First record of a Jurassic mammal (?“Peramura”) from Ethiopia

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Clemens, W.A., Goodwin, M.B., Hutchison, J.H., Schaff, C.R., Wood, C.B., and Colbert, M.W. 2007. First record of a Jurassic mammal (?“Peramura”) from Ethiopia. *Acta Palaeontologica Polonica* 52 (3): 433–439.

The first record of Mesozoic mammals in Ethiopia is a fragment of a lower mammalian molar discovered in residues left after acid dissociation of a small (ca. 4 kg) geological hand sample of a fine-grained bone bed in the lower part of the Mugher Mudstone exposed in the valley of the Jema River. This bone bed is part of a series of estuarine to fluvial deposits that are thought to be of Late Jurassic (Tithonian) age. The fragment preserves the trigonid of a molar; the distal part of its crown is missing. Morphological characters of the trigonid indicate the specimen (JEM-5/21) documents the presence of a mammal with a dentition at either a derived pretribosphenic or primitive tribosphenic grade of evolution. Absence of a well developed basal cingulid around the mesial end of the crown argues against phylogenetic relationships to the australosphenidans. Loss of the distal portion of the crown removed characters critical for determining its grade of evolution. The working hypothesis that JEM-5/21 represents a “peramuran” is advanced for testing. Hypotheses that it represents a mammal with a more derived grade of molar evolution or a previously unknown group of mammals cannot be excluded. JEM-5/21 establishes the presence of mammals in Ethiopia during the Late Jurassic, and its discovery identifies a fossil locality warranting thorough future exploration.

Key words: Mammalia, Peramura, Jurassic, Mugher Mudstone, Ethiopia.

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Introduction

The current record of African Jurassic and Cretaceous mammals is based on a few, geographically scattered fossil localities. With the exception of material derived from the Anoual syncline in Morocco (see Sigogneau-Russell et al. 1998 and references cited therein), samples from African localities usually consist of one or a few isolated teeth or fragments of dentaries. Although limited in number these samples strongly suggest that African Late Jurassic and Early Cretaceous mammalian faunas were taxonomically and biogeographically diverse (see Krause et al. 2003; Kielan-Jaworowska et al. 2004; and references cited therein).

Based on collections made between 1993 and 1998 Goodwin et al. (1999) analyzed a diverse vertebrate fauna preserved in near shore, estuarine, and terrestrial deposits composing the Mugher Mudstone, which are exposed in the valley of the Jema (Zhema) River, a tributary of the Blue Nile (Abay River), and adjacent areas in Ethiopia (Fig. 1). These fossils document the presence of the elasmobranchian *Hybodus*, the batoid ray *Rhinobatos*, osteichthyans *Lepidotes* and *Pycnodus*, as well as the dipnoan *Asiatoceratodus*. The presence of tetrapods is recorded by abundant but fragmentary skeletal remains of turtles and crocodilians as well as isolated teeth of theropod and hypsilophodontid dinosaurs. In 1998 field research in the Jema River valley led to the discovery of a heavily cemented, fine-grained bone bed in the Mugher Mudstone. Small geological hand samples of the bone bed yielded a variety of fossils including the fragment of a mammalian tooth described here. This specimen establishes the presence of mammals in Ethiopia during the Late Jurassic, and its discovery identifies a fossil locality warranting thorough future exploration.

Provenance.—The fragment of mammalian tooth described here (JEM-5/21) was discovered during laboratory processing of geological hand samples recovered from a bone bed in the Mugher Mudstone exposed in the valley of the Jema River (Fig. 1). The Mugher Mudstone was defined by Getaneh (1991) in his study of Mesozoic sediments of the northwestern high plateau on the western margin of the Rift Valley, Ethiopia. This formation rests conformably on the Lagajima Limestone, which was formed during a marine transgression that expanded from the southeast and covered a broad region of what is now Ethiopia. The Mugher Mudstone is either conformably overlain by the Debre Libanos Sandstone or disconformably capped by Tertiary basalts. Algal mats and burrow structures in the lower Mugher Mudstone indicate deposition in estuarine conditions. These lower sub-tidal and lagoonal deposits grade upward into fine-grained, meandering river deposits of mudstones and siltstones (Getaneh 1991).

In 1998 a heavily cemented, fine-grained bone bed in the Mugher Mudstone was discovered northeast of the bridge that crosses the Jema River on the road linking Lemi and Alem Ketema (Fig. 1). It is exposed in the area of the Jema River North and Jema River Sharktooth Hill localities (Goodwin et al. 1999). Here exposures of the Mugher Mudstone are topographically low and predominantly developed along southern and southeastern facing hillsides. The dominant lithology is a well-sorted, medium to fine grained sandstone ranging from red to tan or white in color. Grains are sub-rounded to rounded. The degree of calcareous cementation is variable. The Lagajima Limestone is exposed at the bridge but because of ground cover the precise stratigraphic position of the bone bed in the Mugher Mudstone could not be determined. The small difference in elevation between the bone bed and exposures of the Lagajima Limestone as well as the estuarine nature of the deposits of the Mugher Mudstone in the area indicate the bone bed is in the lower part of the formation.

Getaneh (1991) considered the lower limit of the age of the Mugher Mudstone to be early Kimmeridgian based on its stratigraphic relationship with the underlying Oxfordian to Kimmeridgian Lagijima Limestone. Goodwin et al. (1999) reported discovery of a latest Jurassic (Tithonian) palynoflora in strata near the base of the Mugher Mudstone in the Aleltu River valley (Fig. 1). The Aleltu locality is approximately 50 km southwest of the Jema River, but there are no obvious differences in the large scale stratigraphy of the Mugher Mudstone exposed in the two areas. Fragmentary shark and crocodilian remains found stratigraphically above the palynofloral locality appear to represent forms discovered in exposures of the Mugher Mudstone in the valley of the Jema River. None of the currently identified vertebrates from the Mugher Mudstone permit a greater refinement of the biostratigraphic age determination beyond Late Jurassic. The minimum age of the formation is not constrained as biostratigraphically significant fossils have yet to be discovered in the overlying Debre Libanos Sandstone (Goodwin et al. 1999). Schmidt and Werner (1998) argued that vertebrate fossil localities in the Mugher Mudstone exposed in the Jema River valley were Early Cretaceous in age, but their age assignment is neither confirmed nor supported by independent criteria (e.g., palynomorphs) or by the known biostratigraphic ranges of the vertebrates (Goodwin et al. 1999).

In 1998 a geological hand sample (total ca. 4 kg) was collected from the 1–2 cm thick bone bed in the Mugher Mudstone. The collecting locality is recorded as Ethiopian National Museum locality JEM-5 and UCMP locality V98113. Precise locality data are on file at these museums. In the laboratory these samples were disaggregated in 10% acetic acid and then washed through in a 20 mesh screen. The retained residues, which were sorted under a stereomicroscope, included identifiable remains of chondrichthyans, osteichthyans, dipnoans, and small theropods as well as the fragment of a mammalian tooth described here. This fragment was scanned at the High-Resolution X-ray Computed Tomography Facility of the University of Texas, Austin and a three-dimensional digital cast (UCMP 179500) was produced. This digital cast is illustrated in Fig. 2. All fossils are catalogued in the collections of the National Museum of Ethiopia, Addis Ababa.

Institutional abbreviations.—CAM, prefix to catalogue numbers of Cretaceous mammalian specimens discovered in the Republic of Cameroon (see Brunet et al. 1990); JEM, Jema River, prefix for specimen and locality numbers, National Museum of Ethiopia, Addis Ababa; Loc. V, prefix for collecting area designation in University of California Museum of Paleontology locality catalog; UCMP, University of California Museum of Paleontology.

Systematic paleontology

Mammalia Linnaeus, 1758

Zatheria McKenna, 1975

?"Peramura" McKenna, 1975

Genus and species indet.

Description.—JEM-5/21 (Fig. 2) is a fragment of the trigonid of a left molariform tooth (mesiodistal length = 1.1 mm; labiolingual width = 0.8 mm). The base of the trigonid is missing thus exposing walls of the pulp cavity. Of the trigonid cusps the highest is the semi-conical protoconid that, in horizontal cross-section, is distinctly convex labially but less so lingually. Its apex has been blunted by breakage. A distinct fracture separates the protoconid from the rest of the trigonid. The most probable mesiodistal orientation of the fragment suggests that the metaconid was situated directly lingual to the protoconid. The metaconid is approximately half the height of the protoconid and conical in shape. Its apex is modified by a labially sloping wear facet. The paraconid is lower than the metaconid, less conical, and its apex is blunted by a mesially facing wear facet producing a chisel-like ridge. Distinct ridges extending from the apex of the paraconid to the bases of the protoconid and metaconid encircle the trigonid basin. The angle formed by the paracristid and protocristid is ca. 50°. Close to the paraconid a very small cusp-like expansion is present on the paracristid. At the mesial end of the crown a distinct anterolingual basal cusp (cusp *e*) is present below the paraconid. Although a recognizable wear facet is not present, the distal face of the preserved part of the trigonid is relatively flat. The protocristid forms a carnassial-like notch suggesting this crest functioned as a shearing blade. There is no evidence of

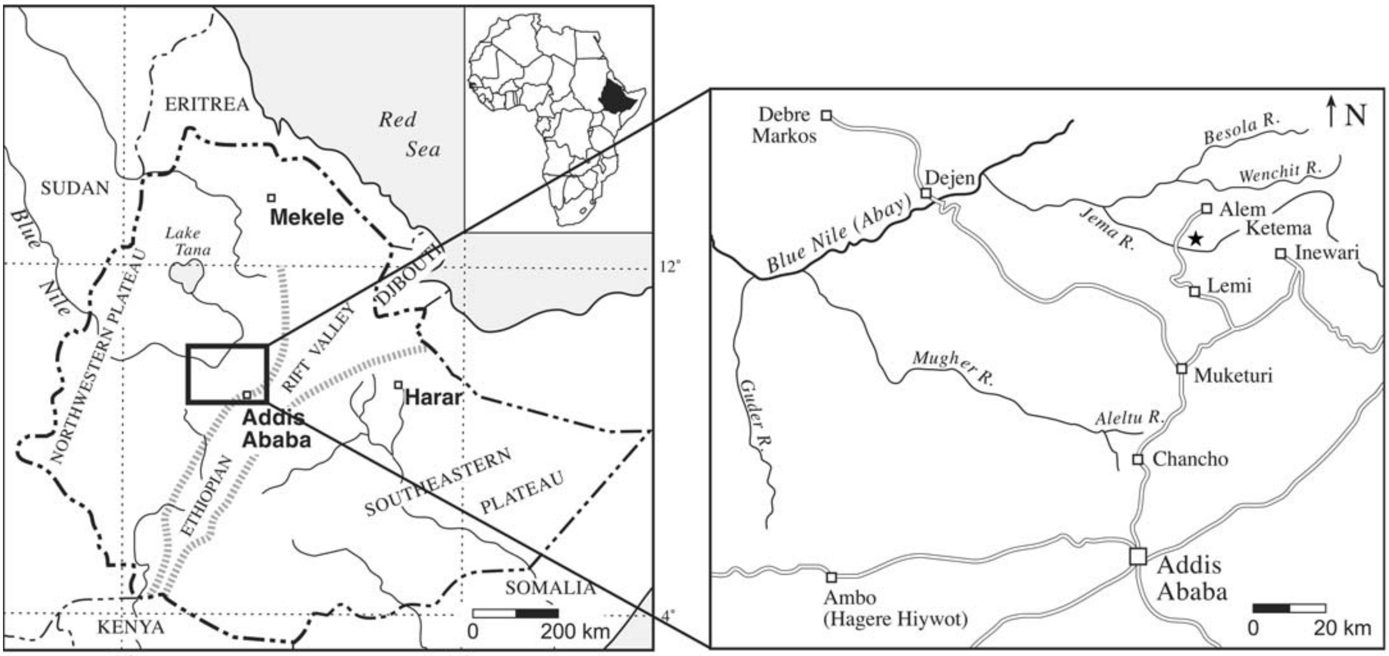

Fig. 1. Locality maps, Jema River valley, Ethiopia. Collecting locality marked with an asterisk. Modified from Goodwin et al. (1999).

the presence of a distal metacristid. If the distal face of the trigonid was a shearing blade a distal cingulid or talonid probably would have been present, but not enough of the tooth is preserved to document the morphology of this part of the crown.

Discussion

The triangular symmetry of three distinct cusps united by connecting ridges supports identification of JEM-5/21 as a fragment of the trigonid of a mammalian lower molariform that might represent almost any of the panoply of clades included in the Holotheria by McKenna and Bell (1997). The tempo of discoveries of new Late Jurassic and Early Cretaceous mammals, particularly on former Gondwanan continents, gives no sign of decreasing and significantly emphasizes the incompleteness of our current knowledge of their evolutionary diversification (note Krause et al. 2003 and Anantharaman et al. 2006 for examples). In the following sections brief comparisons are made with groups of mammals that either are currently documented or might be reasonably expected to have been present in Africa in the Late Jurassic and/or Early Cretaceous. We readily admit that JEM-5/21 could represent a hitherto unknown clade of mammals with either a pretribosphenic or tribosphenic dentition and stress that additional material is needed to decipher its phylogenetic affinities.

The kuehneotheriids are the most primitive known mammals (or mammaliaforms of some classifications). Their lower molars represent a pretribosphenic grade of dental evolution in that they have only a single distal basal cusp and lack a basined talonid (Gill 2004). Currently known records of the kuehneotheriids are older (Late Triassic to Early Jurassic) than the occurrence of JEM-5/21 but have a biogeographic range encompassing Western Europe, Greenland, and India (*Kotatherium*) suggesting a global (Pangean) distribution. Referral of JEM-5/21 to the Kuehneotheriidae appears improbable in that lower molariforms of the latter are characterized by the presence of both anterolingual and anterolabial basal cusps (cusps e and f) while only an anterolingual cusp is present in JEM-5/21. Unlike JEM-5/21 the angle formed by the paracristid and protocristid of kuehneotheriid trigonids tends to be obtuse with the metaconid situated distal to the protoconid and a metaconid that is typically lower than the paraconid. A crest from the metaconid, the metacristid, extends to the most distal cusp of the crown. In sum, these differences in dental morphology argue against referral of JEM-5/21 to the Kuehneotheriidae. In this and subsequent comparisons with pretribosphenic or tribosphenic dentitions it must be stressed that the few available morphological characters preserved in JEM-5/21 are known to vary along the dental arcade of many Mesozoic mammals. As such morphological differences might simply reflect positional differences within the dental arcade.

Luo et al. (2001) hypothesized a dual origin of the tribosphenic grade of molar morphology with distinct Gondwanan (Australosphenida) and Laurasian (Boreosphenida) radiations. Currently *Ambondro* is recognized as the oldest (Middle Jurassic, Madagascar) known australosphenidan. *Asfaltomylos* (Middle or Late Jurassic, Argentina) and several taxa (e.g., *Ausktribosphenos*, *Bishops*, *Steropodon*) from the Early Cretaceous of Australia indicate a broad Gond-

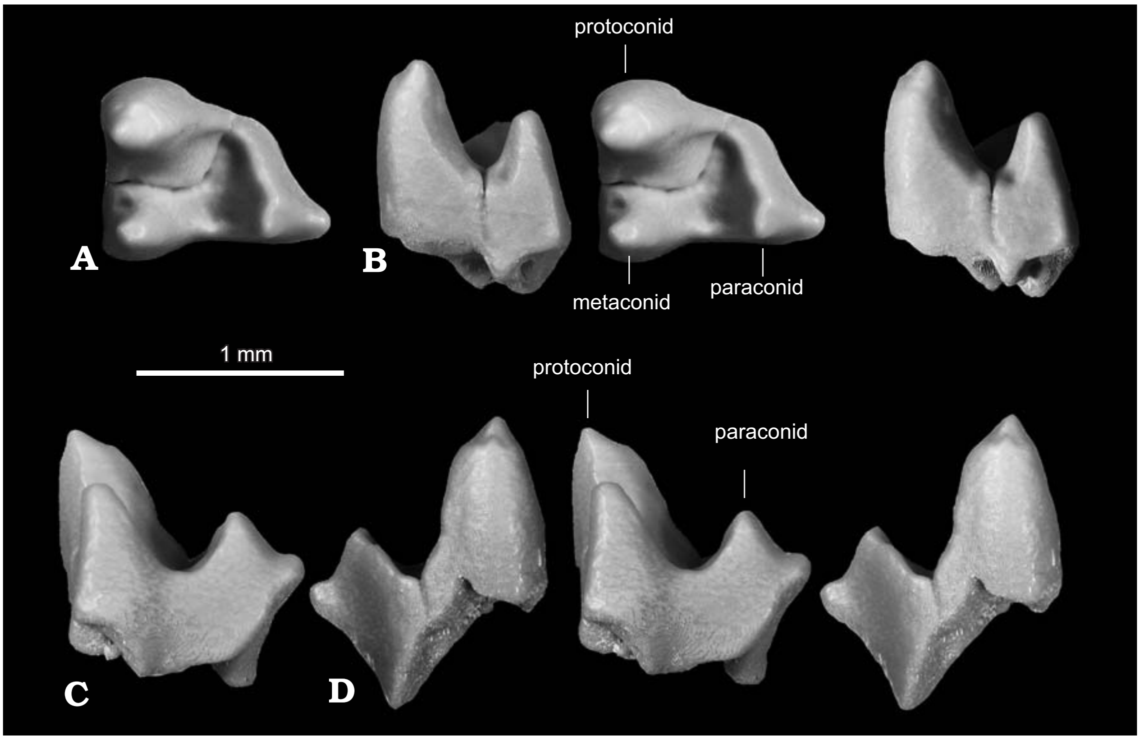

Fig. 2. ?"Peramura", genus and species indet., trigonid of left molariform tooth (JEM-5/21); Latest Jurassic Mugher Mudstone, valley of Jema River, Ethiopia. Stereo-photographs of the digital cast (UCMP 179500) produced at the High-Resolution X-ray Computed Tomography Facility of the University of Texas at Austin, Austin, Texas, USA; in occlusal (**A**), distal (**B**), lingual (**C**), and labial (**D**) views.

wanan distribution of australosphenidans (see Kielan-Jaworowska et al. 2004).

In comparison to most australosphenidans (the order Shuotheridia excluded) JEM-5/21 differs in the absence of a basal cingulid that wraps around the mesial side of the trigonid, one of the major australosphenidan apomorphies (Luo et al. 2001). In *Asfaltomylos*, however, this cingulid is weak and interrupted (Martin and Rauhut 2005). JEM-5 /21 also differs from most australosphenidans in having a broadly open (lingually) trigonid basin. The paracristid–protocristid angle of lower molars of *Asfaltomylos* range from obtuse (m1) to acute, ca. 80° (m2–3), a range interpreted as the primitive condition for australosphenidans (Martin and Rauhut 2005). No evidence of the presence of a talonid is preserved in JEM-5/21, however, if one was present the difference in heights of the trigonid and talonid would have been greater than expected for an australosphenidan lower molar. Because of breakage it cannot be determined how far a cristid obliqua or similar crest linking the metaconid with the distal end of the crown extended up the distal face of the trigonid. Together these differences suggest that JEM-5/21 does not document the presence of a derived australosphenidan in the Late Jurassic of Ethiopia. Morphologically it most closely resembles the molars of the primitive australosphenidan *Asfaltomylos* but the similarities may represent the retention of primitive characters.

In the cladistic classification adopted by Kielan-Jaworowska et al. (2004) the clade Trechnotheria includes the common ancestor of the Spalacotheriidae, the crown group Theria, and all its descendants. This group includes both mammals with pretribosphenic dentitions and the boreosphenidans, which primitively are characterized by tribosphenic dentitions. Our comparisons are focused on trechnotherians currently known to be present in Late Jurassic or Early Cretaceous faunas in Africa.

Approximately 2,500 km south of the Mugher Mudstone locality a recent research project focused on Late Jurassic vertebrate occurrences at Tendaguru, Tanzania, has significantly added to the documented taxonomic diversity of its local faunas (see Heinrich 2001). These local faunas appear to be approximately contemporaneous with those of the Mugher Mudstone (Goodwin et al. 1999). Prior to the new project the only mammal known from Tendaguru was the eupantothere *Brancatherulum tendagurense*, which was typified on an edentulous dentary from the Upper Saurian Bed. Three new taxa—a haramiyid, a eutriconodontan, and a possible peramurid—have now been recovered from the Middle Saurian Bed (Heinrich 1998, 1999).

The possible peramurid, *Tendagurutherium dietrichi*, found at Tendagaru is known from a fragment of lower jaw containing the damaged distal molar (Heinrich 1998). Its trigonid exhibits some similarities to JEM-5/21, which is slightly larger. On both the protoconid is the highest cusp, but in *Tendagurutherium* the paraconid and metaconid appear to have been of subequal height. In *Tendagurutherium* the metaconid is situated slightly distal to the paraconid and the angle formed by the paracristid and protocristid is somewhat greater (ca. 65°) than that of JEM-5/21. The most conspicuous differences between the two teeth are in the morphology of the mesial ends of their crowns. On JEM-5/21 a large, salient anterolingual cusp (cusp e) is present below the paraconid; a cusp f is not present. In contrast the mesial end of *Tendagurutherium* has a distinct basal crest that ends in a pronounced anterolabial cusp (cusp f). A smaller, salient anterolingual cusp (cusp e) is present below the paraconid and is higher than cusp f from which it is distinctly separated. The distal end of the molar of *Tendagurutherium* is damaged but appears to have consisted of a crest ending distally in a single cusp (?hypoconulid). On the distal slope of the metaconid a weak crest was interpreted by Heinrich (1998) as marking the edge of a wear facet and not a distal metacristid.

A second significant group of fossiliferous deposits of Cretaceous (possibly Early Cretaceous) age is exposed in the Songwe Valley, Mbeya Region, southwestern Tanzania (O'Connor et al. 2006) and has yielded the lower jaw of what appears to represent a sudamericid gondwanatherian (Krause et al. 2003). Reference of JEM-5/21 to this clade, which is characterized by highly derived, hypsodont molars, can be rejected.

Early Cretaceous (Barremian) mammalian fossils have been found in the Koum Basin, Cameroon, approximately 2,500 km west of the Mugher Mudstone localities (Jacobs et al. 1988; Brunet et al. 1990). The sample includes a few isolated teeth and an edentulous jaw. The only mammal to be formally named, *Abelodon abeli,* is typified on an isolated upper molar and has been referred to the Peramuridae. A peramurid lower molar, CAM 283, discovered at the same locality was referred to *Abelodon.* It differs from JEM-5/21 in that its trigonid cusps are lower and not as conical or distinct. Its paraconid is higher than the metaconid and the angle formed by the paracristid and protocristid is larger (ca. 100°). It lacks a labial crest closing off the trigonid basin. Illustrations of the specimen (Brunet et al. 1990) suggest the presence of very small labial and lingual basal cusps on the mesial end of the crown, but they are not specifically mentioned in the description. Reference of JEM-5/21 to *Abelodon abeli* appears unlikely.

The Early Cretaceous (Berriasian) fauna found in the Anoual syncline, Morocco, approximately 5,000 km northwest of the Mugher Mudstone localities, is taxonomically the most diverse African Mesozoic fauna with records of at least 15 mammalian taxa (see Sigogneau-Russell et al. 1998, and Kielan-Jaworowska et al. 2004). Of these the following taxa have molars characterized by triangular symmetry: possible "symmetrodontans" of uncertain affinity—*Atlasodon*, *Microderson*, and *Thereuodon*; the dryolestidian donodontid—*Donodon*; zatherians of uncertain affinity— *Afriquiamus*, *Magnimus*, and *Minimus*; a peramurid—*Peramus* sp.; and "tribotherians" (stem boreosphenidans)—*Tribotherium* and *Hypomylos*.

Direct comparisons of JEM-5/21 can be made with only a few of the Anoual taxa. The lower molariforms of the primitive "symmetrodontans" *Atlasodon* and *Microderson* have yet to be recognized and described. Martin (1999, 2002) argued that the teeth of *Thereuodon* are deciduous posterior upper premolars most likely from the dentitions of "eupantotherians". Their lower counterparts have yet to be described, but it would be expected that they would have trigonids longer relative to their width than is the case in JEM-5/21.

Donodon (Sigogneau-Russell 1991a) currently is tentatively referred to the "eupantotherian" order Dryolestida (Kielan-Jaworowska et al. 2004). In the circular outline of its trigonid, when viewed occlusally, and a metaconid that is distinctly smaller than the paraconid the lower molars of *Donodon* are distinctly different from JEM-5/21.

Of the zatherians of uncertain affinity only lower molars of *Magnimus* and *Minimus* have been recognized and described. *Magnimus* (Signogneau-Russell 1999) differs from JEM-5/21 in its distinctly labiolingually compressed trigonid. Also the metaconid is approximately the same height as the paraconid, and the angle formed by the paracristid and protocristid is obtuse. A metacristid extends from the metaconid to the single cusp on the small but basined talonid. Resembling JEM-5/21 a prominent basal anterolingual cusp (cusp e) is present below the paraconid. The lower molars of *Minimus* (Sigogneau-Russell 1999) differ from those of *Magnimus* in having the relatively broader (labiolingually) trigonid, but one that is not as broad as the trigonid of JEM-5/21. Unlike JEM-5/21 the paraconid of *Minimus* is distinctly taller than the metaconid, a lingual basal cingulid extends from the anterolingual cusp (cusp e) toward the base of the metaconid, and an anterolabial cusp (cusp f) as well as a short labial basal cingulid are present. Also, the metaconid is distal to the protoconid and a distal metacristid extends from its apex toward the trenchant talonid. These differences argue against reference of JEM-5/21 to either *Magnimus* or *Minimus*.

Sigogneau-Russell (1999) described what she interpreted to be an upper premolar of a species of *Peramus*. Lower molars from Morocco referable to this taxon have yet to be identified. The lower molariforms of *Peramus tenuirostris* from England, identified as p5 and m1–m3 following McKenna (1975), document morphological variation along the dental arcade (see Clemens and Mills 1971). The trigonid of JEM-5/21 differs from those of the p5 and molars of *P. tenuirostris* in several ways that argue against its reference to this genus. The p5 of *P. tenuirostris* lacks a paraconid and, at best, only a small cusp is present in the position of a metaconid. On m1 the paraconid is higher than the metaconid. The difference in the heights of these cusps is less on m2 and they are subequal on m3. The angle between the paracristid and protocristid varies from obtuse on m1 to acute on m2–3, but the metaconid is consistently situated distal to the significantly higher protoconid. The mesial surface of p5 carries an anterolingual basal cusp (cusp e) and an anterolabial cingulid. On all the molars both anterolingual and anterolabial cusps (cusps e and f) as well as distal metacristids appear to have been present.

Finally, among the mammals from the Anoual syncline comparisons were made with the "tribotherians" (stem boreosphenidans) *Tribotherium* and *Hypomylos*. The single species of *Tribotherium* is typified on an upper molar, but lower molars have been tentatively referred to this taxon (Sigogneau-Russell 1991b). The currently recognized species of *Hypomylos* are typified on lower molars [*H. phelizoni* (Sigogneau-Russell 1992), *H. micros,* and ?*H.* sp. (Sigogneau-Russell 1995)]. Resembling JEM-5/21 on the lower molars of both genera the paraconids are distinctly smaller than the metaconids, but the differences in size of these cusps are at least as great as or greater. Unlike JEM-5/21 the angles formed by the paracristids and protocristids of the trigonids of *Hypomylos* and *Tribotherium* are obtuse with the metaconid positioned distal to the protoconid. At the mesial end of the crown only a small anterolabial cusp (cusp f) is developed in *H. phelizoni*, *H. micros,* and the lower molar tentatively referred to *Tribotherium.* Mesial basal cusps are lacking in ?*H.* sp. Unlike JEM-5/21, the lower molars of *H. phelizoni*, *H. micros*, and the lower molar tentatively referred to *Tribotherium* have a distinct distal metacristid. These differences argue against reference of JEM-5/21 to either *Tribotherium* or *Hypomylos.*

Conclusions

JEM-5/21 preserves a few tantalizing characters suggesting it documents the presence of a mammal with a dentition at either an advanced pretribosphenic or primitive tribosphenic grade of evolution. Comparisons with lower molariforms of Late Jurassic and Early Cretaceous mammals currently known in other African faunas revealed some similarities, primarily in primitive characters, but no bases for positive identification. It must be stressed that most currently known African mammals of this age are represented by isolated teeth that provide minimal information on morphological variation along the dental arcade. The morphological differences exhibited by JEM-5/21 might reflect hitherto undocumented variation within one of these species. Given the rudimentary state of knowledge of Late Jurassic and Early Cretaceous African mammals it is also quite possible that JEM-5/21 represents a previously unknown group of mammals.

At the moment, excluding the australosphenidan *Ambondro* from Middle Jurassic deposits in Madagascar, JEM-5/21 and *Tendagurutherium* provide the oldest known African records of mammals with the cusps of the trigonid organized in a triangular pattern. Mammals referred to or tentatively allied with the “peramurans” (the former order Peramura McKenna, 1975) have been reported from African Late Jurassic or Early Cretaceous faunas in Tanzania, Cameroon, and possibly Morocco. The geographic proximity and approximate contemporaneous age of the fossiliferous deposits in Ethiopia and Tanzania provide additional circumstantial evidence suggesting that JEM-5/21 might represent a “peramuran” allied to *Tendagurutherium,* which is known from only a fragment of a dentary containing the last molar. As noted above the morphological differences distinguishing the trigonids of JEM-5/21 and *Tendagurutherium* are not great and might simply reflect differences in the position in the dental arcade. What remains of the damaged talonid of the last molar of *Tendagurutherium* suggests that it consisted of a trenchant crest and lacked a basin. Loss of the distal end of JEM-5/21 has severely constrained comparisons with *Tendagurutherium* and other pretribosphenic and tribosphenic mammals. The apparently transverse (labiolingual) orientation of the protocristid of JEM-5/21 and lack of evidence of a distal metacristid are considered derived characters suggesting that a distinct basal cingulid or a talonid, which might have been basined, was present. Although not discounting the possibility, reference of JEM-5/21 to *Tendagurutherium* would be premature and not supported by diagnostic apomorphic characters. Until more material is discovered, we feel that JEM-5/21 should be tentatively identified as a member of the “Peramura”, genus and species indeterminate.

The current sample of the Moroccan, Early Cretaceous (Berriasian) mammalian fauna was derived from sorting about two-thirds of the residues remaining after acid treatment of approximately 700 kg of a “…micro-breccia of bones and fish scales…” (Sigogneau-Russell et al. 1998: 177). JEM-5/21 was discovered from processing a small (ca. 4 kg) geological hand sample of a similar deposit. In light of the successes in recovery of the remains of mammals and other microfossils from the Moroccan deposit and other Mesozoic bone beds the possibility of obtaining more specimens of mammals from the Mugher Mudstone bone bed must be tested. Only additional material will provide the information necessary to evaluate the working hypothesis of possible “peramuran” phylogenetic relationships of JEM-5/21 advanced here.

Acknowledgments

We thank our colleagues at the National Museum of Ethiopia and Jara Haile Mariam, Head, the Authority for Research and Conservation of Cultural Heritage of the Ministry of Youth, Sports, and Culture and his staff for their continued support and cooperation. Financial support from UCMP; the National Science Foundation, Division of International Programs (Grant INT-9507819); Tapestry International Productions; and Leibovitz Productions is gratefully acknowledged. C.B.W. is grateful for additional support from the Providence College Committee to Aid Faculty Research. Our colleagues at the University of California, Berkeley, Tim White and the late F. Clark Howell, provided invaluable advice and support. We thank Yasmin Rahman (UCMP) who carefully sorted the material obtained from the geological hand sample and discovered JEM-5/21. The digital cast of this fragmentary tooth was produced at The High-Resolution X-ray Computed Tomography Facility at The University of Texas at Austin, which is supported by NSF Grant EAR-0345710. We also thank Patricia Holroyd (UCMP), who took the stereophotographs of the digital cast and David Smith (UCMP) who prepared Fig. 1. Louis Jacobs (Schuler Museum of Paleontology, Southern Methodist University, Dallas, Texas, USA), David Krause (Health Sciences Center, State University of New York, Stony Brook, New York, USA), and Patrick O’Connor (College of Osteopathic Medicine, Ohio University, Athens, Ohio, USA) provided very helpful reviews of a draft of this manuscript. This is UCMP contribution 1931.

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