



A new helmeted frog of the genus *Thaumastosaurus* from the Eocene of England

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Helmeted frogs with co-ossified skulls (*Thaumastosaurus*) were previously known in Europe only in the Eocene on the basis of *Thaumastosaurus bottii* from southwestern France and *Thaumastosaurus wardi* from coastal southern England. We describe *Thaumastosaurus sulcatus*, that differs from these species in having a different dermal sculpture pattern and tooth morphology. We suggest that the auburn colored tooth crown tips in *T. sulcatus*, as in some other vertebrates, reflect extra hardness for protection against tooth wear. Autochthonous *Thaumastosaurus* species in southern England support the concept that southern England and southwestern France were distinct faunal provinces in the Late Eocene.

Hoffstetter (1945) first recognized that *Thaumastosaurus bottii* De Stefano, 1903 is an anuran, not a lizard. Rage (1981) placed this taxon in the subfamily Ceratophryinae Tschudi, 1838 of the family Leptodactylidae Werner, 1896. Roček and Lamaud (1995) detailed the anatomy of *T. bottii*, designated a neotype, and suggested that *T. bottii* was a leptodactylid that indicated an ancient Gondwanaland connection to Europe.

Holman and Harrison (2002) named *Thaumastosaurus wardi* from Late Eocene sites in Hampshire and the Isle of Wight, England. This taxon has a dermal sculpture pattern identical to *T. bottii* but different maxillary and squamosal characters. Holman and Harrison (2002) found that *T. wardi* was similar to the South American leptodactylid genus *Caudiverbera* Laurenti, 1768, but suggested that *Thaumastosaurus* should be considered of uncertain familial relationships.

Materials and methods

During the 1990s and from 2001–2002, field parties from the Harrison Institute collected microvertebrate fossils from several Late Eocene localities in southern coastal England and the Isle of Wight. Matrix from these localities was processed in the Ward Sieving Apparatus prior to hand picking the fossils from the concentrate. This yielded the new helmeted frog species described here. The new frog is in the Michigan State Museum Vertebrate Paleontology Collections (MSUVP). All measurements are in millimeters (mm). Below, the cranial anuran anatomical terms of Roček and Lamaud (1995) used here are compared with anglicized terms.

Fossa maxillaris (maxillary fossa of maxilla); lamella alaris squamosi (head of squamosal); lamina anterior (anterior process of maxilla); lamina horizontalis (palatine process of maxilla); margo orbitalis (orbital margin of maxilla); processus posterior (otic ramus of maxilla); processus frontalis (preorbital process of maxilla); processus zygomaticus (zygomatic process of squamosal); prootico-occipitalia (prooticooccipitals); and ramus paroticus (parotic ramus of squamosal).

Systematic paleontology

Anura Rafinesque, 1815

Family indeterminate

Genus *Thaumastosaurus* De Stefano, 1903

Thaumastosaurus sulcatus sp. nov.

Holotype: Anterior portion of left maxilla with tooth row and some teeth present (Fig. 1); pigment (auburn color) on all tooth crowns present; Michigan State University Museum Vertebrate Paleontology Collection (MSUVP) no. 1976.

Type locality and horizon: “Mammal Bed”, Hordle Cliff Locality, near Mildford-on-Sea, Hampshire, England; Late Eocene (British Headonian), European Land Mammal Age Zone MP 17 (ca. 36–39.5 Ma, Hooker 1989).

Paratype: Lamella alaris squamosi of right squamosal (Fig. 2), MSUVP 2021 from the “Rodent Bed” of the Hordle Cliff Locality. The rodent bed is considered to be ca. 0.75 million years younger than the “Mammal Bed” of the same locality (Hooker, 1989).

Referred material.—Two left maxillae with teeth (pigmented tooth crowns present), MSUVP 1978–1979. Left maxilla with teeth (tooth crowns absent), MSUVP 2002. Three right maxillae with teeth absent, MSUVP 2016, 2027, and 2033. MSUVP 1978–1979 are from the Hordle Cliff “Mammal Bed”. MSUVP 2022 and 2033 are from the Hordle Cliff “Rodent Bed”. MSUVP 2016 is from the SW Headon Hill (“Headon Hill 3”) Locality, Isle of Wight, England; Late Eocene (British Headonian), European Land Mammal Age Zone MP 17.

Etymology.—The specific name is from the Latin *sulcus*, a furrow, in reflection of furrow-like sulci in the pit and ridge structure of the dermal bones of the skull of the new species.

Diagnosis.—A *Thaumastosaurus* differing from *T. bottii* De Stefano and *T. wardi* Holman and Harrison in having (1) sculpturing of external surfaces of maxilla and squamosal composed

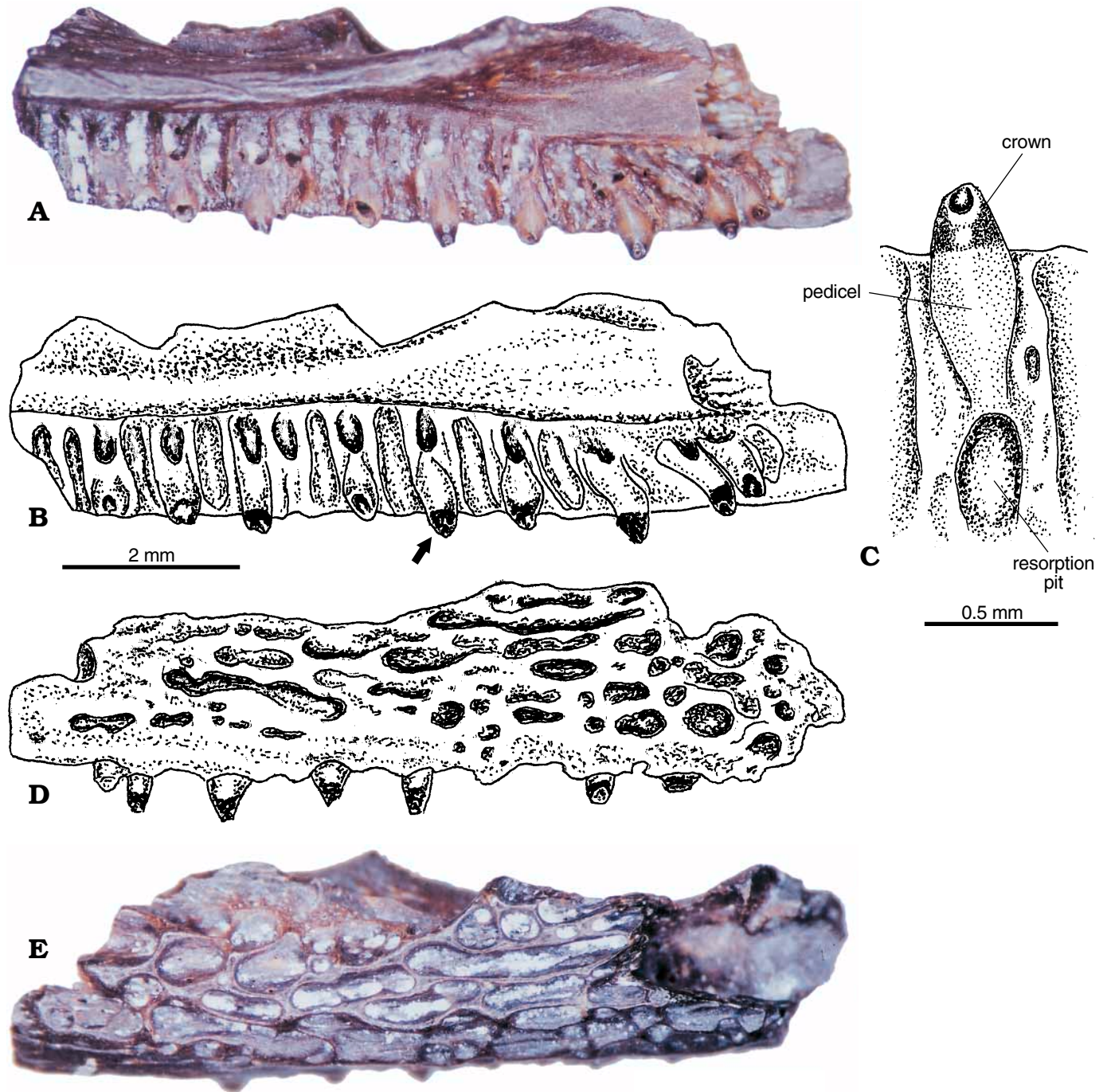


Fig. 1. *Thaumastosaurus sulcatus* sp. nov., partial left maxilla, holotype (MSUVP 1976), Late Eocene "Mammal Bed", Hordle Cliff Locality, Hampshire, England. A, B. Lingual view. C. Enlarged view of tooth indicated by arrow at B. D, E. Labial views.

of a significant number of elongate, ridge-bordered sulci; (2) lamina horizontalis of maxilla thinner and more sharply bowed upward throughout its length; (3) contact area for premaxilla more extensive (area not available in *T. wardi*); (4) tooth crowns relatively narrow, pointed, and with auburn pigmentation (teeth with more bulbous crowns and lacking pigmentation in *T. wardi*; tooth crowns unknown in *T. bottii*); (5) dorsal portion of ramus paroticus of lamella alaris of squamosal arising more posteriorly; (6) ventral border of squamosal less deeply concave.

Description

Holotype.—About the anterior one-half a left maxilla includes teeth and tooth spaces; most of the contact area for the premaxilla; a significant part of the lamina horizontalis; and part of the margo orbitalis. The greatest length of the bone is 8.7. In lingual view, the area for the contact with the premaxilla is extensive; the lamina horizontalis is robust and curved upward throughout its length; and the portion of the margo orbitalis re-

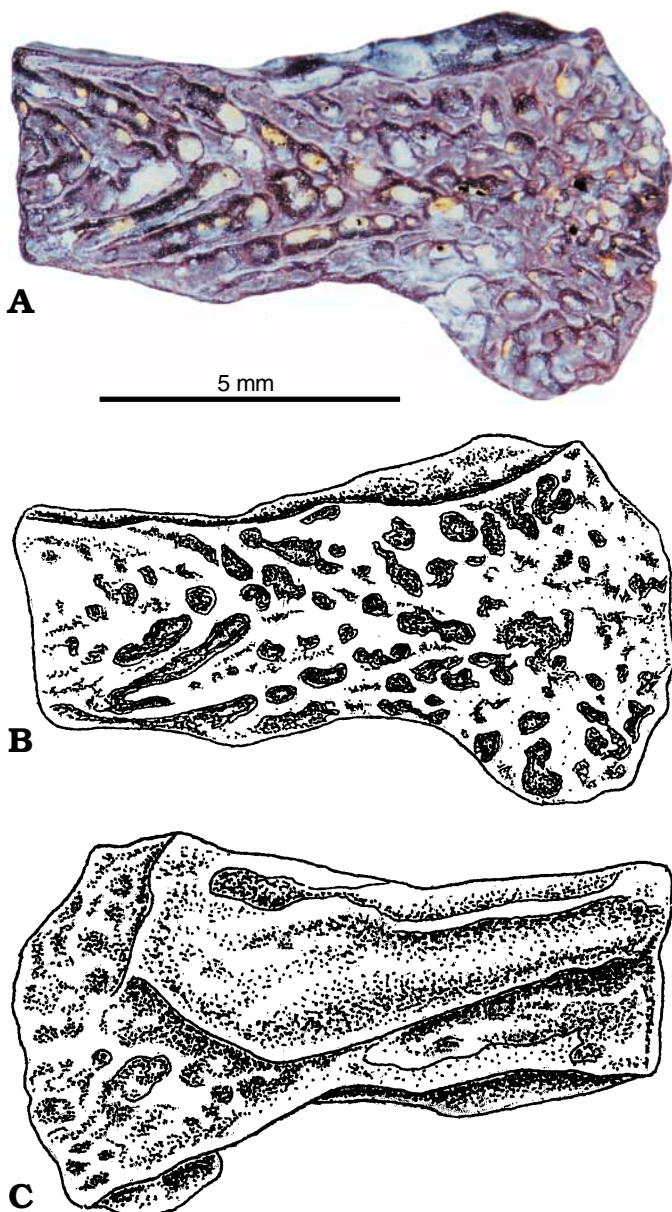


Fig. 2. *Thaumastosaurus sulcatus*, partial right squamosal (lamella alaris squamosi), paratype (MSUVP 2021). Late Eocene "Rodent Bed" of the Hordle Cliff Locality, Hampshire, England. A, B. Lateral views. C. Medial view.

maining on the fossil is much thinner than that of the lamina horizontalis. The tooth row has 9 teeth and 11 tooth spaces for a total of 20. Six of the teeth have crowns. All of the teeth and tooth spaces are directed somewhat anteriorly. All of the tooth pedicels are somewhat bulbous, but the crowns are somewhat narrower and moderately pointed terminally. All of the crowns are lingually worn, indicating that hard surfaces were regularly encountered during feeding. The tooth crowns are also strongly pigmented (auburn color). All of the pedicels and tooth spaces are enclosed in bony sheaths and all pedicels are excavated dorsally. In labial view, the dermal sculpturing clearly shows seven elongated, strongly bordered sulci and seven strongly bordered round to ovoid pits.

Paratype.—In the lamella alaris (head) portion of the paratype squamosal (MSUVP 2021), in lateral view, the elongate sulci are more prominent anteriorly in the narrow portion of the bone than posteriorly, where rounded and ovoid pits are most common. The dorsal margin of this bone is gently concave, whereas it is moderately convex in *Thaumastosaurus bottii* and gently convex in *T. wardi*. The dorsally projecting portion of the ramus paroticus arises more anteriorly than it does in either *T. bottii* or *T. wardi*. The ventral margin of the bone is less concave than in either *T. bottii* or *T. wardi*. The processus posterior is terminally broken. The greatest length of MSUVP 2021 is 10.3. The greatest length of this bone in *T. bottii* is ca. 9.6 (see Roček and Lamaud 1995: 511, fig. 10c); in *T. wardi* this length is 7.5.

Referred material.—In the referred left maxillae with tooth crowns present (MSUVP 1978–1979), the tooth crowns that are present are pointed and pigmented with an auburn coloration as in the holotype. The external sculpturing is composed of both elongated sulci and rounded to ovoid pits as in the holotype. The three right maxillae that lack teeth (MSUVP 2016, 2027, and 2033) also have this type of sculpturing.

Remarks

Tooth pigmentation.—The auburn pigmentation is not present in any part of the *T. sulcatus* skeleton except the tooth crowns, which indicates that the pigment is original and not the product of post mortem mineralization. Reddish to brown (often auburn) tooth tips of shrews (Mammalia: Soricidae, see Dannelid 1994; Dötsch 1985; Dötsch and Von Koenigswald 1978; and Kurta 1995) contain an iron compound that hardens the teeth and that is thought to protect against wear. The iron compound that produces these colored parts in shrews consists of goethite [Fe(OH)] (Akerston et al. 2001). Deposition of ectodermally derived iron oxides in dental tissues is also found in cyprinid fish, lungfishes, salamanders, snakes, and rodents (W. Akerston personal communication June 2002; Akerston et al. 2001; Miles 1963; and Schmidt 1966). In addition J.A.H. has observed tooth pigmentation in a scincid lizard (*Eumeces obsoletus*) and a percid fish (*Stizostedion vitreum*). We are not aware that this condition has ever been reported in frogs.

The conventional wisdom is that a diet of hard objects such as occurs in shrews that commonly eat earthworms (which have silt and sand grains in their guts) minimizes dental erosion during mastication (Akerston et al. 2001). The teeth of most modern frogs function to pierce and retain prey in the swallowing process; but the stout tooth sheaths and pedicels as well as the auburn colored tooth crowns with decided lingual wear patterns in *T. sulcatus* (Fig. 1A) seem to indicate different functions of the of the dental battery.

Familial relationships.—In the process of the description of *T. sulcatus*, we found no additional characters that indicate the relationships of the genus to the Leptodactylidae, thus we suggest that the familial status of the genus is still indeterminate (see Holman and Harrison 2002).

Faunal provinces.—Schmidt-Kittler (1977) and Rage and Ford (1980) have indicated that, based on mammalian faunas,

southern England and southwestern France were distinct faunal provinces in the Late Eocene. Five autochthonous snake genera from the Late Eocene of southern England (Holman 1993, 1996; Holman and Harrison 1998a, b; Rage and Ford 1980) as well as the presence of two autochthonous species of helmeted frogs further support the existence of the two faunal provinces.

Acknowledgments.—We are grateful to the persons who have taken part in the Harrison Institute vertebrate collecting trips to coastal southern England, especially Sarah P. Balcon, Paul J.J. Bates, Nikky M. (Thomas) Hammond, and David J. Ward. We would like to thank the Systematics Association, who kindly gave us a grant for the Leica stereomicroscope drawing attachment. George Ayers and David Ward took the photographs of *Thaumastosaurus sulcatus*. David L. Harrison made the drawings. We are grateful to Zbyněk Roček and an anonymous reviewer for their helpful comments.

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