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Tooth Implantation and Attachment in *Scoloparia glyphanodon* (Parareptilia: Procolophonidae)

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ABSTRACT

We describe tooth implantation, replacement, and attachment in a specimen of the procolophonid *Scoloparia glyphanodon*. Though an earlier description of the specimen made mention of the dentary, splenial, and coronoid, we identify a small sliver of the angular that is also present. We observe two modes of tooth implantation (protothecodonty and acrodonty) and no tooth replacement, though it is likely teeth were added posteriorly over time. Previous interpretations of tooth implantation in procolophonids were conflated with replacement patterns and mode of implantation. Additionally, the combination of dental characters of the specimen suggests *Scoloparia glyphanodon* had an herbivorous diet.

KEYWORDS

Acrodont, thecodont, ankylosis, reptile, dentition, molariform, herbivory, tooth wear, Triassic, tooth replacement

Introduction

Tooth implantation, attachment, and replacement are important characters in determining the diet and lifestyle of extinct vertebrates, and dental features provide important phylogenetic information. Here, we present computed tomography (CT) scans of a specimen from the Division of Vertebrate Paleontology Princeton Collection, Peabody Museum of Natural History, Yale University, New Haven, CT, USA (YPM VPPU 024501), a mandibular ramus of the procolophonid stem-reptile *Scoloparia glyphanodon* from the Upper Triassic Wolfville Formation of Nova Scotia, Canada. Some debate surrounds the dentition of procolophonids, particularly with regard to how their teeth are implanted into the surrounding bone, how tooth replacement influences ankylosed dentition, and how the existence of dental replacement pertains to traditional uses of the term "acrodont" (Gow 1977; Cabreira and Cisneros 2009; MacDougall and Modesto 2011). Because many species of procolophonid are known only from teeth and tooth-bearing elements, information about tooth implantation, attachment, and replacement patterns garnered from these elements is crucial in revealing the pattern of procolophonid radiation following the Permo–Triassic mass extinction.

Materials and Methods

The specimen (YPM VPPU 024501) was scanned using a Nikon XT H 225 S micro CT scanner, housed at Yale University. A series of 3,142 computed tomographs were thus produced. The stack of tomographs was then imported into VGSTUDIOMAX version 3.5 (Volume Graphics 2021) to create the three-dimensional (3D) volumetric model of the specimen used in this study. 3D renderings were created using the Scatter HQ setting. Slice images are shown as is.

Results and Discussion

The specimen is a partial right mandibular ramus (YPM VPPU 024501) measuring 3.28 cm in length with a maximum height of 1.68 cm.

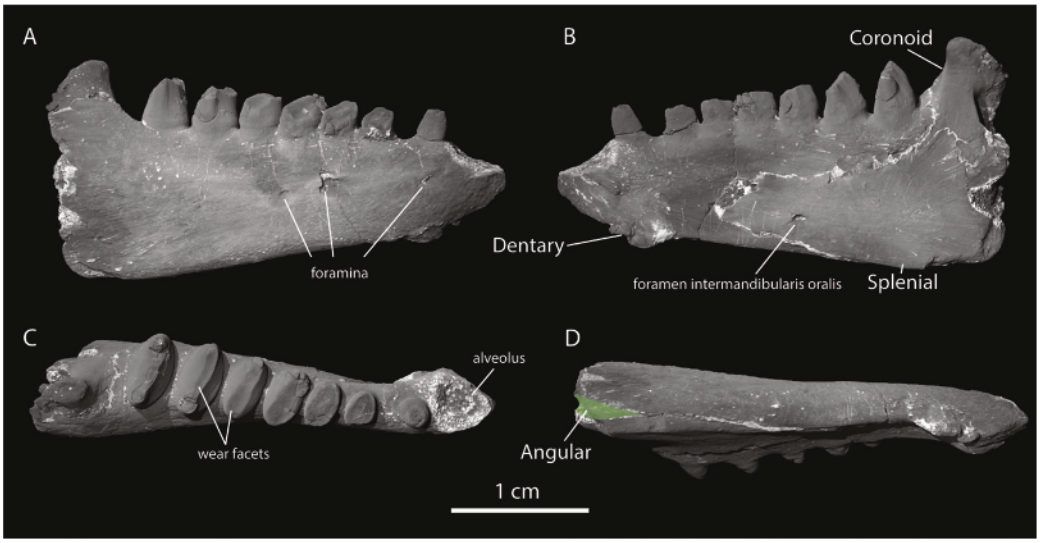

FIGURE 1. Three-dimensional renderings of *Scoloparia glyphanodon*, YPM VPPU 024501. **A.** Lateral. **B.** Medial. **C.** Occlusal. **D.** Ventral. Green overlay has been added to highlight the angular.

The specimen was previously described in detail by Sues and Baird (1998). Though previous work made mention of the dentary, splenial, and coronoid, a small sliver of the angular is also present and is identified for the first time here on the basis of the 3D volumetric model (Figure 1D). Seven teeth are preserved, which increase in height and width posteriorly along the tooth row, though the presence of an alveolus larger in diameter than that of preserved tooth 1 suggests the presence of another more anteriorly located, conical tooth (Figure 1C and Figure 2A). The first preserved tooth is incisiform and conical, while the subsequent teeth are progressively more transversely expanded and molariform, with two cusps located on the lingual and labial portions of the occlusal surface, respectively (Figure 1C).

Anterior teeth are more heavily worn than posterior teeth, with the two anteriormost molariform teeth (i.e., teeth 2 and 3) possessing grinding surfaces that are nearly flat as a result of wear. On the first three molariform teeth (i.e., teeth 2–4), wear is greatest on the labial portion of the occlusal surface. Tooth wear on the first two molariforms has resulted in a squared-off appearance, best seen in coronal-sliced view (Figure 2B). The last two teeth of the tooth row (i.e., teeth 6 and 7) show little wear, and that which does exist is greatest on the lingual portion of the occlusal surface (Figure 1C). Given the heavy wear on the more anteriorly located teeth, and the little wear on the posterior dentition, it is likely that successional teeth were added posteriorly over the animal's lifetime. Alternatively, it is possible that the uneven distribution of wear is a result of chewing more frequently or more heavily in the anterior portion of the mouth.

Tooth implantation in this specimen is acrodont (sensu Jenkins et al. 2017) in the molariform dentition, with teeth located at the apex of the bone, and tooth implantation is accomplished by ankylosis as evidenced by the firm tooth attachment at the tooth–bone interface (Figure 2A). However, the anteriormost, conical teeth possess somewhat deeper implantation, though they are not implanted deeply enough to be designated as thecodont, but rather are better designated as representing the protothecodont condition where the height of the tooth root is less than that of the crown. There are no resorption pits, and no replacement teeth are visible in the CT scans for any of the teeth. As such, tooth replacement in *Scoloparia glyphanodon* was unlikely. Sections reveal that the dentine layer is thick in all seven of the preserved teeth, particularly

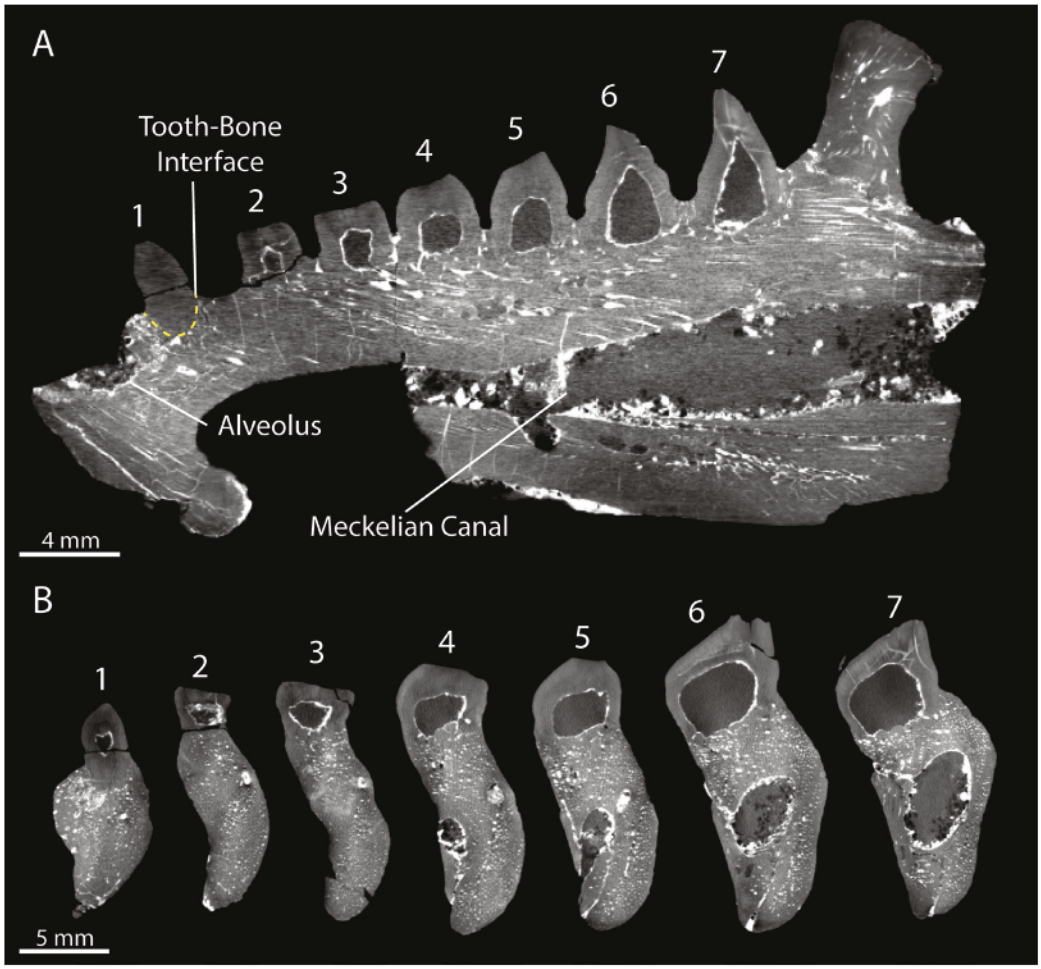

FIGURE 2. Computed tomography slices of *Scoloparia glyphanodon,* YPM VPPU 024501. **A.** Sagittal section oriented anteroposteriorly. **B.** Coronal sections oriented mediolaterally. Numbers correspond to preserved tooth position. The alveolus represents an empty tooth position. Yellow dotted line has been added to the base of tooth 1 to show the implantation.

near the occlusal surface of the less worn teeth, and the pulp cavity in each tooth is relatively large (Figure 2).

Tooth implantation and attachment has been a subject of debate in procolophonids (Gow 1977; Cabreira and Cisneros 2009; MacDougall and Modesto 2011), largely resulting from the conflation of geometric terminology (acrodont, thecodont, pleurodont, etc.) with replacement patterns and mode of tooth attachment. For example, "acrodont"—a term strictly used to denote the apical position of the tooth in relation to the jawbone—is often associated with little to no tooth replacement and ankylosing attachment, particularly among lepidosaurs (Jenkins and Shaw 2020). However, this is not the case for all taxa with acrodont tooth implantation. In procolophonids, a combination of varying tooth implantations and replacement patterns are seen across different species, with some exhibiting acrodont dentition and regular tooth replacement (e.g., Li 1983; Small 1997; MacDougall and Modesto 2011), or both acrodont and protothecodont implantation within the same jaw with no tooth replacement, as is seen here in *Scoloparia glyphanodon*. However, ankylosis seems to be the mode of attachment for all known

procolophonids. Separation of these features into separate characters will certainly aid in future phylogenetic analyses of reptiles.

Such a combination of dental characters (i.e., lack of replacement, heavy wear, low tooth count, and molariform morphology of most of the teeth) in this specimen is consistent with *Scoloparia glyphanodon* having had an herbivorous diet—likely one consisting of high-fiber plant material, which would require greater oral processing than carnivorous or insectivorous diets—as was suggested for other taxa with a similar suite of dental characters (Sues and Reisz 1998).

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