An azhdarchid pterosaur eaten by a velociraptorine theropod

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Abstract: Tooth-marked bones are more common in the fossil record than published accounts would lead us to believe, but with rare exceptions, the animals that made the marks cannot be identified. A partial skeleton of an azhdarchid pterosaur found in Upper Cretaceous strata of Dinosaur Provincial Park was eaten by the theropod *Saurornitholestes langstoni*, which left tooth marks and the broken tip of one tooth imbedded in one of the bones. The presence of the broken dinosaur tooth is the first reported in association with tooth-marked bone, and probably indicates that the dromaeosaur was a scavenger in this case. Because the bitten pterosaur bone was thin walled, the bone must have been very tough to have broken the theropod tooth.

Résumé : Les marques de dents laissées par des morsures sont plus fréquentes dans le registre fossile que le laissent croire les articles publiés, néanmoins il est très rare que les animaux qui ont laissé de telles empreintes puissent être identifiés. Un squelette partiel d'un ptérosaure azhdarchide, trouvé dans les strates du Crétacé supérieur dans le Parc provincial des Dinosaures, avait été mordu par le théropode *Saurornitholestes langstoni*, lequel a laissé les marques de ses dents, et en plus l'extrémité brisée d'une dent est demeurée encastrée dans un des os. C'est la première fois qu'on rapporte une dent brisée d'un dinosaure en association avec l'os qui exhibe l'empreinte de la dent, ce qui suggère dans ce cas que le dromaeosaure était nécrophage. L'os mordu du ptérosaure avait une paroi mince, par conséquent il devait être très dur pour avoir brisé la dent du théropode.
[Traduit par la rédaction]

Introduction

Determining predator–prey relationships from fossil evidence alone is difficult. Nevertheless, it has been possible to generally separate predatory and herbivorous taxa by using morphology alone (Abler 1992; Farlow et al. 1991). In recent years, it has been noted that tooth-marked bones are quite common in the Upper Cretaceous sediments of Dinosaur Provincial Park (Alberta, Canada), and perhaps would be even more commonly found if systematic observations were made of broken, uncollected bones. In some cases, it is possible to determine the family or even the genus of a theropod that bit a bone by looking at the spacing between the tooth marks, or between marks left by the denticles of the teeth. Teeth of feeding theropods were often damaged (Farlow and Brinkman 1987; Farlow et al. 1991), and flakes of enamel and even broken tips of theropod teeth are recovered as fossils associated with tooth-marked specimens. Such teeth are taxonomically distinctive (Currie et al. 1990) and can be identified on the basis of size, shape, serration density, and denticle morphology.

In 1992, an associated skeleton of an azhdarchid pterosaur was collected in Dinosaur Provincial Park near Brooks, Alberta. It was collected from white, fine- to medium-grained sandstones at a site (quarry 207) low in the Dinosaur Park Formation near the centre of the badlands within the park. Although azhdarchids had been found in the region before (Currie and Russell 1982; Padian and Smith 1992), the discovery is noteworthy because it is the only pterosaur from Canada that consists of more than one bone from a single skeleton. This specimen, Royal Tyrrell Museum of Palaeontology (RTMP) 92.83, includes a diagnostic cervical vertebra (RTMP 92.83.7), a rib (RTMP 92.83.5), a humerus (RTMP 92.83.4), a pteroid (RTMP 92.83.3), metacarpals III (RTMP 92.83.6) and IV (RTMP 92.83.1), and a tibia (RTMP 92.83.2). Comparison of the lengths of the humerus (24.5 cm) and fourth metacarpal (62.5 cm) with published information on other pterosaurs (Eaton 1910; Padian 1984; Padian and Smith 1992) suggests that RTMP 92.83 had a wingspan of about 6 m.

RTMP 92.83.2 has no evidence of coossification with either the fibula or the proximal tarsals, suggesting that the animal was immature despite its great size. The proximal end of the bone has an unfinished bone surface, which also indicates immaturity. This is not unreasonable, considering the fact that the azhdarchid *Quetzalcoatlus* (Langston 1981) has a humerus more than double the length of RTMP 92.83.4. As in *Quetzalcoatlus*, the tibia is only slightly shorter than the fourth metacarpal (W. Langston, personal communication, 1994). It is 58.5 cm long, with a minimum shaft diameter of 2 cm. The tibia is hollow with walls 1.0–1.5 mm thick. The surface of the tibia is tooth-marked, and the broken tip of a tooth is lodged in the bone. Theropod teeth can be found at the same sites as tooth-marked bones (Fiorillo

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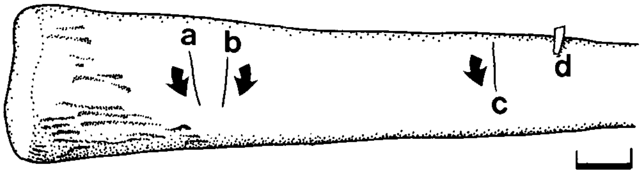


Fig. 1. Distal end of RTMP 92.83.2 showing the location of the three tooth marks (a, b, c) and the tooth (d). Arrows show direction of jaw action as determined by redirected bone fibres. Scale bar = 1 cm.

1991), but the authors are aware of no published reports of Cretaceous teeth that are imbedded in bones. However, a hadrosaur bone found recently in the Two Medicine Formation of Montana is tooth-marked and includes the tip of a tyrannosaurid tooth (J. Brandvold, personal communication, 1993).

Description

Three transverse tooth furrows, none of which are parallel, are found near the distal end of the tibia (Fig. 1), and presumably represent several bites. These would be classified as scoring marks using the classification of Binford (1981). Redirection of the bone fibres (Fig. 2) within the furrows shows the direction in which the teeth were being pulled across the bone when the theropod was feeding (Fig. 1). The lengths of the tooth marks are, respectively, 11.7, 17.3, and 10.4 mm.

The broken tooth is 10.8 cm from the distal end of the tibia. Postdepositional cracks in the bone are much narrower than the tooth, and are not aligned with the anteroposterior axis of the tooth. This shows that the tooth could not have been washed into a crack in the bone before it was buried. The anteroposterior axis of the tooth is perpendicular to the longitudinal axis of the bone, showing the theropod was biting across the bone. Seven millimetres of tooth protrude from the bone. It has an anteroposterior length of 3.9 mm, and a labiolingual width of 1.85 mm. Amongst the theropods of Dinosaur Provincial Park, only teeth of *Saurornitholestes langstoni* show this degree of labiolingual flattening. Breakage removed all of the posterior denticles, but there are 16 denticles visible along the 3 mm of anterior carina. Both the shape and size of these denticles confirm the identification of the tooth as *S. langstoni* (Currie et al. 1990).

There are at least three fracture surfaces on the tooth (Fig. 3). The main break (c–c in Fig. 3) was an oblique anteroproximal to posterodistal fracture that twists slightly distolingually. A thin, narrow flake (a–a) was removed from the proximal end of the anterior carina of the imbedded tooth tip. A wider, but still thin fragment was spalled off from the labial surface of the tooth tip. The surface of this break (Fig. 3, b) shows concoidal fracturing.

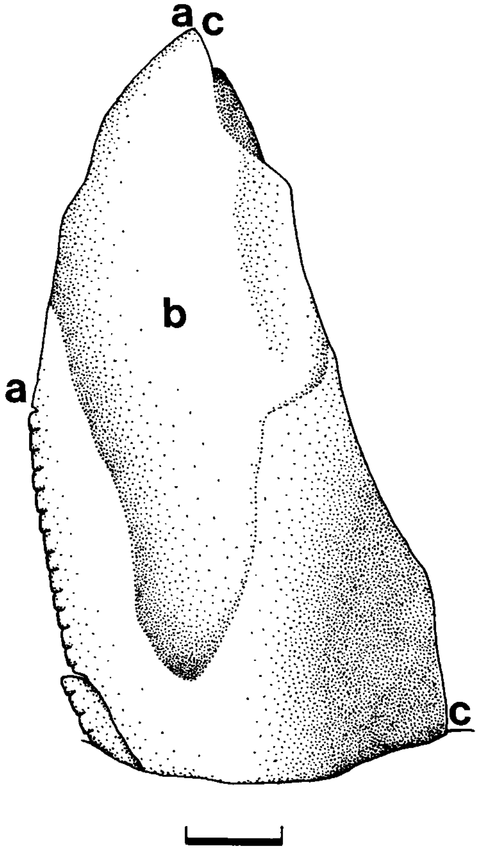
Discussion

The famous fighting *Velociraptor* and *Protoceratops* from Mongolia (Jerzykiewicz et al. 1993) provide strong evidence that velociraptorine dromaeosaurs were active hunters capable of attacking prey larger than themselves. However, the size disparity between *Saurornitholestes* (with an estimated body length of less than 2 m) and the enormous azhdarchid represented by RTMP 92.83 is great enough that one suspects the former could not have killed the latter, and therefore may have been scavenging. When the theropod was scraping the flesh from the bones, one of its teeth punctured the pterosaur tibia and was caught. The twisted nature of the fractured surfaces suggest that the tooth shattered when the theropod twisted its head and attempted to pull it out.

It is also possible but less likely that the theropod was gnawing on or chewing the bone after all of the flesh had decomposed. This is commonly done by mammals as a means of acquiring calcium and phosphorous, to get at the marrow inside the bone, and (or) to wear down constantly growing teeth (Binford 1981). It is unlikely that the *Sauror-*

Fig. 2. Close-up drawing of tooth mark b (Fig. 1) showing redirected bone fibres along margins. Scale bar = 1 mm.

Fig. 3. Specimen drawing of *Saurornitholestes* tooth (RTMP 92.83.2) showing anterior denticles and fractures. The proximal end of the tooth is up, and the distal end is down. a–a, edge of anteroproximal fracture; b, concoidal fracture on labial side of tooth; c–c, edge of major fracture along back of tooth. Scale bar = 1 mm.



nitholestes was gnawing the bone, which does not show the repetitive gnaw marks characteristic of such behaviour. Theropods did not have constantly growing teeth, and therefore there was no need for the animal to try and wear them down. And finally, pterosaur bones were pneumatic and did not contain any marrow. It is therefore reasonable to assume that there probably was still flesh on the *Quetzalcoatlus* bones when the theropod broke and lost its tooth. One can also assume that the *Saurornitholestes* contributed to the scattering of the pterosaur skeleton.

This is the second record of a pterosaur that has been eaten by another animal. An incomplete, disarticulated skeleton of a Late Triassic (Norian) pterosaur was found in what may have been a gastric pellet of a fish (Dalla Vecchia et al. 1988). Although the ends of some of the bones may have been bitten off, there are neither tooth marks nor teeth that can be used to identify the predator.

Velociraptorines do not have microprismatic enamel (Dauphin et al. 1989), but their teeth would have been stronger than most bone. The pterosaur bone must have been remarkably tough to break a tooth with a minimum labiolingual width of almost double the thickness of the walls of the bone. Pterosaurs reduced weight and increased strength primarily by decreasing the thicknesses of the walls of bones at the same time as they increased overall shaft diameters (Padian et al. 1992). The broken tooth suggests that the bone composing the walls of the shaft was also structurally stronger.

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