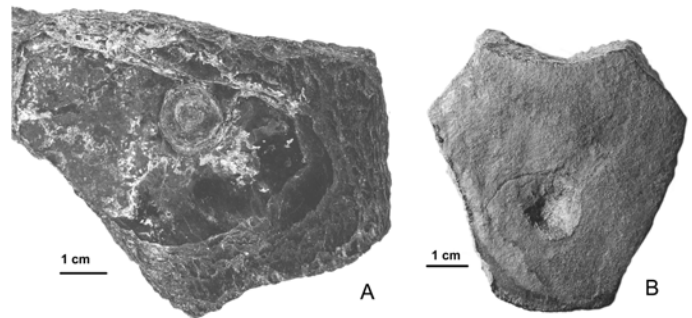


FIGURE 4. Representative crocodylian bite marks on marine pleurodire turtle (*Chedighaii barberi*) fragments from the Blufftown Formation, locality as in Figure 1. **A**, Small costal fragment, CSUK-09-02-03, with ablated edges, bite mark 1.1 cm diameter; **B**, Neural CSUK-09-02-04, with bite mark ~1.0 cm diameter. Note that bite marks in the neural region (Fig. 4B) would be at the center of the turtle’s carapace: see Fig. 7 for reconstruction of the event.

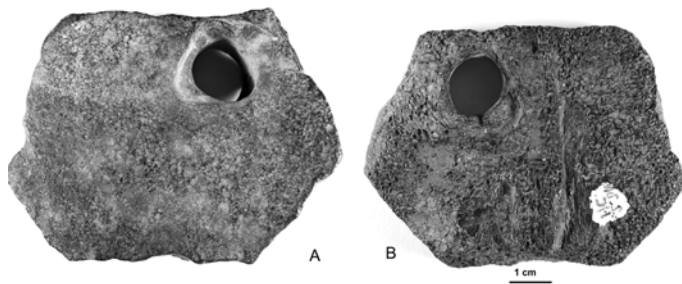


FIGURE 5. Penetrating, circular trace on a large pleurodire turtle neural (*Chedighaii barberi*), from Blufftown Formation (early Campanian), High Log Creek, Russell County, Alabama, CSUK-09-02-05. **A**, Dorsal view, showing the nearly circular trace, with some ablation around the margins, presumably from shattering during the bite; **B**, Internal aspect, showing similar ablation around the opening. Note that the hole is parallel sided and appears to shatter as much bone internally as on the external. Maximum diameter of the hole is ~1.55 cm, minimum diameter ~ 1.25 cm.

assuming typical proportions of teeth and vertebrae to length). In recent years, reports of Campanian-age, large or giant crocodylian material have come from virtually all peri-marine, fossiliferous Campanian deposits located from Montana southward (Wahl and Hogbin, 2003; Lucas et al., 2006; Titus et al., 2008; Rivera-Sylva et al., 2009) indicating that *Deinosuchus* species were ubiquitous across at least the more southern sea coasts.

Deinosuchus is characterized, besides the size, by having unusually thick, poorly-keeled osteoderms with very large pits, and most significantly here, low-crowned, posterior teeth with unusually thick dentin-enamel layers, and, in some populations (perhaps a specific character), with strongly infolded enamel surfaces (Fig. 2). Emmons' (1856) specific name "*rugosus*" for the North Carolina specimens was based on the rugged appearance of tooth surfaces. The thick cross-sectional tooth morphology results from having numerous generations of replacement teeth present at the same time within the crown, forming a nearly solid tooth mass with a small medial nutritive cavity (Fig. 3). This heavy, low-crowned morphology was either an adaptation or exaptation that favored bone-crushing by *Deinosuchus*.

DEINOSUCHUS BITE MARKS

Preserved evidence of giant crocodylian bites in the Late Cretaceous is best observed on larger, thick bone surfaces, simply because these provide sufficient areal surface and depth of bone tissue to preserve the circular, blunt marks, with enough depth to indicate the source. To date, all such preserved bite traces are on bones of sea turtles and dinosaurs. No such evidence has yet been found on bones of contemporary mosasaurs, plesiosaurs (*sensu lato*), or fishes. This may reflect the habitat of the crocodylians, feeding upon shore-based rather than open-marine prey.

Bite marks from crocodylians may take several characteristic shapes (Schwimmer, 2002; Mikuláš et al., 2006; Njau and Blumenschine, 2006) but the most definitively "crocodylian" are deep, circular or oval, bluntly terminating pits, and circular, penetrating holes impressed through a substantial thickness of bone. Njau and Blumenschine undertook an extensive study of modern *Crocodylus niloticus* (Nile Crocodile) feeding traces, and noted that in their sample of observed captive bred crocodiles, ranging in length from 0.9 to 4.0 m, the bite marks left on bones included pits ranging from 1.0 to 6.0 mm, and incised bite marks ("punctures") with chipped edges, ranged from 1.0 to 11.0 mm (with one outlier reported of 21.0 mm diameter). These sizes are significant because the bite marks on the Late Cretaceous bones in this study are generally larger, and include round pits averaging 5 to 22 mm, a single round, through-puncture of ~12.0 mm diameter, and a single marine turtle specimen with numerous oval pits ranging up to 9.0 by 21.0 mm. The average

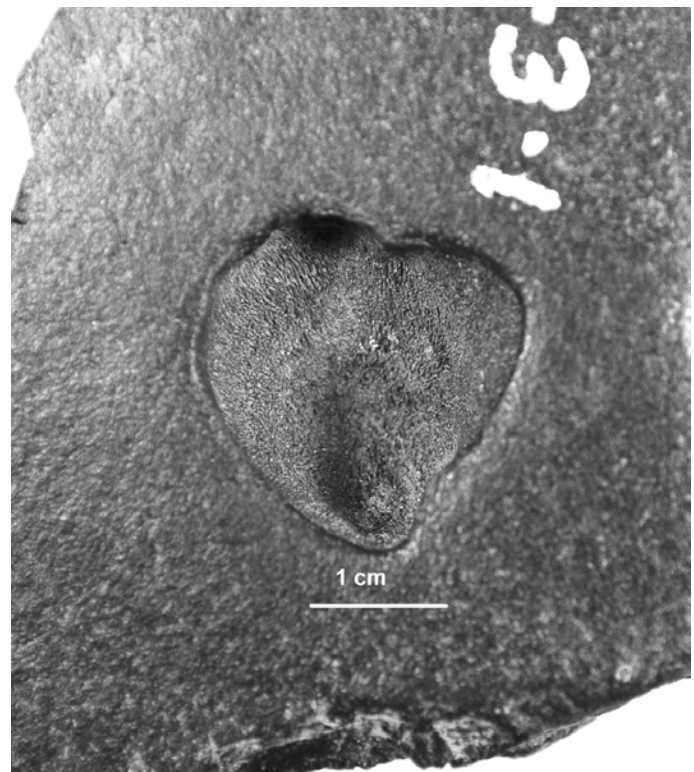


FIGURE 6. Healed bite mark on a fragmentary pleurodire turtle (*Chedighaii barberi*) plastron, Blufftown Formation, locality as in Figure 1, CSUK-96-03-1. The slightly irregular exterior outline of the trace averages 20 mm in diameter, and the deepest penetration is ~0.9 mm. The margins of the pit are sharply incised, indicating that the perimeter of the tooth tip forming the bite mark was approximately the same diameter as the trace. The depression is lined with fine-textured bone tissue, which would not be the typical bone texture at that depth below the surface of the plastron, indicating that bone regeneration occurred after the bite.

sizes of these bite marks suggest that the Cretaceous crocodylians in the study were significantly larger than Njau and Blumenschine's subjects (i.e., they were >4.0 m overall body length).

Bite Marks on Marine Turtles

More than a dozen Late Cretaceous sea turtle specimens have been observed with crocodylian-type bite traces. These are typically discrete ("singular" in the sense of Mikuláš et al., 2006), circular bite marks, rather than the overlapping "gnawing traces" (Mikuláš et al., 2006; Njau and Blumenschine, 2006) found on a few dinosaur bones, as discussed below. These bite marks are presumed to be from *Deinosuchus* based on size and prey selection, and their age (Campanian), which coincides with the age of *Deinosuchus* fossils deposits on both the western and the eastern sides of the North American Interior Seaway. These *Deinosuchus* bite marks are found most commonly on the thick carapace and plastron bones of the large, common, pelomedusid pleurodire turtle *Chedighaii (Bothremys) barberi* (Gaffney et al., 2006), in the eastern marine deposits.

Among the specimens I have observed in the Campanian of Georgia are several turtle bones with non-penetrating, circular bite marks (Fig. 4), and a single circular bite mark that penetrated a large pleurodire neural (Fig. 5). One of the larger non-penetrating bite marks (Fig. 6) is quite notable because the inner surface of the 9.0 mm-deep bite mark shows evidence of bone regeneration. This latter specimen, therefore, indicates that the bite was not fatal. It is evident from the relatively large number of *Deinosuchus* bite marks on sea turtle fossils in the Southeastern USA that these may have been a preferred prey. Figure 7 reconstructs the

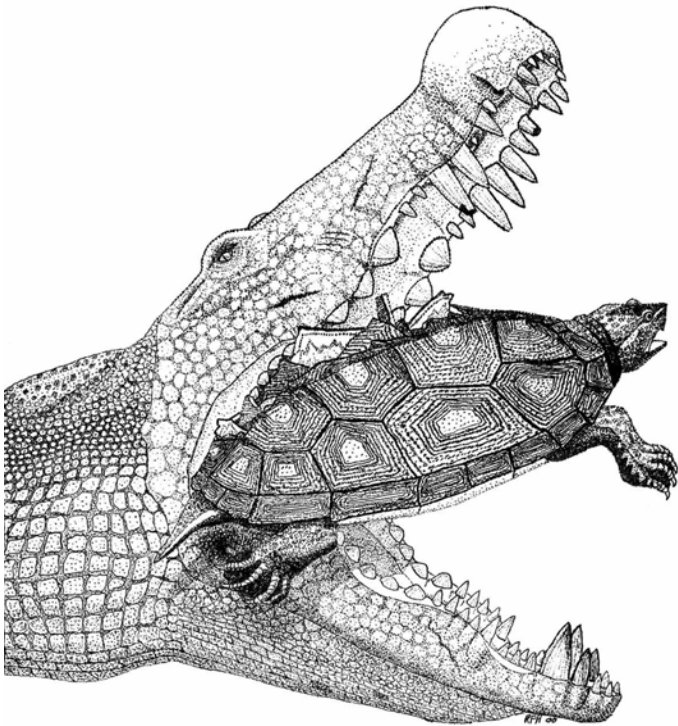


FIGURE 7. Illustration of the hypothetical *Deinosuchus*-on-pleurodire bite, based on the position of typical bite marks. Wide gape biting would allow the posterior teeth to do most of the crushing, without putting the sharper anterior teeth in danger of fracture. With this bite pattern, there would also be numerous marks on turtle neurals and approximately equal numbers of carapace and plastron bite traces. In addition, various regions of the turtle shell would receive varying pressures and depth of bite marks. Drawing by Ron Hirzel, reproduced from Schwimmer (2002).

assumed use of the blunt, thick, rear teeth of *Deinosuchus* on a medium-sized marine turtle. The posterior location of the rugose, low-crowned teeth would put them at the region of maximum leverage as a bone-crushing adaptation (and see below for additional consideration of the evidence for posterior crushing tooth morphology).

Most of the turtle bite marks are observed as singular traces; however, this singularity is more likely the result of regional fossil preservation than of the actual paleobiology of the events. In the eastern Upper Cretaceous sediments where most figured specimens were found, nearly all preserved bones are isolated specimens, scattered by near shore marine regression and transgression events (Schwimmer, 1986). Therefore, it is impossible to determine how many bites were originally present on an individual turtle, since the carapace or plastron was usually separated *post mortem* into scattered bones.

As the exception that proves the rule, it is noteworthy that where larger and articulated vertebrate fossils are common, numerous crocodylian-type bite marks have been found covering a single surface of turtle bone. Figure 8 shows a xiphiplastron of the marine protostegid turtle *Chelospargus advena* Zangerl, 1953, from the open-marine Mooreville (Chalk) Formation in western Alabama, with numerous crocodylian-type bite marks covering a single surface. The bite marks on this specimen vary widely in size, ranging from ~0.5 to 1.3 cm diameter, and are more oval, rather than round, externally. Because this is an open ocean specimen rather than from the nearshore (which would be the more probable habitat of *Deinosuchus*), and because the sizes range down to fairly small, it is not certain that *Deinosuchus* is the crocodylian species responsible for these bites. Nevertheless, this specimen does show that the isolation of bite marks on most turtle specimens is likely taphonomic, not biological (Schwimmer, 2002). And, overall, it is evident from the relatively large number of *Deinosuchus* bite marks on sea turtles in the

Southeastern USA (for example, with nine separate occurrences in my collections from one site in southwestern Georgia) that this may have been a frequent feeding mode.

Deinosuchus Bite Marks on Dinosaur Bones

Interactions between *Deinosuchus* and dinosaurs are rarely documentable. For example, there are no Cretaceous coprolite specimens that

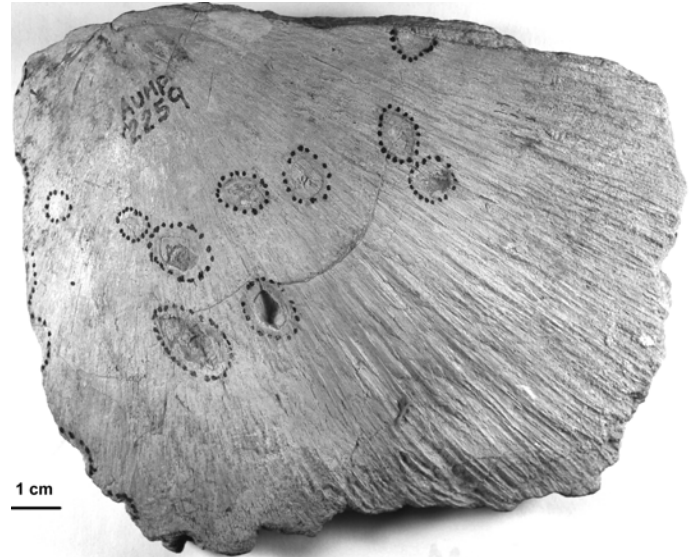


FIGURE 8. Xiphiplastron of the protostegid marine turtle *Chelospargus advena*, Mooreville Formation (Early Campanian), Dallas County, Alabama, Auburn Museum of Paleontology (AUMP) 2259. The plastron shows numerous crocodylian-type bite marks, ranging from ~0.5 to 1.2 cm in maximum diameter; however, many are poorly demarcated and shallow, suggest a raking bite rather than the crushing bites evident in the other figured turtle bones.

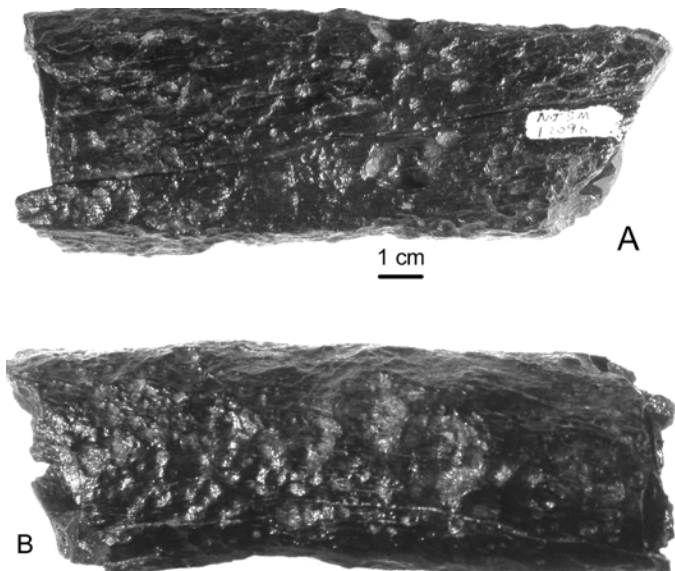


FIGURE 9. Theropod tibial or metatarsal limb shaft fragment, Ellisdale Site, (Upper Campanian), Monmouth County, New Jersey, New Jersey State Museum (NJSM) 13096. The bone is covered almost entirely by overlapping crocodylian-type bite traces. Figures 9A and 9B show opposite sides of the bone, with the largest bite marks on side B. 1.8 cm in diameter. Not illustrated is the cross-section of the bone, which is distorted from its original sub-round dimensions, evidently by the bite pressures.

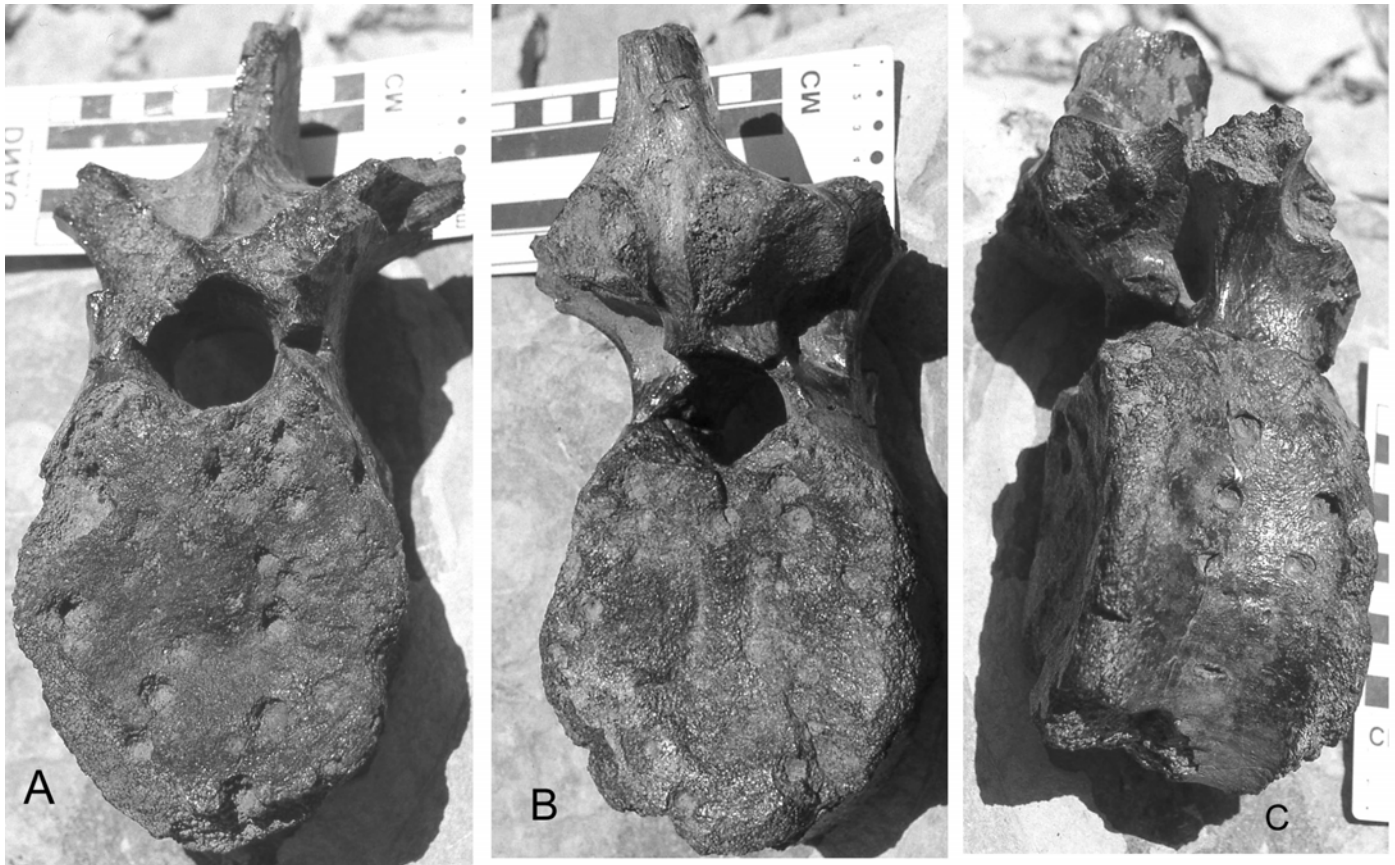


FIGURE 10. Hadrosaur presacral vertebra, Aguja (?) Formation, vicinity of Big Bend National Park, Brewster County, Texas. Specimen in private collection of Ken Barnes, Terlingua, Texas. **A**, Cranial aspect, showing 10 distinct circular bite marks on the centrum, ~1.0 cm diameter; **B**, Caudal aspect, with numerous, less distinct bite marks; **C**, Right lateral aspect, with five distinct bite marks, averaging 1.0 cm. It is notable that these circular traces in the centrum do not show surface cracking, indicating that they were impressed in fresh bone, rather than by any post-mortem process. The size and shape of bite marks on this specimen resemble the single bite mark on a hadrosaur vertebra figured by Rivera-Sylva et al. (2009) from the Aguja Formation in neighboring Coahuila, Mexico.

have so far been identified as both unambiguously crocodylian (Schwimmer, 2002) and which also contain dinosaur bone remains. However, a few fossil bone specimens have been identified with bite traces indicating the giant crocodylians either fed upon or scavenged some Campanian dinosaurs. Two sets of specimens, one each from strata on eastern and western sides of the Interior Seaway, show such characteristic giant crocodylian bite marks.

Bite Marks on a Theropod Limb

The eastern specimen, from New Jersey, is a theropod limb-shaft fragment (Fig. 9), possibly a tibia or metatarsal, which shows very numerous large, blunt gnawing traces. The bone comes from the Ellisdale Locality, which is at the stratigraphic boundary between the Campanian Marshalltown and underlying Englishtown formations (Gallagher, 1993). The bone is identified as a theropod bone shaft because the medullary cavity is smoothly lined and hollow, typical of all derived theropods (and birds). Both bone ends are ablated, and the original cross-sectional dimensions are difficult to estimate (averaging 7.0 cm) because the bone was extensively crushed and distorted by the bite forces that imposed the numerous marks on the cortex. Because there are so many overlapping bites (“gnawing” in the sense of Njau and Blumenschine, 2006), it is difficult to count individual bites or to measure their precise diameters: the largest bite traces are ~18.0 mm in diameter.

The bone was obviously chewed thoroughly by the crocodylian, but it is not determinable whether this was during predatory or scaveng-

ing activity. The best assumption of the identification of the theropod from the size, shape and cross section of the bone, is that it is a metatarsal from an immature (~5-6 m long) tyrannosauroid, such as the holotype of the Campanian genus *Appalachiosaurus* (Carr et al., 2005), known primarily in the Southeastern USA. An alternative identification is *Dryptosaurus* (Cope, 1866), known from the Maastrichtian holotype from New Jersey, and tentatively identified from the Campanian (Gallagher, 1993) in the same region. Either identification presents the scenario of a smaller tyrannosauroid dinosaur as either victim or scavenger of a larger *Deinosuchus*. Since the theropod bone is from a rear limb (a preferred crocodylian attack point) and since the theropod was a smaller individual, this was more likely a predatory event.

Bite Marks on Hadrosaur Vertebrae

On the western side of the Seaway, a remarkably well-preserved set of circular bite marks is present on a single hadrosaur pre-sacral vertebra and two additional caudal specimens from the region of Big Bend National Park, West Texas, which is also the locality of the holotype *Phobosuchus riograndensis* specimen. The well-preserved, pre-sacral dorsal vertebra (Fig. 10) shows numerous circular, blunt depressions on all surfaces, which are remarkably uniform in their circularity and size. At least ten distinct bite marks of approximately 1.0 cm diameter are clearly visible on the cranial side (Fig. 10A), with approximately as many smaller or less incised traces on the same surface, suggesting that each represents a single tooth impression with little or no overlap. The

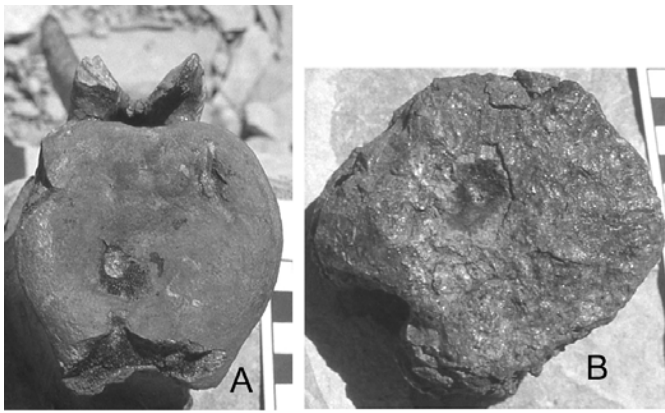


FIGURE 11. Hadrosaur caudal vertebrae, provenance same as the presacral vertebra in Figure 10, and probably from the same specimen: **A**, Mid-caudal with one well-demarcated and two less definitive bite traces; **B**, Ablated centrum, probably from a more distal vertebra, with a single bite mark. The bite traces on these specimens are approximately 1.0 cm diameter, as in Figure 10. **A** shows the same preservational characteristics and color as the vertebra in Figure 10, whereas **B** is considerably more weathered and ablated.

caudal side of the centrum (Fig. 10B) shows more numerous, but less distinct, bite marks. The right lateral surface (Fig. 10C) shows at least five distinct, ~ 1.0 cm round bite marks. The presence of bite marks on all sides of this vertebra indicates that the bone was chewed after the body region was separated from the rest of the corpse; and, since this vertebra is from the pre-sacral region of the trunk (and therefore central and deeply buried in soft tissue), it is probable that the event took place either late in the dismemberment of the hadrosaur, or that it was a result of scavenging.

Beside the single pre-sacral vertebra from Texas discussed above, the associated collection includes two smaller caudal vertebrae, each with one or more round, blunt depressions (Fig. 11). The depressions appear to be *Deinosuchus* bites, but their identification may be questioned since they are fairly shallow. All three hadrosaur specimens here are in an amateur collection, and the exact provenance is uncertain; but, the preservation and regional occurrence would suggest that these are from the Aguja Formation, which is also the formation from which the holotype *Phobosuchus* specimen derived (Colbert and Bird, 1954), from a locality proximal to Big Bend National Park.

A recent report (Rivera-Sylva et al., 2009) describes a similar, large, circular bite mark in a large hadrosaur caudal vertebra from the Aguja Formation in Coahuila, Mexico, located not too far south of Big Bend Park. I have not personally examined the specimen, but the morphology of the single bite mark as illustrated does indeed conform with the bite marks on the specimens I have described, notably the hadrosaur vertebra in Figure 10. The authors of this report comment on the probability that a crocodylian would likely attack a larger dinosaur from the tail end, explaining the presence of bite marks there, and suggesting that this single bite mark in their specimen documents predation, rather than a scavenging event.

BONE-CRUSHING AND BROKEN TOOTH TIPS

The morphology of *Deinosuchus rugosus* posterior teeth should be sufficient evidence that they were used for biting resilient surfaces, given their deeply ridged surface enamel (Fig. 2), thick cross-sections (Fig. 3), and blunt crown profiles. However, it is also interesting to observe that a majority of posterior *Deinosuchus* teeth in large collections (e.g., my own from the Blufftown Formation in Georgia and Alabama, and those of the North Carolina State Museum) show tip wear and fractures consistent with repeated durophagy. Figure 12 illustrates a representative sample of posterior teeth with various degrees of apical

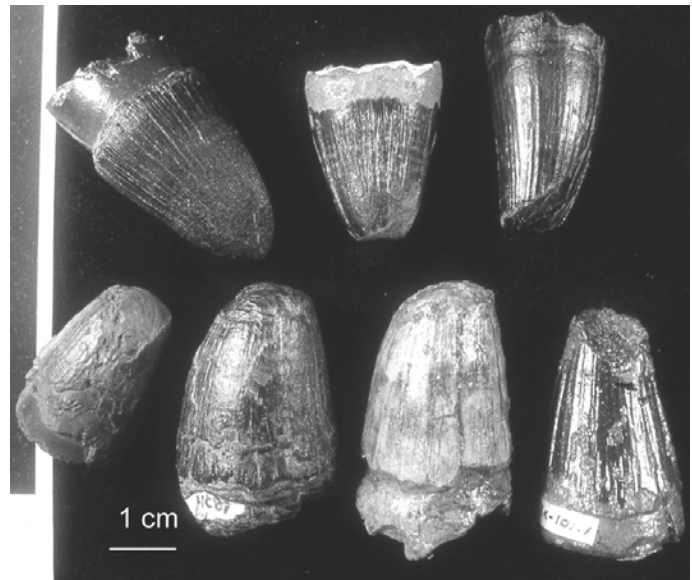


FIGURE 12. Representative posterior *Deinosuchus* teeth, from the Blufftown Formation (early to mid-Campanian), Stewart County, Georgia, and Russell County, Alabama, all specimens in the CSUK research collections. The two teeth at right show the characteristic obliquely sheared tips found in many *Deinosuchus* posterior teeth in regional collections, likely the result of feeding on the regionally abundant, heavy-boned pleurodire turtles. The teeth in the center show the result of repeated wear on already broken tooth tips. The specimen in the upper left corner is a rare, unbroken posterior tooth, possibly a fresh replacement crown exposed after the broken external surface exfoliated (see Figure 2 for an example of this process).

wear and breakage.

In many examples of the posterior teeth showing heavy use, the tips are obliquely sheared, presumably broken from extreme pressure, and then subsequently worn around the sheared edges. Because there are multiple sets of replacement crowns within each tooth, and each crown has thick infolded enamel surface, the wear around the tips actually exposes new enamel surfaces. This adaptation is somewhat analogous to the wear patterns observed in many grazing mammal teeth, as well as that in hadrosaurs, where heavy use actually creates more durable biting surfaces by wearing back the softer dentin and exposing enamel ridges. We may assume this tooth morphology was an adaptation to better cope with the extreme breakage and abrasion generated by bite pressures of *Deinosuchus* jaws approaching 1.0 m in length.

SUMMARY AND CONCLUSIONS

The identification of crocodylian bite marks on fossil bones may sometimes be tentative, but generally the source of such traces can be documented. In the Late Cretaceous of North America, larger crocodylian bite traces may be attributed with reasonable confidence to the giant eusuchian genus *Deinosuchus*, especially in sedimentary settings in or adjacent to marine paleoenvironments. Marine turtles appear to have been frequent prey of *Deinosuchus* in the Campanian of southeastern USA. However, there is ample evidence that *Deinosuchus* species either preyed upon or scavenged hadrosaur and smaller theropod dinosaurs on both sides of the Interior Seaway.

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