

Online Supplementary Material related to *New middle Eocene proboscidean from Togo illuminates the early evolution of elephantiforms.*

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1. Biostratigraphic analyses based on planktonic foraminifera

A biostratigraphic study of the deposits cropping out in the Dagbati quarry was performed using planktonic foraminifera. Fourteen samples were collected in the different sedimentary facies of the section (see below Figure S1, and also Figure 1 in the main text).

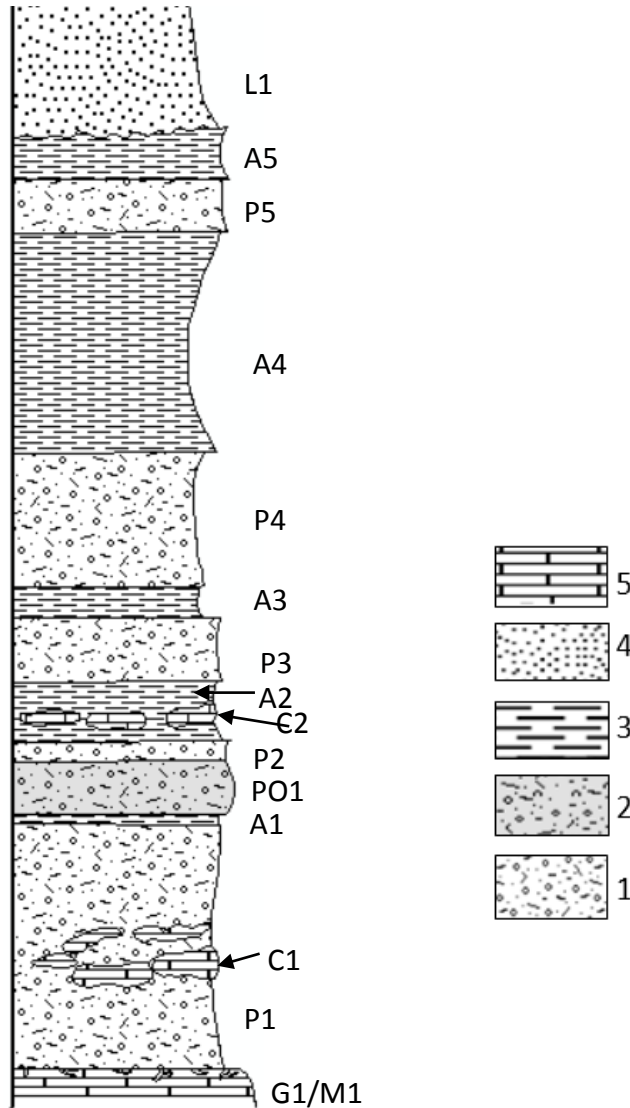


Figure S1 : Lithostratigraphy of the deposits recovered from the Dagbati Quarry with location of the studied samples for planktonic foraminiferal biostratigraphic analyses. 1, Phospharenite (P1, P2, P2, P4, P5); 2, Oxidized phosphate (PO1); 3, Claystone (A1, A2, A3, A4, A5); 4, Ferruginous duricrust (L1); 5, Limestone (C1-C2, G1/M1).

The samples were washed over a 65 μm screen. The residues were dry-sieved and the size fractions coarser than 150 μm were used for planktonic foraminiferal analyses. Our biostratigraphic analyses are based on a complete inventory of the identifiable planktonic

foraminiferal species (see below), following the taxonomic concepts and nomenclature of Pearson *et al.* [1]. The Eocene (E) zonal scheme and taxon ranges of Berggren and Pearson [2], applicable to the (sub)tropical latitudes of the world oceans and emended by Wade *et al.* [3], was used for this study.

Results

Most of the 14 samples yielded a microfauna dominated by benthic foraminifera, echinoids, and molluscs (bivalves and gastropods). Elasmobranch and osteichthyan remains are particularly abundant in all samples. The abundance and diversity of the planktonic foraminifera is low (samples M1 and P2) to very low (G1, P1, C1, A2, P3, A3, P4, P5) in 10 samples, and four samples were barren (C2, A4, A5, L1). Preservation of the planktonic foraminiferal shells is very poor in all samples that yielded planktonic foraminifera (the shells are recrystallized and have been worn out). Consequently, only a few specimens per sample could be identified at the species level.

Sample M1

Preservation: very poor. *Acarinina cuneicamerata* (Zone E6 to E9), *Acarinina bullbrooki* (Zone E7 to E11), *Acarinina mcgowrani* (Zone E7 to E13), *Acarinina praetopilensis* (Zone E7 to E12), *Acarinina primitiva* (Zone E6 to E13), *Morozovelloides crassatus* (Zone E8 to E13).

Sample G1

Preservation: very poor. *Subbotina yeguaensis* (Zone E7 to E16), *A. cuneicamerata* (Zone E6 to E9), *Acarinina collactea* (Zone E7 to E14).

Sample P1

Preservation: very poor. *Subbotina eocenica* (Zone E6 to Oligocene), *Subbotina yeguaensis* (Zone E7 to E16), *Turborotalia frontosa* (Zone E7 to E11).

Sample C1

Preservation: very poor. *Morozovelloides crassatus* (Zone E8 to E13), *A. praetopilensis* (Zone E7 to E12), *A. cuneicamerata* (Zone E6 to E9).

Sample P2

Preservation: very poor. *Parasubbotina varianta* (Paleocene to Zone E10), *Globigerinatheka* sp. (Zone E8 to E16), *Turborotalita carcoselleensis* (Zone E9 to E14), *T. frontosa* (Zone E7 to E11), *Turborotalia carcosellensis* (Zone E9 to E14), *Globorotaloides quadrocameratus*, *Paraglobototalia griffinoides*?, *Parasubbotina pseudowilsoni* (Zone E7 to E11), *A. cuneicamerata* (Zone E6 to E9), *A. collactea* (Zone E7 to E14), *A. bullbrooki* (Zone E7 to E11).

Sample A2

Preservation: very poor. *Acarinina* spp.

Sample C2

Barren.

Sample P3

Preservation: very poor. *Acarinina bullbrooki* (Zone E7 to E11), *A. primitiva* (Zone E6 to E13), *A. cuneicamerata* (Zone E6 to E9), *T. frontosa* (Zone E7 to E11).

Sample A3

Preservation: very poor. *Acarinina bullbrooki* (Zone E7 to E11), *A. cuneicamerata* (Zone E6 to E9), *T. frontosa* (Zone E7 to E11), *P. varianta* (Paleocene to Zone E10).

Sample P4

Preservation: very poor. *Acarinina cuneicamerata* (Zone E6 to E9), *T. frontosa* (Zone E7 to E11), *P. varianta* (Paleocene to Zone E10).

Sample A4

Barren.

Sample P5

Preservation: very poor. *Acarinina bullbrooki* (Zone E7 to E11), *A. cuneicamerata* (Zone E6 to E9), *T. frontosa* (Zone E7 to E11), *P. varianta* (Paleocene to Zone E10).

Sample A5

Barren.

Sample L1

Barren.

Interpretation

Because of the very poor preservation of the planktonic foraminifera found in the deposits of the Dagbati quarry, the biostratigraphic interpretation below is based on a low number of specimens per sample that could be identified at the species level. This interpretation should also be considered cautiously because apart *Turborotalia frontosa*, the classical index species that delineate the Middle Eocene (sub)tropical zonal schemes are absent from the studied samples.

Based on the co-occurrence of *Acarinina cuneicamerata* and *Morozovelloides crassatus* in samples M1 and C1, the base of the section points to planktonic foraminiferal Zones E8 (*partim*) or E9 (*partim*) of Berggren and Pearson [2] and deposited during the middle Lutetian, probably after ~48 Ma and before ~44.5 Ma. This zonal interval correlates with

Zones E7b (*partim*) and E8 of Wade *et al.* [3] and is further supported by the occurrence of *T. frontosa* from sample P1 and upward.

The occurrences of *Globigerinatheka* sp. and *Turborotalita carcoselleensis* in sample P2, associated with the occurrence of *A. cuneicamerata* in the same sample and up to sample P5, suggest that the middle part of the section points to Zone E9 (*partim*) of Pearson and Berggren (2005) and Zone E8 of Wade *et al.* [3]. This middle part of the section deposited during the middle Lutetian, probably after ~45.8 Ma and before ~44.5 Ma.

The age of the upper part of the section cannot be estimated.

The estimated ages proposed here are calibrated against the magnetobiochronology of Berggren *et al.* [4]. The bio-events used have not been calibrated against the GPTS 2012 but the zonal interval recovered in the section corresponds to the ~46.5~44.0 Ma time interval following the time scale of Gradstein *et al.* [5].

2. Phylogenetic analysis – Character modifications, character list, results

Matrix and character modifications

In order to take into account our morphological observations, and to highlight the anatomical diversity of the proboscidean lower molars, we have been led to modify five phylogenetic characters from [6] and add one character modified from Gheerbrant (2009). These modifications are explained below.

Character #121 (in [6]), describing the orientation of the cristid obliqua, was removed since we could not confidently reproduce the coding procedure. It was then replaced by a new character (#115 in our matrix), which simply describes the presence/absence of this cristid.

Considering the difficulties to accurately define the tritolophid, we decided to remove characters #122 and #123 (in [6]), which describe the presence/absence of the tritolophid of the first and second lower molars, respectively. We then decomposed the morphological variation of the talonid into a single new character (#116 in our matrix), which describes the development and position of the postentoconulid.

Characters #119 and #120 (in [6]), which respectively described the presence/absence and the shape of the pre-entocristid, were merged into a single new character (#112 in our matrix) to avoid information redundancy.

Furthermore, character #22 (in [7]) was added to highlight the lower molar pattern diversity in early proboscideans and was slightly modified to fit the current taxonomic sample by removing the first character state “molar pattern tribosphenic, with high trigonid and sharp cusps”.

In addition, ten phylogenetic characters from [6] have been removed: Character #75, describing the orientation of the crista obliqua, was removed since it corresponds to a dependent morphological character, inapplicable in most taxa (following [8], the crista obliqua is defined as the association of the metaconule and the postprotocrista). Characters #14, #51, #88, #92, #99, #107, #170 and #194 were removed since they are parsimony-uninformative, as long with character #171 that is constant considering the current taxonomic sample.

In total, we added seven new characters, including two new characters on the enamel microstructure (following [9]):

*Character 112** – M_{1-2} = Preentocristid present and straight (0); present and curved (1); absent (2)

*Character 114** – M_{1-2} = Mesoconid absent (0); present (1)

*Character 115** – M_{1-2} = Cristid obliqua present (0); absent (1)

*Character 116** – M_{1-2} = Postentoconulid absent (0); present, reduced and close to the entoconid (1); present, less developed than the hypoconulid, and distant from the entoconid (2); present, at least as developed as the hypoconulid, distant from the entoconid, and associated to a distal cingulum (3)

*Character 117** – M_{1-2} = Hypoconulid absent or reduced on the cingulid (0); large and isolated on the cingulid (1).

*Character 125** – Enamel microstructure: Radial enamel (0) Radial enamel present through enamel layer; (1) limited to the outer zone; (2) Absent.

*Character 126** – Enamel microstructure: (0) weakly defined Hunter-Schreger-Bands-(HSB); (1) well defined HSB; (2) 3D enamel limited to inner zone and HSB limited to the median zone; (3) 3D enamel through enamel layer.

Character list

SKULL

1. Frontal:

Character 001 Delmer (2009)

- 0. in contact with the premaxillary
- 1. not in contact with the premaxillary

2. Posterior extension of the nares:

Character 002 Delmer (2009)

- 0. weak
- 1. strong

3. Opening of the orbit:

Character 003 Delmer (2009)

- 0. into the jugal
- 1. into the maxillary

4. Position of the orbit:

Character 004 Delmer (2009)

- 0. above the molars
- 1. above the premolars
- 2. in front of the premolars

5. Processus orbitalis of the palatine:

Character 005 Delmer (2009)

- 0. present
- 1. absent

6. Jugal:

Character 006 Delmer (2009)

- 0. extends to the anterior border of the glenoid fossa
- 1. extends to the rear border of the glenoid fossa

7. External auditory meatus:

Character 007 Delmer (2009)

- 0. low
- 1. high

8. External auditory meatus:

Character 008 Delmer (2009)

- 0. open
- 1. closed ventrally by post-tympanic and postglenoid parts of the squamosal

9. Squamosal:

Character 009 Delmer (2009)

- 0. cerebral part not inflated
- 1. cerebral part inflated dorsally

10. Parietal:

Character 010 Delmer (2009)

- 0. in contact with the alisphenoid
- 1. not in contact with the alisphenoid

11. Petrosal bone:

Character 011 Delmer (2009)

- 0. pars mastoidea smaller than the pars cochlearis
- 1. pars mastoidea larger than the pars cochlearis

12. Foramen ovale:

Character 012 Delmer (2009)

- 0. foramen ovale separated from foramen lacerum medium
- 1. confluent (= foramen metoticum)

13. Pneumatisation:

Character 013 Delmer (2009)

- 0. weak
- 1. medium

2. significant
- 14. Postorbital process of the frontal:**
Character 015 Delmer (2009)
0. massive
1. small
- 15. Maxillary processus pyramidalis - anterior extension:**
Character 016 Delmer (2009)
0. reduced
1. weakly extended anteriorly
2. strongly extended anteriorly
- 16. Maxillary processus pyramidalis - posterior extension:**
Character 017 Delmer (2009)
0. to the level of M3/
1. to the level of M2/-M3/
2. to the level of P4/-M1/
- 17. Zygomatic arches:**
Character 018 Delmer (2009)
0. weakly divergent
1. strongly divergent
- 18. Position of the postglenoid foramen:**
Character 019 Delmer (2009)
0. lateral
1. weakly medial
2. strongly medial (i.e., homologous of the canal temporalis)
- 19. Condylar foramina:**
Character 020 Delmer (2009)
0. present
1. absent
- 20. Zygomatic extension of the squamosal:**
Character 021 Delmer (2009)
0. low
1. high

MANDIBLE

- 21. Mandibular symphysis:**
Character 022 Delmer (2009)
0. short
1. lengthened
- 22. Origin of the vertical ramus:**

Character 023 Delmer (2009)

- 0. behind the M/3
- 1. at the level of M/3
- 2. between M/2 and M/3
- 3. at the level of M/2

23. Angle between vertical and horizontal rami:

Character 024 Delmer (2009)

- 0. obtuse
- 1. sharp
- 2. at 90°

24. Coronoid process of the vertical ramus:

Character 025 Delmer (2009)

- 0. high
- 1. low above the teeth

25. Coronoid process of the vertical ramus:

Character 026 Delmer (2009)

- 0. higher than the condyle
- 1. lower than the condyle

26. Angular process:

Character 027 Delmer (2009)

- 0. very massive
- 1. massive
- 2. small

27. Symphysis fusion:

Character 028 Delmer (2009)

- 0. not fused
- 1. fused

28. Posterior extension of the symphysis:

Character 029 Delmer (2009)

- 0. in front of P/1
- 1. at the level of P/2
- 2. between P/2 and P/3
- 3. between P/3 and P/4
- 4. between P/4 and M/1
- 5. clearly in front of the premolars

29. Lateral thickening of the horizontal ramus:

Character 030 Delmer (2009)

- 0. poor
- 1. significant, starting at the level of the premolars
- 2. significant, starting at the level of the symphysis

30. Coronoid foramen:

Character 031 Delmer (2009)

- 0. absent
- 1. present

31. Diastema between the jugal and anterior teeth:

Character 032 Delmer (2009)

- 0. reduced to absent
- 1. significant

TEETH

32. M1/1 size:

Character 033 Delmer (2009)

- 0. much shorter than M2/2 (30% or more)
- 1. slightly shorter than M2/2 (10% or less)
- 2. of the same length as M2/2

33. Incisor growth:

Character 034 Delmer (2009)

- 0. not evergrowing
- 1. evergrowing

34. I1/:

Character 035 Delmer (2009)

- 0. present
- 1. absent

35. I3/:

Character 036 Delmer (2009)

- 0. present
- 1. absent

36. Upper incisors:

Character 037 Delmer (2009)

- 0. of similar size
- 1. I2/ significantly larger than the others

37. Upper canine:

Character 038 Delmer (2009)

- 0. present
- 1. absent

38. Lower incisors:

Character 039 Delmer (2009)

- 0. upwards vertically oriented
- 1. proclives
- 2. downward vertically oriented

39. I/1:

Character 040 Delmer (2009)

- 0. with enamel covering the whole crown
- 1. with enamel covering half of the crown
- 2. without enamel

40. I/2:

Character 041 Delmer (2009)

- 0. present
- 1. absent

41. I/3:

Character 042 Delmer (2009)

- 0. present
- 1. absent

42. Lower incisors size:

Character 043 Delmer (2009)

- 0. of similar size
- 1. I/1 significantly larger than the others
- 2. I/2 significantly larger than the others

43. Lower canine:

Character 044 Delmer (2009)

- 0. present
- 1. absent

44. P1/:

Character 045 Delmer (2009)

- 0. present
- 1. absent

45. P2/:

Character 046 Delmer (2009)

- 0. reduced
- 1. inflated and caniniform

46. P2/ parasyle:

Character 047 Delmer (2009)

- 0. absent
- 1. present

47. Shape of P2/ in occlusal view:

Character 048 Delmer (2009)

- 0. oval, longer than wide
- 1. wider posteriorly

48. P2/ protocone:

Character 049 Delmer (2009)

- 0. absent
- 1. present

49. **P2/ metacone:**
Character 050 Delmer (2009)
0. present
1. absent
50. **P2/ metastyle:**
Character 052 Delmer (2009)
0. absent
1. present
51. **P2/ lingual cingulum:**
Character 053 Delmer (2009)
0. absent
1. present
52. **P2/ mesial cingulum:**
Character 054 Delmer (2009)
0. present
1. absent
53. **P3-4/ mesial cingulum:**
Character 055 Delmer (2009)
0. present
1. absent
54. **P3/ parastyle:**
Character 056 Delmer (2009)
0. present
1. absent
55. **P3/ metacone:**
Character 057 Delmer (2009)
0. fused with the paracone
1. individualised from the paracone
56. **P3/ metastyle:**
Character 058 Delmer (2009)
0. absent
1. present
57. **P3/ hypocone:**
Character 059 Delmer (2009)
0. absent
1. present
58. **P3/ lingual cingulum:**
Character 060 Delmer (2009)
0. present
1. absent

- 59. P3/ lingual cingulum extension:**
Character 061 Delmer (2009)
0. incomplete
1. complete
- 60. P4/ paraconule:**
Character 062 Delmer (2009)
0. present
1. absent
- 61. P4/ metacone:**
Character 063 Delmer (2009)
0. massive and fused with the paracone
1. reduced
2. massive, forming an ectoloph with the paracone
3. massive and independent from the paracone
- 62. P4/ hypocone:**
Character 064 Delmer (2009)
0. absent
1. present
- 63. P4/ lingual cingulum:**
Character 065 Delmer (2009)
0. present
1. absent
- 64. P4/ lingual cingulum extension:**
Character 066 Delmer (2009)
0. incomplete
1. complete
- 65. P4/ mesial cingulum extension:**
Character 067 Delmer (2009)
0. complete
1. incomplete
- 66. M1-2/ parastyle :**
Character 068 Delmer (2009)
0. massive
1. reduced to absent
- 67. M1-2-3/ paraconule:**
Character 069 Delmer (2009)
0. present
1. absent
- 68. M1-2/ paraconule shape:**
Character 070 Delmer (2009)

- 0. individualised from the protoloph
 - 1. forming a massive crest on the anterior wall of the protoloph
- 69. M1-2/ metaconule:**
Character 071 Delmer (2009)
- 0. present
 - 1. absent
- 70. M1-2/ metaconule:**
Character 072 Delmer (2009)
- 0. individualised from the metaloph
 - 1. constituting a massive crest on the anterior wall of the metaloph
 - 2. reduced to a fine crest on the anterior wall of the metaloph
- 71. M1-2/ mesostyle:**
Character 073 Delmer (2009)
- 0. present
 - 1. absent
- 72. M1-2-3/ post-paracrista II:**
Character 074 Delmer (2009)
- 0. absent
 - 1. present
- 73. M1-2/ convolute:**
Character 076 Delmer (2009)
- 0. absent
 - 1. present
- 74. M1-2/ lingual cingulum:**
Character 077 Delmer (2009)
- 0. absent
 - 1. present
- 75. M1/ postentoconule:**
Character 078 Delmer (2009)
- 0. absent
 - 1. present
- 76. M1/ postentoconule shape:**
Character 079 Delmer (2009)
- 0. reduced, only defined by a small groove at the top of the distocrista
 - 1. well individualised from the hypocone
 - 2. independent from the hypocone
- 77. M1/ centrocrista:**
Character 080 Delmer (2009)
- 0. present
 - 1. absent

- 78. M1/ tritoloph:**
Character 081 Delmer (2009)
0. absent
1. present
- 79. M1/ mesial cingulum:**
Character 082 Delmer (2009)
0. present
1. absent
- 80. M2-3/ centrocrista:**
Character 083 Delmer (2009)
0. present
1. absent
- 81. M2-3/ tritoloph:**
Character 084 Delmer (2009)
0. absent
1. present
- 82. M2-3/ mesial cingulum:**
Character 085 Delmer (2009)
0. present
1. absent
- 83. M2/ postentoconule:**
Character 086 Delmer (2009)
0. absent
1. present
- 84. M2/ postentoconule shape:**
Character 087 Delmer (2009)
0. reduced, only defined by a small groove at the top of the distocrista
1. well individualised from the hypocone
2. independent from the hypocone
- 85. M3/ parastyle:**
Character 089 Delmer (2009)
0. reduced to absent
1. massive
- 86. M3/ paraconule:**
Character 090 Delmer (2009)
0. individualised from the protoloph
1. constituting a crest on the anterior wall of the loph
- 87. M3/ metaconule:**
Character 091 Delmer (2009)
0. present
1. absent

- 88. M3/ mesostyle:**
Character 093 Delmer (2009)
0. present
1. absent
- 89. M3/ metaloph:**
Character 094 Delmer (2009)
0. buccally displaced from the dental axis
1. in the dental axis
- 90. M3/ lingual cingulum:**
Character 095 Delmer (2009)
0. present
1. absent
- 91. P/1:**
Character 096 Delmer (2009)
0. present
1. absent
- 92. P/2:**
Character 097 Delmer (2009)
0. present
1. absent
- 93. P/2 occlusal:**
Character 098 Delmer (2009)
0. sub-oval
1. triangular
- 94. P/2 metaconid:**
Character 100 Delmer (2009)
0. absent
1. present
- 95. P/2 hypoconid:**
Character 101 Delmer (2009)
0. low, significantly lower than the protoconid
1. high, slightly lower than the protoconid
- 96. P/2-3-4 mesial cingulid:**
Character 102 Delmer (2009)
0. present
1. absent
- 97. P/3-4 protostylid:**
Character 103 Delmer (2009)
0. present
1. absent

- 98. P/3 occlusal:**
Character 104 Delmer (2009)
0. rectangular
1. square
- 99. P/3 paraconid:**
Character 105 Delmer (2009)
0. massive and anteriorly positioned
1. small, on the mesial side of the anterior face of the crown
- 100. P/3 metaconid:**
Character 106 Delmer (2009)
0. lower than the protoconid, posterior to it
1. as high as the protoconid, lingual to it
2. small, on the lingual side of the protoconid
3. reduced to a small enlargement of the postero-lingual wall of the protoconid
- 101. P/3 premetacristid:**
Character 108 Delmer (2009)
0. absent
1. present
- 102. P/4 occlusal:**
Character 109 Delmer (2009)
0. rectangular
1. square
- 103. P/4 paraconid:**
Character 110 Delmer (2009)
0. present
1. absent
- 104. P/4 paraconid size:**
Character 111 Delmer (2009)
0. massive, in anterior position
1. small, on the antero-vestibular side of the crown
- 105. P/4 accessory cusp in front of the metaconid:**
Character 112 Delmer (2009)
0. absent
1. present
- 106. P/4 entoconid:**
Character 113 Delmer (2009)
0. absent
1. present
- 107. P/4 premetacristid:**
Character 114 Delmer (2009)

- 0. absent
- 1. present

108. P/4 metalophid:

Character 115 Delmer (2009)

- 0. absent
- 1. present

109. M/1-2 accessory cusp in front of the metaconid:

Character 116 Delmer (2009)

- 0. absent
- 1. present

110. M/1-2-3 preprotocristid:

Character 117 Delmer (2009)

- 0. more massive than the premetacristid
- 1. as developed as the premetacristid

111. M/1-2 postmetacristid:

Character 118 Delmer (2009)

- 0. present
- 1. absent

112. M/1-2 preentocristid:

This study - modified from Character 119 and 120 Delmer (2009)

- 0. present and straight
- 1. present and curved
- 2. absent

113. M/2-3 buccal cingulid:

Character 124 Delmer (2009)

- 0. present
- 1. absent

114. M/1-2 mesoconid:

This study

- 0. absent
- 1. present

115. M/1-2 cristid obliqua:

This study - modified from Character 121 Delmer (2009)

- 0. present
- 1. absent

116. M/1-2 postentoconulid:

This study

- 0. absent
- 1. present, reduced and close to the entoconid
- 2. present, less developed than the hypoconulid, and distant from the entoconid

3. present, at least as developed as the hypoconulid, distant from the entoconid, and associated to a distal cingulid

117. M/1-2 hypoconulid:

This study

0. absent or reduced on the cingulid
1. large and isolated on the cingulid

118. M/1-2 molar pattern:

modified from Character 22 Gheerbrant (2009)

0. bunodont
1. bunodont-lophodont
2. lophodont
3. bunolophodont

119. M/3 accessory cusp on the premetacristid:

Character 125 Delmer (2009)

0. absent
1. present

120. M/3 postmetacristid :

Character 126 Delmer (2009)

0. present
1. absent

121. M/3 preentocristid:

Character 127 Delmer (2009)

0. present
1. absent

122. M/3 preentocristid shape:

Character 128 Delmer (2009)

0. straight
1. curved

123. M/3 talonid:

Character 129 Delmer (2009)

0. bearing only one cusp
1. bearing two cusps

124. M/3 talonid position:

Character 130 Delmer (2009)

0. buccally displaced
1. in the mesiodistal axis of the crown

125. Enamel microstructure Radial Enamel:

This study

0. Radial enamel present through enamel layer
1. Limited to the outer zone
2. Absent

126. Enamel microstructure HSB 3DE:

This study

- 0. Weakly defined Hunter-Schreger-Bands-(HSB)
- 1. Well defined HSB
- 2. 3D enamel limited to inner zone and HSB limited to the median zone
- 3. 3D enamel through enamel layer

POSTCRANIAL SKELETON

127. Atlas distal articular facet:

Character 131 Delmer (2009)

- 0. strongly posteriorly extended
- 1. weakly posteriorly extended

128. Atlas proximodistal flattening:

Character 132 Delmer (2009)

- 0. weak
- 1. significant

129. Atlas dorsoventral flattening:

Character 133 Delmer (2009)

- 0. weak
- 1. significant

130. Scapula supraglenoidal tubercle:

Character 134 Delmer (2009)

- 0. massive
- 1. very massive
- 2. reduced

131. Scapula scapular spine:

Character 135 Delmer (2009)

- 0. ventrally positioned
- 1. medially positioned
- 2. dorsally positioned

132. Scapula coracoid process:

Character 136 Delmer (2009)

- 0. massive, easily distinguishable from the supraglenoidal tubercle
- 1. reduced, weakly distinguishable from the supraglenoidal tubercle

133. Scapula glenoid cavity:

Character 137 Delmer (2009)

- 0. oval
- 1. rectangular

134. Humerus humeral crest:

Character 138 Delmer (2009)

- 0. weakly laterally extended
- 1. moderately laterally extended
- 2. significantly laterally extended

135. Humerus deltoid process:

Character 139 Delmer (2009)

- 0. medium-sized
- 1. reduced to a scar on the humeral crest

136. Humerus medial supracondylar crest:

Character 140 Delmer (2009)

- 0. strongly extended laterally
- 1. poorly extended laterally

137. Humerus entepicondylar foramen:

Character 141 Delmer (2009)

- 0. present
- 1. absent

138. Humerus lateral supracondylar crest:

Character 142 Delmer (2009)

- 0. low
- 1. high (1/4 of the length of the femur)

139. Humerus lateral supracondylar crest lateral extension:

Character 143 Delmer (2009)

- 0. not extended laterally
- 1. weakly extended laterally
- 2. strongly extended laterally

140. Humerus humeral trochlea:

Character 144 Delmer (2009)

- 0. strongly concave
- 1. almost flat

141. Humerus medial condyle of the trochlea:

Character 145 Delmer (2009)

- 0. narrower than the the lateral condyl
- 1. wider than the the lateral condyl

142. Humerus olecranon fossa:

Character 146 Delmer (2009)

- 0. deep
- 1. shallow

143. Humerus trochiter:

Character 147 Delmer (2009)

- 0. anterior to the head
- 1. lateral to the head

144. Ulna diaphysis:

Character 148 Delmer (2009)

- 0. anteromedially flattened
- 1. triangular to quadrangular

145. Ulna synovial groove:

Character 149 Delmer (2009)

- 0. present
- 1. absent

146. Ulna proximal surface for the radius:

Character 150 Delmer (2009)

- 0. rugose
- 1. smooth, with a well delimited facet

147. Ulna olecranon:

Character 151 Delmer (2009)

- 0. narrow
- 1. weakly enlarged posteriorly
- 2. significantly enlarged posteriorly

148. Ulna proximal extension:

Character 152 Delmer (2009)

- 0. extended proximally (of more than the height of the sigmoid cavity)
- 1. extended proximally (of less than the height of the sigmoid cavity)
- 2. not extended proximally (olecranon perpendicular to the sigmoid cavity)

149. Ulna lateral sigmoid facet:

Character 153 Delmer (2009)

- 0. reduced to absent
- 1. developed

150. Radius size:

Character 154 Delmer (2009)

- 0. as massive as the ulna
- 1. less massive than the ulna

151. Radius proximal extremity:

Character 155 Delmer (2009)

- 0. as wide as the proximal articulation of the ulna
- 1. narrower than the proximal articulation of the ulna

152. Lunar shape in proximal view:

Character 156 Delmer (2009)

- 0. rectangular, longer than wider
- 1. triangular

153. Lunar contact facet for the ulna:

Character 157 Delmer (2009)

- 0. absent
- 1. present

154. Lunar contact facet for a free central bone:

Character 158 Delmer (2009)

- 0. present
- 1. absent

155. Lunar contact facet for the unciform:

Character 159 Delmer (2009)

- 0. present
- 1. absent

156. Lunar contact for the scaphoid:

Character 160 Delmer (2009)

- 0. unique contact for the scaphoid
- 1. double contact for the scaphoid

157. Lunar contact for the scaphoid position:

Character 161 Delmer (2009)

- 0. perpendicular with respect of the distal articulation of the lunar
- 1. inclined with respect of the distal articulation of the lunar

158. Cuneiform in occlusal view:

Character 162 Delmer (2009)

- 0. lateral hook perpendicular to the mediolateral axis of the bone
- 1. lateral hook at 45° to the mediolateral axis of the bone

159. Cuneiform contact for the lunar:

Character 163 Delmer (2009)

- 0. unique contact for the lunar
- 1. double contact for the lunar

160. Cuneiform ulnar facet shape:

Character 164 Delmer (2009)

- 0. antero-posteriorly concave
- 1. antero-posteriorly concave and medio-laterally convex weakly distinguishable from the supraglenoidal tubercle

161. Cuneiform contact facet for the Mc V:

Character 165 Delmer (2009)

- 0. absent
- 1. present

162. Cuneiform contact facet for the pisiform:

Character 166 Delmer (2009)

- 0. wide
- 1. narrow

163. Cuneiform contact facet for the pisiform shape:

Character 167 Delmer (2009)

- 0. concave
- 1. flat

164. Magnum facet for the Mc II:

Character 168 Delmer (2009)

- 0. absent
- 1. present

165. Magnum facet for the lunar:

Character 169 Delmer (2009)

- 0. concave in lateral or medial view
- 1. convex in lateral or medial view

166. Ilium:

Character 172 Delmer (2009)

- 0. narrow
- 1. wide

167. Femur diaphysis:

Character 173 Delmer (2009)

- 0. quadrangular
- 1. antero-posteriorly flattened

168. Femur neck:

Character 174 Delmer (2009)

- 0. present
- 1. absent

169. Femur head:

Character 175 Delmer (2009)

- 0. medially inclined to the diaphysis axis
- 1. parallel to the diaphysis axis
- 2. perpendicular to the diaphysis axis

170. Femur greater trochanter:

Character 176 Delmer (2009)

- 0. massive, high above the head
- 1. massive, lower than the head
- 2. reduced

171. Femur neck size:

Character 177 Delmer (2009)

- 0. long
- 1. short

172. Femur small trochanter:

Character 178 Delmer (2009)

- 0. massive and medially extended
- 1. reduced and poorly medially extended

- 2. massive and posteriorly extended
- 173. Femur third trochanter:**
Character 179 Delmer (2009)
 - 0. present
 - 1. absent
- 174. Femur third trochanter size:**
Character 180 Delmer (2009)
 - 0. massive and strongly laterally extended
 - 1. reduced
- 175. Femur distal extremity:**
Character 181 Delmer (2009)
 - 0. as wide as the proximal extremity
 - 1. narrower than the proximal extremity
- 176. Femur trochlea:**
Character 182 Delmer (2009)
 - 0. strongly proximally extended on the anterior face of the diaphysis
 - 1. weakly proximally extended on the anterior face of the diaphysis
- 177. Femur head orientation:**
Character 183 Delmer (2009)
 - 0. antero-medially oriented
 - 1. medially oriented
- 178. Femur medial condyle:**
Character 184 Delmer (2009)
 - 0. as wide as the lateral condyle
 - 1. wider than the lateral condyle
- 179. Femur size:**
Character 185 Delmer (2009)
 - 0. as long as the tibia
 - 1. much longer than the tibia
- 180. Tibia diaphysis:**
Character 186 Delmer (2009)
 - 0. triangular
 - 1. oval
- 181. Tibia tuberuculum intercondylare:**
Character 187 Delmer (2009)
 - 0. absent
 - 1. present
- 182. Tibia area intercondilaris cranialis:**
Character 188 Delmer (2009)
 - 0. horizontal

1. at 45°
2. vertical

183. Tibia anterior tuberosity:

Character 189 Delmer (2009)

0. developed
1. massive
2. very reduced

184. Tibia diaphysis shape:

Character 190 Delmer (2009)

0. straight
1. postero-laterally twisted
2. postero-medially twisted

185. Tibia tibial cochlea:

Character 191 Delmer (2009)

0. two concavities
1. one concavity

186. Fibula:

Character 192 Delmer (2009)

0. strongly inclined with respect of the facet for the calcaneum
1. weakly inclined with respect of the facet for the calcaneum

187. Astragalus tuberculum mediale:

Character 193 Delmer (2009)

0. absent
1. present

188. Astragalus sustentacular facet:

Character 195 Delmer (2009)

0. does not join the navicular facet
1. joins the navicular facet

189. Astragalus ectal facet:

Character 196 Delmer (2009)

0. as wide as the sustentacular facet
1. narrower than the sustentacular facet
2. wider than the sustentacular facet

190. Astragalus fibular facet:

Character 197 Delmer (2009)

0. wide
1. narrow

191. Astragalus foramen astragali:

Character 198 Delmer (2009)

0. present
1. absent

- 192. Astragalus fibular facet orientation:**
Character 199 Delmer (2009)
0. weakly inclined with respect of the tibial facet
1. antero-ventrally oriented
- 193. Astragalus in lateral view:**
Character 200 Delmer (2009)
0. navicular facet anteriorly oriented
1. navicular facet antero-ventrally oriented
- 194. Astragalus in anterior view:**
Character 201 Delmer (2009)
0. navicular facet horizontally oriented
1. navicular facet disto-medially oriented
- 195. Astragalus neck:**
Character 202 Delmer (2009)
0. long
1. short
- 196. Astragalus crista capitatis:**
Character 203 Delmer (2009)
0. present
1. absent
- 197. Astragalus tibial facet:**
Character 204 Delmer (2009)
0. strongly concave
1. weakly concave
2. flat
- 198. Calcaneum ectal and sustentacular facets:**
Character 205 Delmer (2009)
0. inclined with respect of the facet for the cuboid
1. perpendicular to the facet for the cuboid
- 199. Calcaneum tuber calcanei:**
Character 206 Delmer (2009)
0. narrow
1. enlarged posteriorly
- 200. Calcaneum sustentacular facet shape:**
Character 207 Delmer (2009)
0. strongly convex in its posterior half
1. strongly convex in its anterior half

Results

In order to assess the phylogenetic position of ULDG-DAG1, we tabulated a matrix of 200 characters coded for 17 taxa. The cladistics analysis, performed with PAUP*, retained 4 most parsimonious trees of a length (L) of 390 steps, with a low consistency index (CI = 0.6436) and a low retention index (RI = 0.7030). The topology of the strict consensus tree (L = 393; CI = 0.6387; RI = 0.6966) is illustrated in Figure S2. The topological structure of this strict consensus tree is consistent with that of [6], although it conveys a sister clade relationship between *Barytherium* and *Numidotherium*. ULDG-DAG1 is found as the first offshoot of the elephantiforms. The clade (*Dagbatitherium*–Elephantiformes) is supported by three synapomorphies, including two non-ambiguous ones: the presence of a mesoconid on M/1-2 (114¹; RI = 1.00), and the presence of a large and isolated hypoconulid on the cingulid (117¹; RI = 1.00). *Dagbatitherium* is defined by four autapomorphies: preprotocristid as developed as the premetacristid (110¹; RI = 0.50), postmetacristid absent (111¹; RI = 0.71), preentocristid present and curved (112¹; RI = 0.86), and a 3D enamel limited to inner zone and HSB limited to the median zone (126¹; RI = 0.33). The position of *Chilgatherium* as sister taxa of Elephantiformes has been extensively discussed in [6]. Detailed results are included in the display buffer.

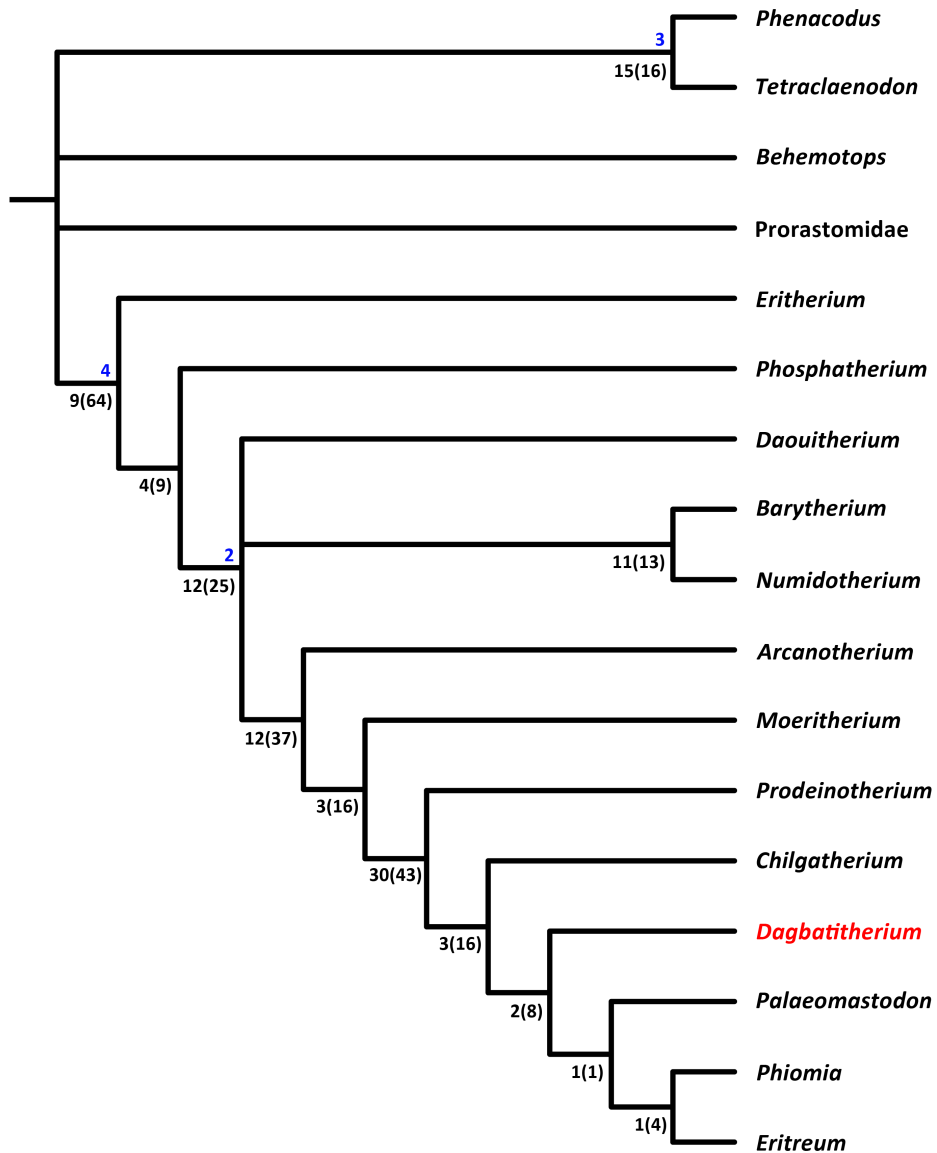


Figure S2 - Topology of the strict consensus of the 4 most parsimonious trees (390 steps). Bremer supports (superior to 1) are indicated in blue. The number of synapomorphies are indicated in black as follows: non-ambiguous synapomorphies (total number of synapomorphies).

Display buffer

P A U P *

Version 4.0a (build 169) for 32-bit Microsoft Windows (built on Feb 10 2021 at 22:12:44)

Mon May 31 07:07:01 2021

-----NOTICE-----

This is a test version that is still changing rapidly.

Please report bugs to dave@phylosolutions.com

Running on Intel(R) Core(TM) i5-6500 CPU @ 3.20GHz

Current processor contains 4 CPU cores on 1 socket

Executable built for IA-32 architecture (64-bit word length)

SSE vectorization enabled

SSSE3 instructions supported

Multithreading enabled using Pthreads

Processing of file "C:\Users\Mourl\Desktop\Dagbatitherium_Manuscript_Figures\Matrix\Nexus Dagbatitherium MM 05 31.nex" begins...

Data matrix has 17 taxa, 200 characters

Valid character-state symbols: 012345678

Missing data identified by '?'

Gaps identified by '.'

*** Skipping "NOTES" block

Processing of input file "Nexus Dagbatitherium MM 05 31.nex" completed.

paup> outgroup 1-4;

Outgroup status changed:

4 taxa transferred to outgroup

Total number of taxa now in outgroup = 4

Number of ingroup taxa = 13

paup> pset mstaxa=polymorph;

paup> hsearch addseq=random nreps=10000 hold=100;

Heuristic search settings:

Optimality criterion = parsimony

Character-status summary:

Of 200 total characters:

All characters are of type 'unord'

All characters have equal weight

All characters are parsimony-informative

Gaps are treated as "missing"

Multistate taxa interpreted as polymorphism

Starting tree(s) obtained via stepwise addition

Addition sequence: random

Number of replicates = 10000

Starting seed = generated automatically
Number of trees held at each step = 100
Branch-swapping algorithm: tree-bisection-reconnection (TBR) with reconnection limit = 8
Steepest descent option not in effect
Initial 'Maxtrees' setting = 100
Branches collapsed (creating polytomies) if maximum branch length is zero
'MulTrees' option in effect
No topological constraints in effect
Trees are unrooted

Heuristic search completed
Total number of rearrangements tried = 34085638
Score of best tree(s) found = 390
Number of trees retained = 4
Time used = 00:08:16 (CPU time = 00:08:16.0)

Tree-island profile:

Island	First Size	Last tree	tree	First Score	Times replicate	hit
1	4	1	4	390	1	10000

paup> describeTrees all;

Tree description:

Unrooted tree(s) rooted using outgroup method
Optimality criterion = parsimony
Character-status summary:
Of 200 total characters:
All characters are of type 'unord'
All characters have equal weight
All characters are parsimony-informative
Gaps are treated as "missing"
Multistate taxa interpreted as polymorphism ("min" values for CI, RI, and RC are minimum-possible character lengths)
Character-state optimization: Accelerated transformation (ACCTRAN)

Tree 1 (rooted using user-specified outgroup)

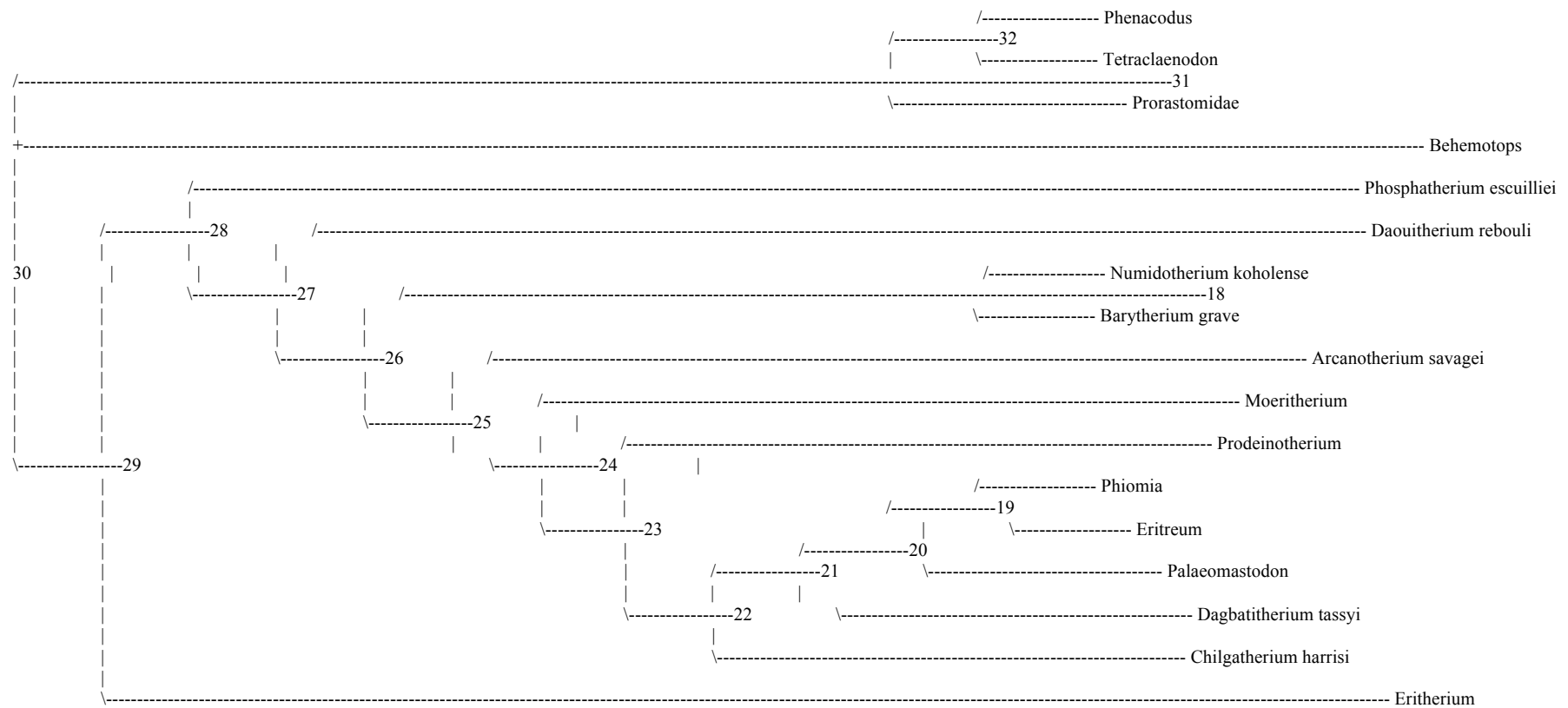
Tree length = 390

Consistency index (CI) = 0.6436

Homoplasy index (HI) = 0.3769

Retention index (RI) = 0.7030

Rescaled consistency index (RC) = 0.4524



Tree 2 (rooted using user-specified outgroup)

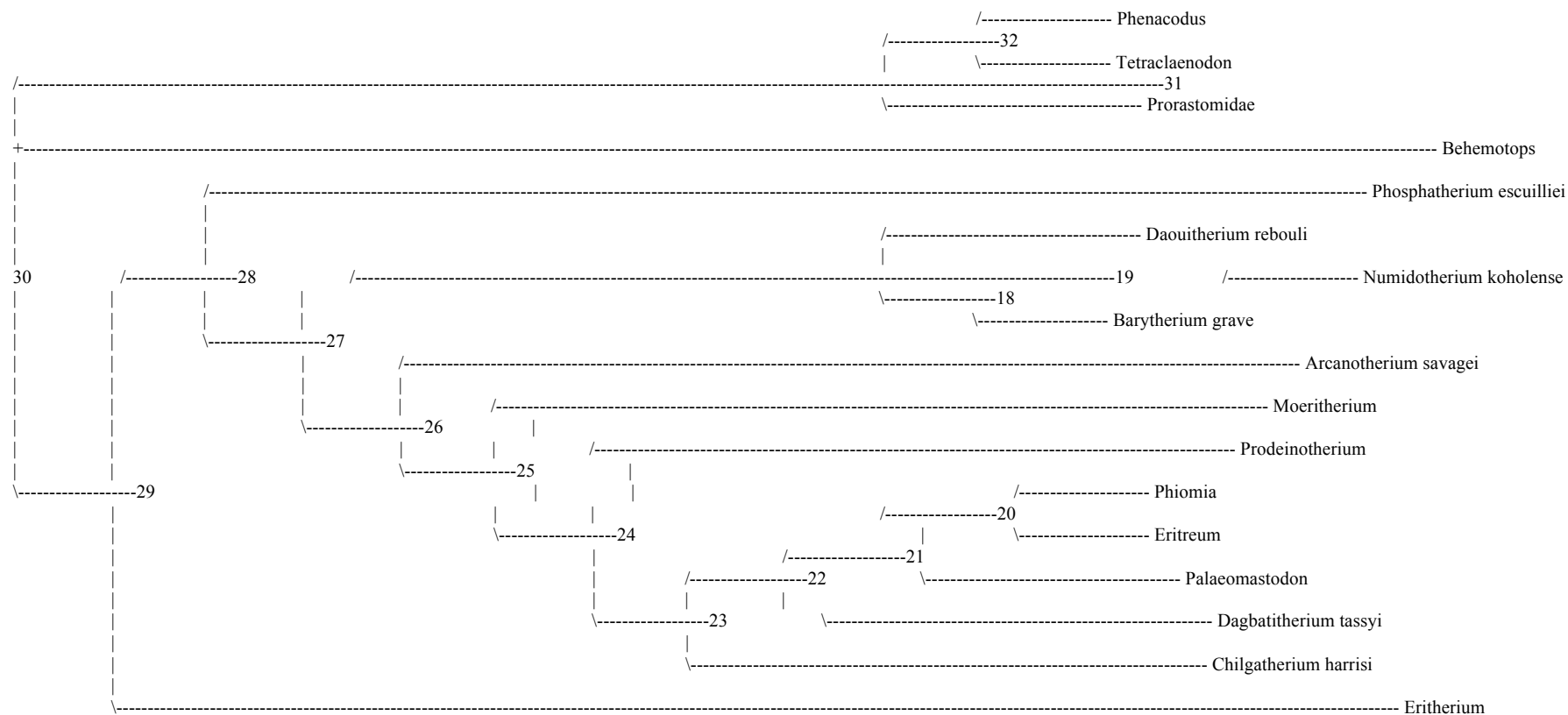
Tree length = 390

Consistency index (CI) = 0.6436

Homoplasy index (HI) = 0.3769

Retention index (RI) = 0.7030

Rescaled consistency index (RC) = 0.4524



Tree 3 (rooted using user-specified outgroup)

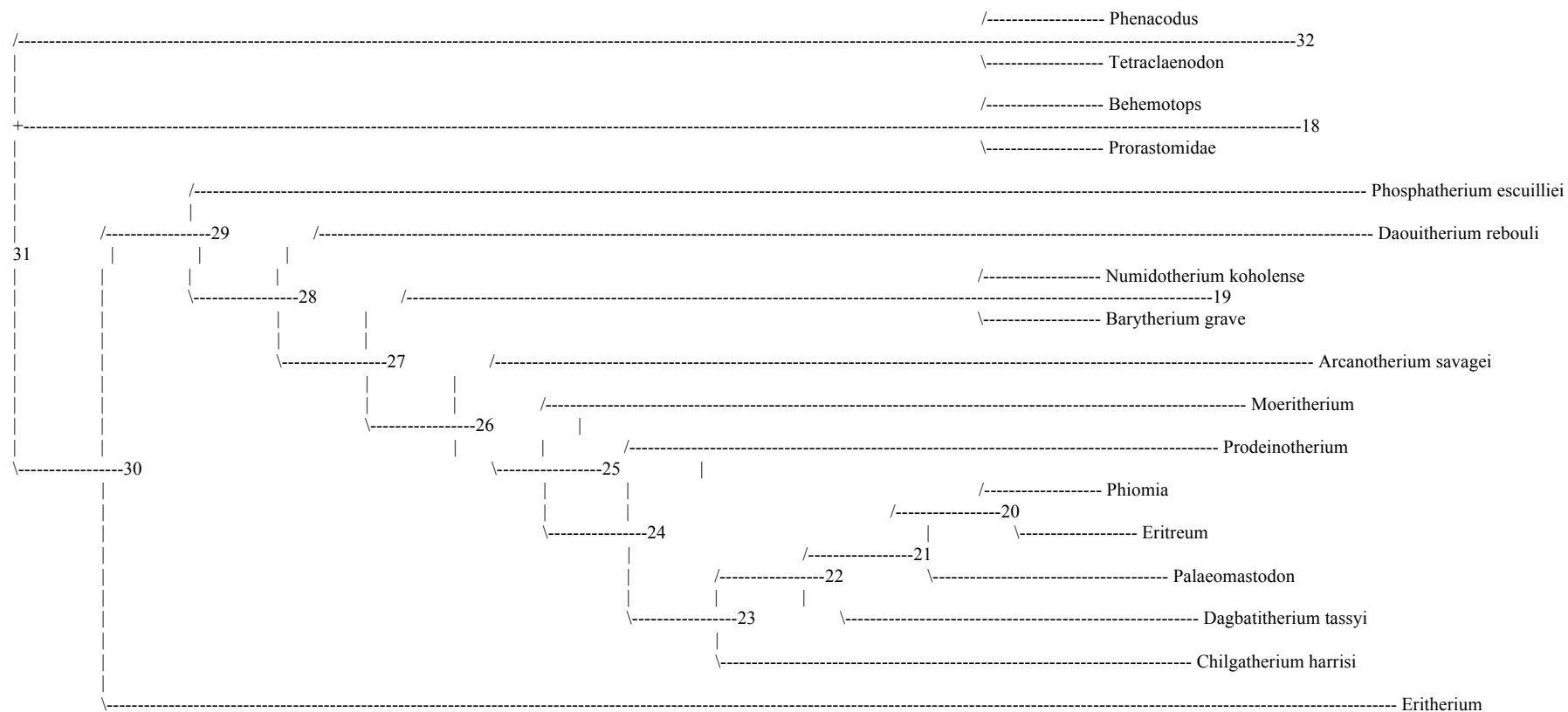
Tree length = 390

Consistency index (CI) = 0.6436

Homoplasy index (HI) = 0.3769

Retention index (RI) = 0.7030

Rescaled consistency index (RC) = 0.4524



Tree 4 (rooted using user-specified outgroup)

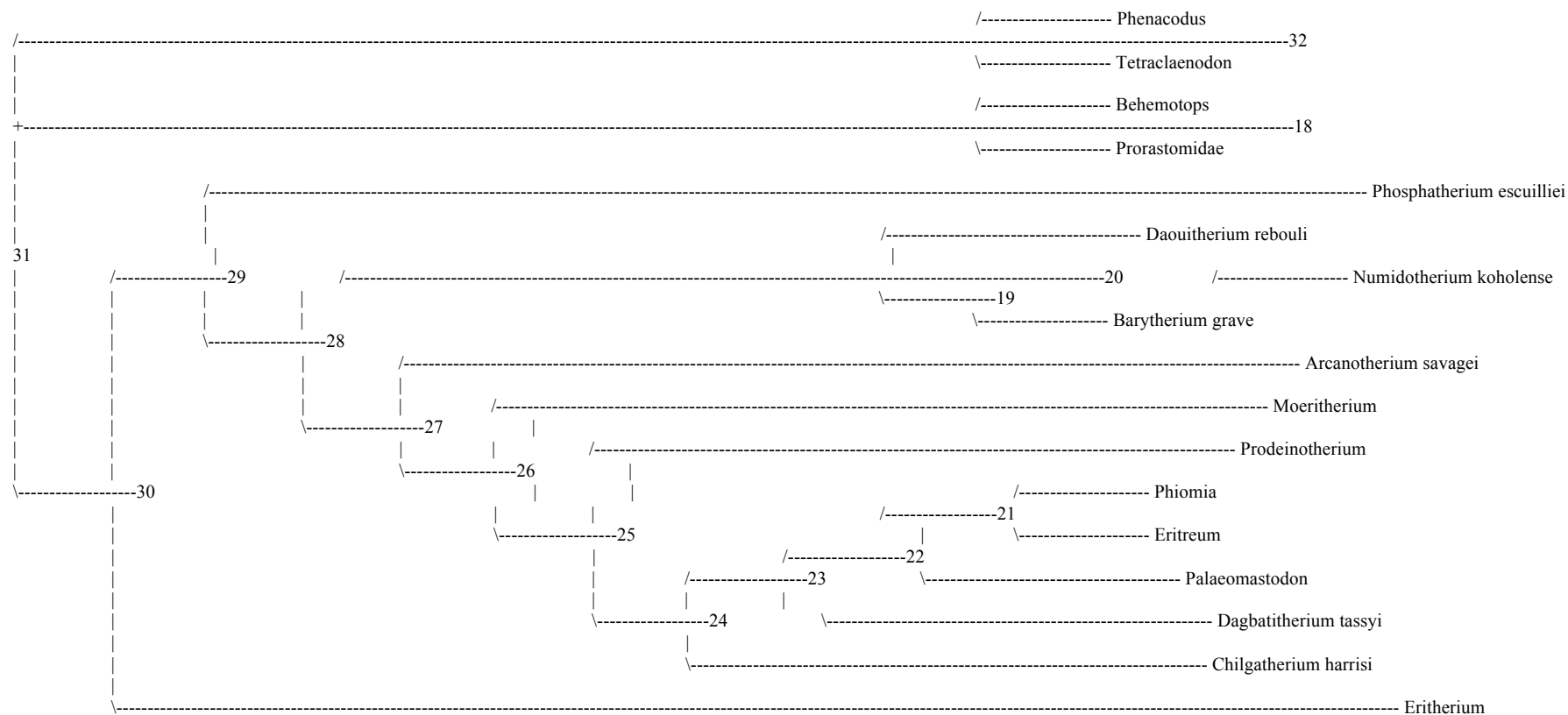
Tree length = 390

Consistency index (CI) = 0.6436

Homoplasy index (HI) = 0.3769

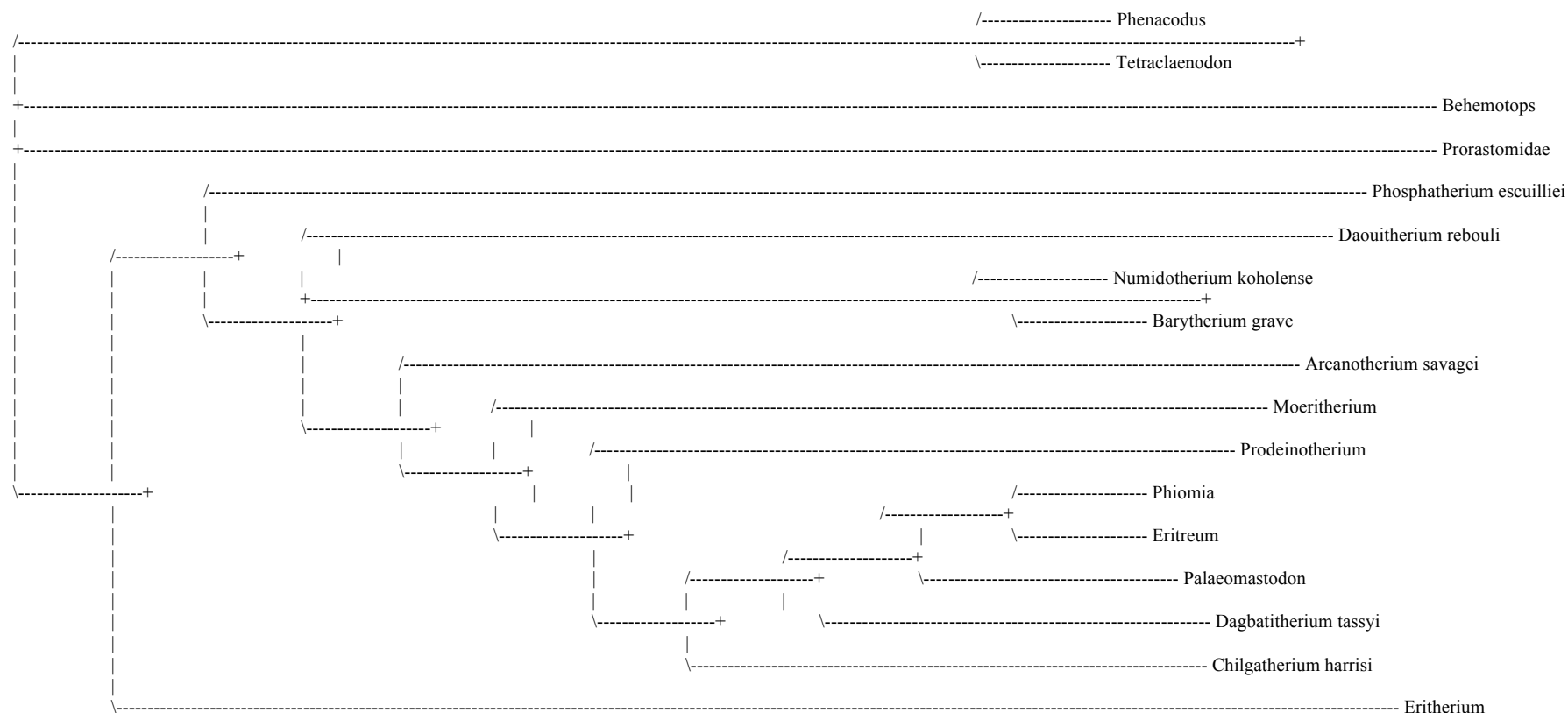
Retention index (RI) = 0.7030

Rescaled consistency index (RC) = 0.4524



```
paup> Contre all/treefile=DagbatitheriumCons.tre;
```

Strict consensus of 4 trees:



Consensus tree(s) written to treefile: C:\Users\Mourl\Desktop\Dagbatitherium_Manuscript_Figures\Matrix\DagbatitheriumCons.tre

```
paup> execute DagbatitheriumCons.tre;
```

Processing of file "C:\Users\Mourl\Desktop\Dagbatitherium_Manuscript_Figures\Matrix\DagbatitheriumCons.tre" begins...

1 tree read from TREES block; time used = 0.03 sec (CPU time = 0.00 sec)

Processing of input file "DagbatitheriumCons.tre" completed.

```
paup> describeTrees / plot=Both apoList diagnose;
```

Tree description:

Unrooted tree(s) rooted using outgroup method
Optimality criterion = parsimony

Of 200 total characters:

All characters are of type 'unord'

All characters have equal weight

All characters are parsimony-informative

Gaps are treated as "missing"

Multistate taxa interpreted as polymorphism ("min" values for CI, RI, and RC are minimum-possible character lengths)

Character-state optimization: Accelerated transformation (ACCTTRAN)

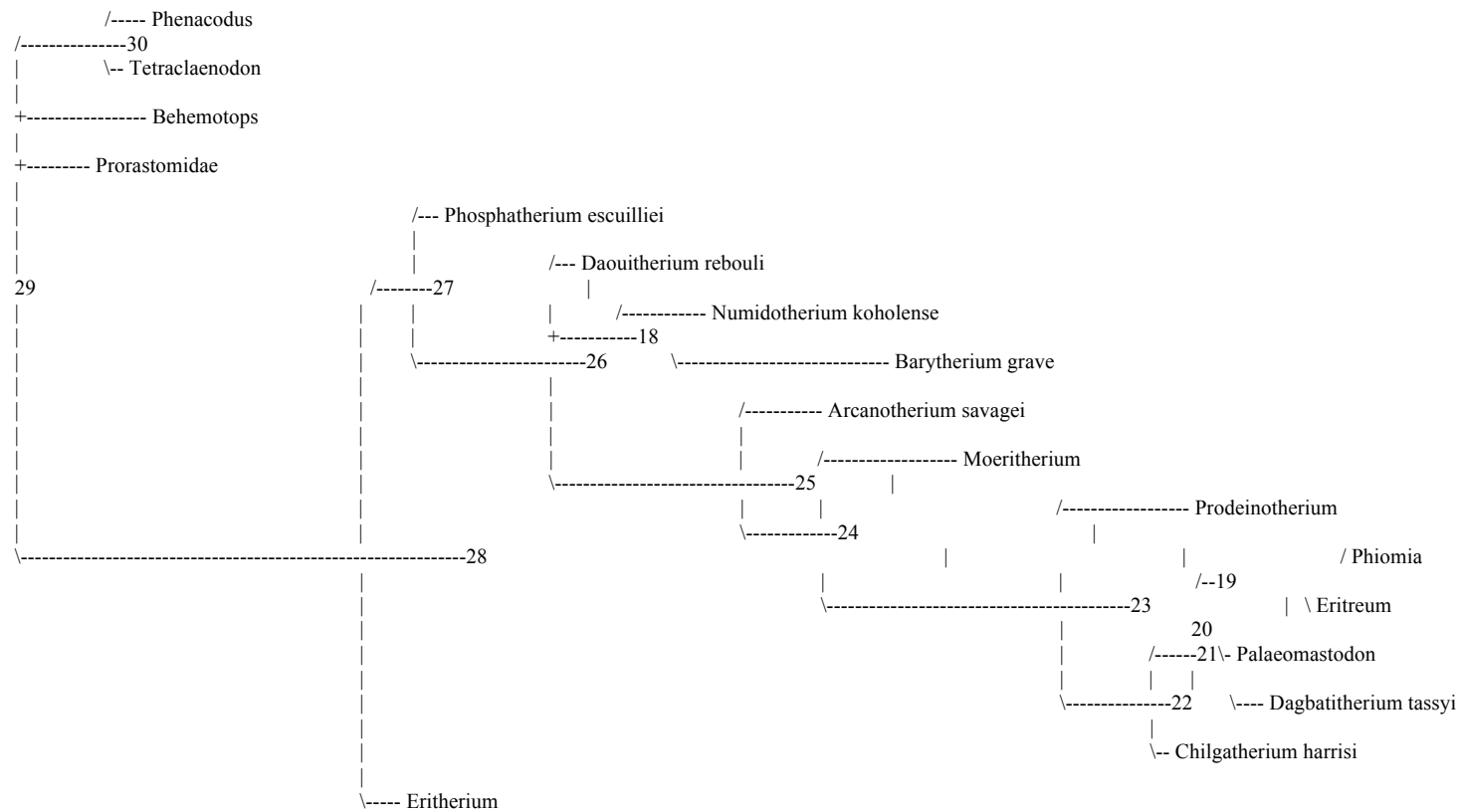
Tree length = 393

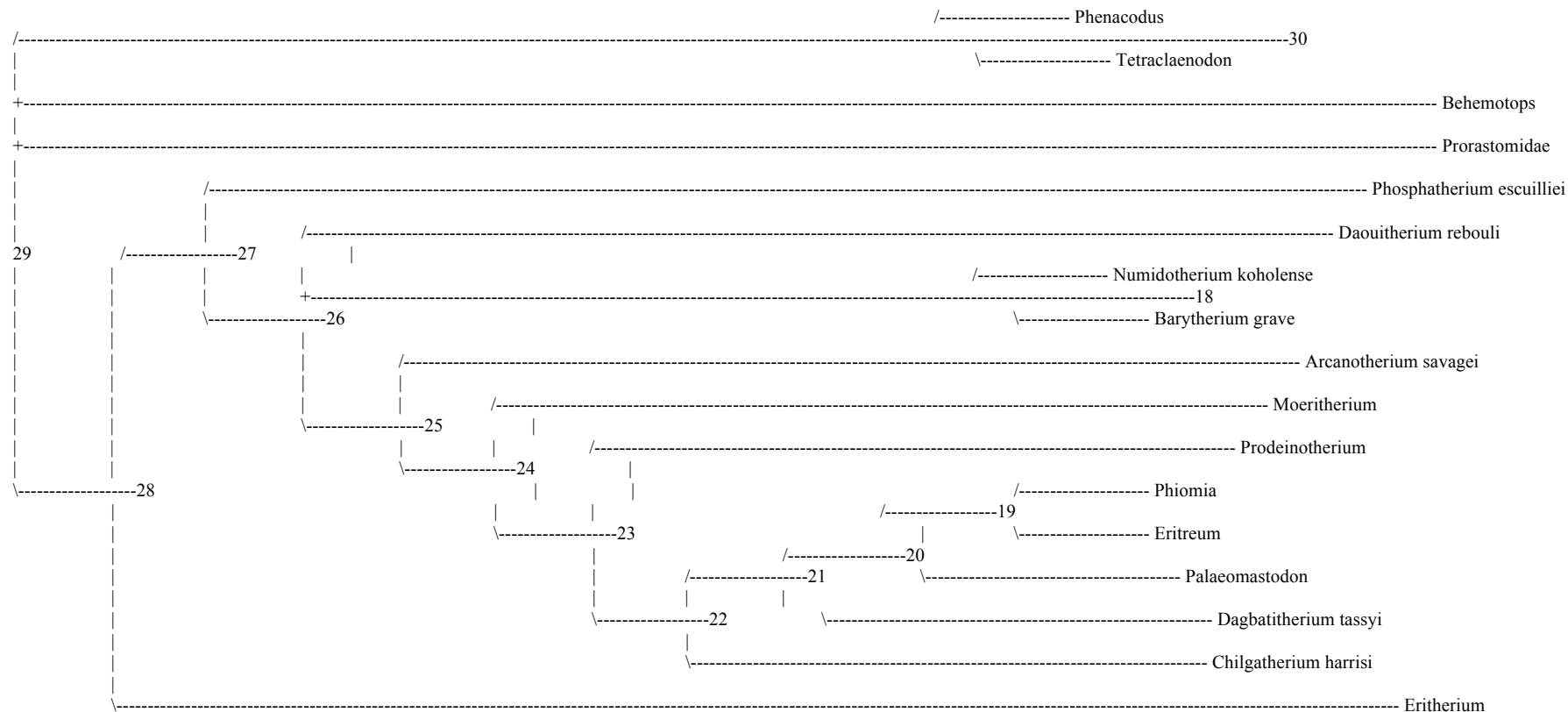
Consistency index (CI) = 0.6387

Homoplasy index (HI) = 0.3817

Retention index (RI) = 0.6966

Rescaled consistency index (RC) = 0.4449





Apomorphy lists:

Branch	Character	Steps	CI	Change
node_29 --> node_30	23 (Angle between vertical and horizontal rami)	1	0.667	1 ==> 0
	30 (Coronoid foramen)	1	1.000	1 ==> 0
	32 (M1/1 size)	1	0.500	0 ==> 2
	64 (P4/ lingual cingulum extension)	1	1.000	1 ==> 0
	65 (P4/ mesial cingulum extension)	1	0.500	1 ==> 0
	66 (M1-2/ parastyle)	1	0.333	1 ==> 0
	83 (M2/ postentoconule)	1	0.333	1 ==> 0
	97 (P/3-4 protostylid)	1	0.500	1 ==> 0
	104 (P/4 paraconid size)	1	0.500	1 ==> 0
	118 (M/1-2 molar pattern)	1	0.750	1 ==> 0
	125 (Enamel microstructure Radial Enamel)	1	0.400	0 --> 1
	167 (Femur diaphysis)	1	1.000	1 ==> 0
	174 (Femur third trochanter size)	1	1.000	1 ==> 0
	176 (Femur trochlea)	1	0.500	1 ==> 0
	179 (Femur size)	1	1.000	1 ==> 0
	184 (Tibia diaphysis shape)	1	1.000	2 ==> 0

node_30 --> Phenacodus	54 (P3/ parastyle)	1 0.333 0 ==> 1
	55 (P3/ metacone)	1 0.333 0 ==> 1
	56 (P3/ metastyle)	1 0.333 0 ==> 1
	74 (M1-2/ lingual cingulum)	1 0.167 0 --> 1
	85 (M3/ parastyle)	1 0.250 0 --> 1
node_30 --> Tetracaelonodon	47 (Shape of P2/ in occlusal view)	1 0.500 1 ==> 0
	87 (M3/ metaconule)	1 0.333 1 ==> 0
node_29 --> Behemotops	26 (Angular process)	1 0.500 0 ==> 1
	27 (Symphysis fusion)	1 0.333 0 --> 1
	28 (Posterior extension of the symphysis)	1 0.667 1 ==> 2
	31 (Diastema between the jugal and anterior teeth)	1 0.500 0 ==> 1
	38 (Lower incisors)	1 0.667 0 --> 1
	71 (M1-2/ mesostyle)	1 0.500 0 ==> 1
	74 (M1-2/ lingual cingulum)	1 0.167 0 --> 1
	80 (M2-3/ centrocrista)	1 0.333 0 ==> 1
	84 (M2/ postentoconule shape)	1 0.667 0 --> 1
	88 (M3/ mesostyle)	1 0.500 0 --> 1
	100 (P3 metaconid)	1 0.750 0 ==> 2
	106 (P4 entoconid)	1 0.500 0 ==> 1
	111 (M1-2 postmetacristid)	1 0.333 0 ==> 1
	115 (M1-2 cristid obliqua)	1 0.500 0 ==> 1
	120 (M3 postmetacristid)	1 0.500 0 ==> 1
	121 (M3 preentocristid)	1 0.500 0 ==> 1
node_29 --> Prorastomidae	1 (Frontal)	1 0.500 0 ==> 1
	2 (Posterior extension of the nares)	1 0.500 0 ==> 1
	15 (Maxillary processus pyramidalis - anterior extension)	1 0.400 0 --> 1
	27 (Symphysis fusion)	1 0.333 0 --> 1
	28 (Posterior extension of the symphysis)	1 0.667 1 ==> 3
	79 (M1/ mesial cingulum)	1 0.333 0 ==> 1
	82 (M2-3/ mesial cingulum)	1 0.333 0 ==> 1
	90 (M3/ lingual cingulum)	1 0.500 0 ==> 1
	170 (Femur greater trochanter)	1 0.667 0 --> 1
node_29 --> node_28	3 (Opening of the orbit)	1 1.000 0 ==> 1
	4 (Position of the orbit)	1 0.400 0 --> 1
	5 (Processus orbitalis of the palatine)	1 1.000 0 --> 1
	6 (Jugal)	1 1.000 0 --> 1
	10 (Parietal)	1 1.000 0 --> 1
	11 (Petrosal bone)	1 1.000 0 --> 1
	16 (Maxillary processus pyramidalis - posterior extension)	1 0.667 0 ==> 1
	17 (Zygomatic arches)	1 1.000 0 ==> 1
	18 (Position of the postglenoid foramen)	1 1.000 0 --> 1
	36 (Upper incisors)	1 1.000 0 --> 1
	38 (Lower incisors)	1 0.667 0 --> 1
	46 (P2/ parasyle)	1 0.500 0 --> 1
	49 (P2/ metacone)	1 0.333 0 --> 1
	51 (P2/ lingual cingulum)	1 0.500 0 --> 1
	58 (P3/ lingual cingulum)	1 0.500 0 --> 1
	59 (P3/ lingual cingulum extension)	1 1.000 0 --> 1
	60 (P4/ paraconule)	1 0.500 0 ==> 1

63 (P4/ lingual cingulum)	1	0.333	0 ==> 1
67 (M1-2-3/ paraconule)	1	0.333	0 ==> 1
68 (M1-2/ paraconule shape)	1	1.000	0 --> 1
69 (M1-2/ metaconule)	1	0.333	0 ==> 1
70 (M1-2/ metaconule)	1	1.000	0 --> 1
75 (M1/ postentoconule)	1	0.500	0 --> 1
85 (M3/ parastyle)	1	0.250	0 --> 1
86 (M3/ paraconule)	1	0.500	0 --> 1
96 (P2-3-4 mesial cingulid)	1	0.500	0 --> 1
99 (P/3 paraconid)	1	0.500	0 ==> 1
110 (M/1-2-3 preprotocristid)	1	0.500	0 --> 1
113 (M/2-3 buccal cingulid)	1	0.500	0 ==> 1
119 (M/3 accessory cusp on the premetacristid)	1	0.500	0 --> 1
128 (Atlas proximodistal flattening)	1	0.333	0 --> 1
131 (Scapula scapular spine)	1	1.000	0 --> 2
132 (Scapula coracoid process)	1	0.500	0 --> 1
134 (Humerus humeral crest)	1	0.667	0 --> 1
137 (Humerus entepicondylar foramen)	1	0.500	0 --> 1
138 (Humerus lateral supracondylar crest)	1	0.500	0 --> 1
145 (Ulna synovial groove)	1	0.500	0 --> 1
147 (Ulna olecranon)	1	0.667	0 --> 1
148 (Ulna proximal extension)	1	0.667	0 --> 1
153 (Lunar contact facet for the ulna)	1	1.000	0 --> 1
155 (Lunar contact facet for the unciform)	1	1.000	0 --> 1
158 (Cuneiform in occlusal view)	1	1.000	0 --> 1
160 (Cuneiform ulnar facet shape)	1	1.000	0 --> 1
161 (Cuneiform contact facet for the Mc V)	1	1.000	0 --> 1
163 (Cuneiform contact facet for the pisiform shape)	1	0.500	0 --> 1
164 (Magnum facet for the Mc II)	1	1.000	0 --> 1
166 (Ilium)	1	0.500	0 --> 1
171 (Femur neck size)	1	1.000	0 --> 1
172 (Femur small trochanter)	1	1.000	0 --> 1
175 (Femur distal extremity)	1	1.000	0 --> 1
177 (Femur head orientation)	1	0.333	0 --> 1
181 (Tibia tuberculum intercondylare)	1	1.000	0 --> 1
183 (Tibia anterior tuberosity)	1	0.667	0 --> 1
184 (Tibia diaphysis shape)	1	1.000	2 --> 1
185 (Tibia tibial cochlea)	1	1.000	0 --> 1
187 (Astragalus tuberculum mediale)	1	1.000	0 --> 1
189 (Astragalus ectal facet)	1	1.000	0 --> 2
191 (Astragalus foramen astragali)	1	1.000	0 --> 1
192 (Astragalus fibular facet orientation)	1	1.000	0 --> 1
195 (Astragalus neck)	1	1.000	0 --> 1
196 (Astragalus crista capitatis)	1	1.000	0 --> 1
197 (Astragalus tibial facet)	1	1.000	0 --> 2
199 (Calcaneum tuber calcanei)	1	0.500	0 --> 1

node_28 --> node_27	15 (Maxillary processus pyramidalis - anterior extension)	1	0.400	0 --> 1
	31 (Diastema between the jugal and anterior teeth)	1	0.500	0 --> 1
	41 (I/3)	1	1.000	0 ==> 1
	42 (Lower incisors size)	1	1.000	0 ==> 1
	43 (Lower canine)	1	1.000	0 ==> 1
	88 (M3/ mesostyle)	1	0.500	0 --> 1
	95 (P/2 hypoconid)	1	0.500	0 --> 1

118 (M1-2 molar pattern)	1	0.750	1	==> 2
125 (Enamel microstructure Radial Enamel)	1	0.400	0	--> 1
node_27 --> Phosphatherium escuilliei 66 (M1-2/ parastyle)				
	1	0.333	1	==> 0
90 (M3/ lingual cingulum)	1	0.500	0	--> (01)
96 (P2-3-4 mesial cingulid)	1	0.500	1	--> 0
109 (M1-2 accessory cusp in front of the metaconid)	1	0.500	0	==> 1
node_27 --> node_26				
7 (External auditory meatus)	1	1.000	0	==> 1
8 (External auditory meatus)	1	1.000	0	==> 1
9 (Squamosal)	1	1.000	0	==> 1
13 (Pneumatisation)	1	0.667	0	--> 1
14 (Postorbital process of the frontal)	1	0.500	0	--> 1
15 (Maxillary processus pyramidalis - anterior extension)	1	0.400	1	--> 2
18 (Position of the postglenoid foramen)	1	1.000	1	--> 2
19 (Condylar foramina)	1	1.000	0	==> 1
20 (Zygomatic extension of the squamosal)	1	1.000	0	==> 1
25 (Coronoid process of the vertical ramus)	1	0.500	0	--> 1
27 (Symphysis fusion)	1	0.333	0	--> 1
44 (P1/)	1	1.000	0	==> 1
52 (P2/ mesial cingulum)	1	0.500	0	--> 1
53 (P3-4/ mesial cingulum)	1	0.500	0	==> 1
65 (P4/ mesial cingulum extension)	1	0.500	1	--> 0
71 (M1-2/ mesostyle)	1	0.500	0	==> 1
76 (M1/ postentoconule shape)	1	1.000	0	--> 1
79 (M1/ mesial cingulum)	1	0.333	0	==> 1
82 (M2-3/ mesial cingulum)	1	0.333	0	==> 1
84 (M2/ postentoconule shape)	1	0.667	0	--> 1
85 (M3/ parastyle)	1	0.250	1	--> 0
91 (P1)	1	0.500	0	--> 1
112 (M1-2 preentocristid)	1	0.667	0	==> 1
122 (M3 preentocristid shape)	1	1.000	0	==> 1
125 (Enamel microstructure Radial Enamel)	1	0.400	1	--> 2
node_26 --> Daouitherium rebouli				
23 (Angle between vertical and horizontal rami)	1	0.667	1	==> 2
25 (Coronoid process of the vertical ramus)	1	0.500	1	--> 0
91 (P1)	1	0.500	1	--> 0
node_26 --> node_18				
48 (P2/ protocone)	1	1.000	0	==> 1
72 (M1-2-3/ post-paracrista II)	1	1.000	0	==> 1
75 (M1/ postentoconule)	1	0.500	1	==> 0
83 (M2/ postentoconule)	1	0.333	1	==> 0
90 (M3/ lingual cingulum)	1	0.500	0	==> 1
126 (Enamel microstructure HSB 3DE)	1	0.600	1	==> 3
127 (Atlas distal articular facet)	1	0.500	0	==> 1
134 (Humerus humeral crest)	1	0.667	1	--> 2
139 (Humerus lateral supracondylar crest lateral extension)	1	1.000	0	==> 2
146 (Ulna proximal surface for the radius)	1	1.000	0	==> 1
157 (Lunar contact for the scaphoid position)	1	1.000	0	==> 1
165 (Magnum facet for the lunar)	1	1.000	0	==> 1
170 (Femur greater trochanter)	1	0.667	0	--> 1
node_18 --> Numidotherium koholense				
49 (P2/ metacone)	1	0.333	1	==> 0
66 (M1-2/ parastyle)	1	0.333	1	==> 0

85 (M3/ parastyle)	1	0.250	0 --> 1
119 (M/3 accessory cusp on the premetacristid)	1	0.500	1 ==> 0
132 (Scapula coracoid process)	1	0.500	1 --> 0
133 (Scapula glenoid cavity)	1	0.500	0 ==> 1
137 (Humerus entepicondylar foramen)	1	0.500	1 --> 0
145 (Ulna synovial groove)	1	0.500	1 --> 0
163 (Cuneiform contact facet for the pisiform shape)	1	0.500	1 --> 0
176 (Femur trochlea)	1	0.500	1 ==> 0
177 (Femur head orientation)	1	0.333	1 --> 0
197 (Astragalus tibial facet)	1	1.000	2 ==> 1

node_18 --> Barytherium grave	4 (Position of the orbit)	1	0.400	1 --> 2
16 (Maxillary processus pyramidalis - posterior extension)	1	0.667	1 ==> 2	
22 (Origin of the vertical ramus)	1	1.000	0 ==> 3	
24 (Coronoid process of the vertical ramus)	1	0.500	0 ==> 1	
28 (Posterior extension of the symphysis)	1	0.667	1 ==> 4	
29 (Lateral thickening of the horizontal ramus)	1	0.667	0 ==> 1	
35 (I3/)	1	0.500	0 ==> 1	
37 (Upper canine)	1	0.500	0 ==> 1	
39 (I/1)	1	1.000	0 ==> 1	
50 (P2/ metastyle)	1	0.500	0 ==> 1	
54 (P3/ parastyle)	1	0.333	0 ==> 1	
61 (P4/ metacone)	1	0.750	0 ==> 1	
62 (P4/ hypocone)	1	0.500	0 ==> 1	
93 (P/2 occlusal)	1	0.500	0 ==> 1	
94 (P/2 metaconid)	1	0.500	0 ==> 1	
98 (P/3 occlusal)	1	0.500	0 ==> 1	
100 (P/3 metaconid)	1	0.750	0 ==> 1	
101 (P/3 premetacristid)	1	0.500	0 ==> 1	
102 (P/4 occlusal)	1	0.500	0 ==> 1	
103 (P/4 paraconid)	1	0.333	0 ==> 1	
105 (P/4 accessory cusp in front of the metaconid)	1	0.500	0 ==> 1	
107 (P/4 premetacristid)	1	0.500	0 ==> 1	
109 (M/1-2 accessory cusp in front of the metaconid)	1	0.500	0 ==> 1	
130 (Scapula supraglenoidal tubercle)	1	0.667	0 ==> 1	
168 (Femur neck)	1	0.500	0 ==> 1	
169 (Femur head)	1	0.667	0 ==> 1	
186 (Fibula)	1	0.500	0 ==> 1	
188 (Astragalus sustentacular facet)	1	0.500	0 ==> 1	
189 (Astragalus ectal facet)	1	1.000	2 ==> 1	

node_26 --> node_25	12 (Foramen ovale)	1	1.000	0 --> 1
22 (Origin of the vertical ramus)	1	1.000	0 ==> 2	
24 (Coronoid process of the vertical ramus)	1	0.500	0 --> 1	
26 (Angular process)	1	0.500	0 --> 1	
29 (Lateral thickening of the horizontal ramus)	1	0.667	0 ==> 1	
47 (Shape of P2/ in occlusal view)	1	0.500	1 --> 0	
51 (P2/ lingual cingulum)	1	0.500	1 --> 0	
55 (P3/ metacone)	1	0.333	0 --> 1	
56 (P3/ metastyle)	1	0.333	0 --> 1	
58 (P3/ lingual cingulum)	1	0.500	1 --> 0	
63 (P4/ lingual cingulum)	1	0.333	1 --> 0	
67 (M1-2-3/ paraconule)	1	0.333	1 ==> 0	
69 (M1-2/ metaconule)	1	0.333	1 ==> 0	

74 (M1-2/ lingual cingulum)	1	0.167	0 --> 1
77 (M1/ centrocrista)	1	1.000	0 ==> 1
87 (M3/ metaconule)	1	0.333	1 --> 0
95 (P/2 hypoconid)	1	0.500	1 --> 0
100 (P/3 metaconid)	1	0.750	0 ==> 1
104 (P/4 paraconid size)	1	0.500	1 --> 0
110 (M/1-2-3 preprotocristid)	1	0.500	1 ==> 0
111 (M/1-2 postmetacristid)	1	0.333	0 ==> 1
112 (M/1-2 preentocristid)	1	0.667	1 ==> 2
125 (Enamel microstructure Radial Enamel)	1	0.400	2 --> 1
129 (Atlas dorsoventral flattening)	1	0.500	0 ==> 1
135 (Humerus deltoid process)	1	0.500	0 --> 1
140 (Humerus humeral trochlea)	1	1.000	0 --> 1
141 (Humerus medial condyle of the trochlea)	1	1.000	0 --> 1
147 (Ulna olecranon)	1	0.667	1 --> 2
149 (Ulna lateral sigmoid facet)	1	1.000	0 ==> 1
150 (Radius size)	1	1.000	0 --> 1
151 (Radius proximal extremity)	1	1.000	0 --> 1
152 (Lunar shape in proximal view)	1	1.000	0 ==> 1
182 (Tibia area intercondilaris cranialis)	1	1.000	0 --> 2
183 (Tibia anterior tuberosity)	1	0.667	1 --> 2
200 (Calcaneum sustentacular facet shape)	1	1.000	0 --> 1
node_25 --> Arcanotherium savagei	70 (M1-2/ metaconule)	1	1.000 1 --> 2
93 (P/2 occlusal)	1	0.500	0 ==> 1
94 (P/2 metaconid)	1	0.500	0 ==> 1
98 (P/3 occlusal)	1	0.500	0 ==> 1
101 (P/3 premetacristid)	1	0.500	0 ==> 1
102 (P/4 occlusal)	1	0.500	0 ==> 1
103 (P/4 paraconid)	1	0.333	0 ==> 1
105 (P/4 accessory cusp in front of the metaconid)	1	0.500	0 ==> 1
107 (P/4 premetacristid)	1	0.500	0 ==> 1
109 (M/1-2 accessory cusp in front of the metaconid)	1	0.500	0 ==> 1
126 (Enamel microstructure HSB 3DE)	1	0.600	1 ==> 2
node_25 --> node_24	28 (Posterior extension of the symphysis)	1	0.667 1 --> 3
73 (M1-2/ convolute)	1	1.000	0 ==> 1
99 (P/3 paraconid)	1	0.500	1 --> 0
118 (M/1-2 molar pattern)	1	0.750	2 --> 3
119 (M/3 accessory cusp on the premetacristid)	1	0.500	1 ==> 0
120 (M/3 postmetacristid)	1	0.500	0 ==> 1
121 (M/3 preentocristid)	1	0.500	0 --> 1
128 (Atlas proximodistal flattening)	1	0.333	1 --> 0
130 (Scapula supraglenoidal tubercle)	1	0.667	0 --> 1
148 (Ulna proximal extension)	1	0.667	1 --> 0
154 (Lunar contact facet for a free central bone)	1	1.000	0 --> 1
156 (Lunar contact for the scaphoid)	1	1.000	0 --> 1
159 (Cuneiform contact for the lunar)	1	1.000	0 --> 1
162 (Cuneiform contact facet for the pisiform)	1	1.000	0 --> 1
173 (Femur third trochanter)	1	0.500	0 --> 1
node_24 --> Moeritherium	4 (Position of the orbit)	1	0.400 1 --> 2
13 (Pneumatisation)	1	0.667	1 --> 0
15 (Maxillary processus pyramidalis - anterior extension)	1	0.400	2 --> 1

16 (Maxillary processus pyramidalis - posterior extension)	1	0.667	1 ==> 2
42 (Lower incisors size)	1	1.000	1 ==> 2
49 (P2/ metacone)	1	0.333	1 ==> 0
50 (P2/ metastyle)	1	0.500	0 ==> 1
52 (P2/ mesial cingulum)	1	0.500	1 --> 0
80 (M2-3/ centrocrista)	1	0.333	0 ==> 1
97 (P3-4 protostylid)	1	0.500	1 ==> 0
113 (M/2-3 buccal cingulid)	1	0.500	1 ==> 0
131 (Scapula scapular spine)	1	1.000	2 ==> 1
138 (Humerus lateral supracondylar crest)	1	0.500	1 --> 0
147 (Ulna olecranon)	1	0.667	2 --> 1
166 (Ilion)	1	0.500	1 --> 0
169 (Femur head)	1	0.667	0 ==> 2
172 (Femur small trochanter)	1	1.000	1 ==> 2
199 (Calcaneum tuber calcanei)	1	0.500	1 --> 0

node_24 --> node_23	1 (Frontal)	1	0.500	0 ==> 1
	2 (Posterior extension of the nares)	1	0.500	0 ==> 1
	14 (Postorbital process of the frontal)	1	0.500	1 --> 0
	21 (Mandibular symphysis)	1	1.000	0 ==> 1
	22 (Origin of the vertical ramus)	1	1.000	2 ==> 1
	23 (Angle between vertical and horizontal rami)	1	0.667	1 ==> 2
	29 (Lateral thickening of the horizontal ramus)	1	0.667	1 ==> 2
	33 (Incisor growth)	1	1.000	0 ==> 1
	34 (I1/)	1	1.000	0 ==> 1
	35 (I3/)	1	0.500	0 ==> 1
	37 (Upper canine)	1	0.500	0 ==> 1
	39 (I/1)	1	1.000	0 ==> 2
	40 (I/2)	1	1.000	0 ==> 1
	45 (P2/)	1	1.000	0 --> 1
	46 (P2/ parasyle)	1	0.500	1 --> 0
	57 (P3/ hypocone)	1	0.500	0 --> 1
	61 (P4/ metacone)	1	0.750	0 ==> 2
	62 (P4/ hypocone)	1	0.500	0 ==> 1
	74 (M1-2/ lingual cingulum)	1	0.167	1 --> 0
	76 (M1/ postentoconule shape)	1	1.000	1 --> 2
	78 (M1/ tritoloph)	1	1.000	0 ==> 1
	84 (M2/ postentoconule shape)	1	0.667	1 --> 2
	86 (M3/ paraconule)	1	0.500	1 --> 0
	89 (M3/ metaloph)	1	0.500	0 --> 1
	92 (P/2)	1	1.000	0 ==> 1
	106 (P/4 entoconid)	1	0.500	0 ==> 1
	108 (P/4 metalophid)	1	1.000	0 ==> 1
	116 (M/1-2 postentoconulid)	1	1.000	0 --> 2
	130 (Scapula supraglenoidal tubercle)	1	0.667	1 --> 2
	133 (Scapula glenoid cavity)	1	0.500	0 ==> 1
	136 (Humerus medial supracondylar crest)	1	1.000	0 ==> 1
	139 (Humerus lateral supracondylar crest lateral extension)	1	1.000	0 ==> 1
	142 (Humerus olecranon fossa)	1	1.000	0 ==> 1
	143 (Humerus trochiter)	1	1.000	0 ==> 1
	144 (Ulna diaphysis)	1	1.000	0 ==> 1
	148 (Ulna proximal extension)	1	0.667	0 --> 2
	170 (Femur greater trochanter)	1	0.667	0 --> 2
	178 (Femur medial condyle)	1	1.000	0 ==> 1

	180 (Tibia diaphysis)	1	1.000	0 ==>	1
	190 (Astragalus fibular facet)	1	1.000	0 ==>	1
	193 (Astragalus in lateral view)	1	1.000	0 ==>	1
	194 (Astragalus in anterior view)	1	1.000	0 ==>	1
	198 (Calcaneum ectal and sustentacular facets)	1	1.000	0 ==>	1
node_23 -->	Prodeinotherium	13 (Pneumatisation)	1	0.667	1 --> 2
	32 (M1/1 size)	1	0.500	0 ==>	2
	38 (Lower incisors)	1	0.667	1 ==>	2
	63 (P4/ lingual cingulum)	1	0.333	0 -->	1
	67 (M1-2-3/ paraconule)	1	0.333	0 ==>	1
	69 (M1-2/ metaconule)	1	0.333	0 ==>	1
	83 (M2/ postentoconule)	1	0.333	1 ==>	0
	87 (M3/ metaconule)	1	0.333	0 -->	1
	90 (M3/ lingual cingulum)	1	0.500	0 ==>	1
	116 (M/1-2 postentoconulid)	1	1.000	2 -->	(02)
	117 (M/1-2 hypoconulid)	1	1.000	0 -->	(01)
	118 (M/1-2 molar pattern)	1	0.750	3 -->	2
	125 (Enamel microstructure Radial Enamel)	1	0.400	1 ==>	2
	126 (Enamel microstructure HSB 3DE)	1	0.600	1 ==>	3
	127 (Atlas distal articular facet)	1	0.500	0 ==>	1
	128 (Atlas proximodistal flattening)	1	0.333	0 -->	1
	129 (Atlas dorsoventral flattening)	1	0.500	1 ==>	0
	168 (Femur neck)	1	0.500	0 ==>	1
	169 (Femur head)	1	0.667	0 ==>	1
node_23 -->	node_22	4 (Position of the orbit)	1	0.400	1 --> 0
	28 (Posterior extension of the symphysis)	1	0.667	3 -->	1
	53 (P3-4/ mesial cingulum)	1	0.500	1 -->	0
	54 (P3/ parastyle)	1	0.333	0 ==>	1
	79 (M1/ mesial cingulum)	1	0.333	1 -->	0
	81 (M2-3/ tritoloph)	1	1.000	0 ==>	1
	100 (P/3 metaconid)	1	0.750	1 -->	3
	123 (M/3 talonid)	1	1.000	0 ==>	1
	134 (Humerus humeral crest)	1	0.667	1 -->	2
	135 (Humerus deltoid process)	1	0.500	1 -->	0
	173 (Femur third trochanter)	1	0.500	1 -->	0
	177 (Femur head orientation)	1	0.333	1 -->	0
	182 (Tibia area intercondilaris cranialis)	1	1.000	2 -->	1
	183 (Tibia anterior tuberosity)	1	0.667	2 -->	0
	186 (Fibula)	1	0.500	0 -->	1
	188 (Astragalus sustentacular facet)	1	0.500	0 -->	1
node_22 -->	node_21	55 (P3/ metacone)	1	0.333	1 --> 0
	56 (P3/ metastyle)	1	0.333	1 -->	0
	57 (P3/ hypocone)	1	0.500	1 -->	0
	74 (M1-2/ lingual cingulum)	1	0.167	0 -->	1
	80 (M2-3/ centrocrista)	1	0.333	0 -->	1
	114 (M/1-2 mesoconid)	1	1.000	0 ==>	1
	116 (M/1-2 postentoconulid)	1	1.000	2 -->	3
	117 (M/1-2 hypoconulid)	1	1.000	0 ==>	1
node_21 -->	node_20	115 (M/1-2 cristid obliqua)	1	0.500	0 ==> 1

23 (Angle between vertical and horizontal rami)		2	2	3	6	0.667	0.750	0.500	0.333	0.750
24 (Coronoid process of the vertical ramus)		1	1	2	5	0.500	0.750	0.375	0.500	0.750
25 (Coronoid process of the vertical ramus)		1	1	2	6	0.500	0.800	0.400	0.500	0.750
26 (Angular process)	1	1	2	5	0.500	0.750	0.375	0.500	0.750	
27 (Symphysis fusion)	1	1	3	4	0.333	0.333	0.111	0.667	0.600	
28 (Posterior extension of the symphysis)		4	4	6	6	0.667	0.000	0.000	0.333	0.600
29 (Lateral thickening of the horizontal ramus)		2	2	3	7	0.667	0.800	0.533	0.333	0.750
30 (Coronoid foramen)	1	1	1	2	1.000	1.000	1.000	0.000	1.000	
31 (Diastema between the jugal and anterior teeth)		1	1	2	4	0.500	0.667	0.333	0.500	0.750
32 (M1/I size)	1	1	2	3	0.500	0.500	0.250	0.500	0.750	
33 (Incisor growth)		1	1	1	3	1.000	1.000	1.000	0.000	1.000
34 (I1/)	1	1	1	3	1.000	1.000	1.000	0.000	1.000	
35 (I3/)	1	1	2	4	0.500	0.667	0.333	0.500	0.750	
36 (Upper incisors)		1	1	1	3	1.000	1.000	1.000	0.000	1.000
37 (Upper canine)		1	1	2	4	0.500	0.667	0.333	0.500	0.750
38 (Lower incisors)		2	2	3	4	0.667	0.500	0.333	0.333	0.750
39 (I/1)	2	2	2	4	1.000	1.000	1.000	0.000	1.000	
40 (I/2)	1	1	1	3	1.000	1.000	1.000	0.000	1.000	
41 (I/3)	1	1	1	5	1.000	1.000	1.000	0.000	1.000	
42 (Lower incisors size)		2	2	2	5	1.000	1.000	1.000	0.000	1.000
43 (Lower canine)		1	1	1	5	1.000	1.000	1.000	0.000	1.000
44 (P1/)	1	1	1	6	1.000	1.000	1.000	0.000	1.000	
45 (P2/)	1	1	1	2	1.000	1.000	1.000	0.000	1.000	
46 (P2/ parasyle)	1	1	2	4	0.500	0.667	0.333	0.500	0.750	
47 (Shape of P2/ in occlusal view)		1	1	2	3	0.500	0.500	0.250	0.500	0.750
48 (P2/ protocone)		1	1	1	2	1.000	1.000	1.000	0.000	1.000
49 (P2/ metacone)		1	1	3	4	0.333	0.333	0.111	0.667	0.600
50 (P2/ metastyle)	1	1	2	2	0.500	0.000	0.000	0.500	0.750	
51 (P2/ lingual cingulum)		1	1	2	4	0.500	0.667	0.333	0.500	0.750
52 (P2/ mesial cingulum)		1	1	2	4	0.500	0.667	0.333	0.500	0.750
53 (P3-4/ mesial cingulum)		1	1	2	4	0.500	0.667	0.333	0.500	0.750
54 (P3/ parastyle)	1	1	3	5	0.333	0.500	0.167	0.667	0.600	
55 (P3/ metacone)	1	1	3	4	0.333	0.333	0.111	0.667	0.600	
56 (P3/ metastyle)	1	1	3	4	0.333	0.333	0.111	0.667	0.600	
57 (P3/ hypocone)	1	1	2	2	0.500	0.000	0.000	0.500	0.750	
58 (P3/ lingual cingulum)		1	1	2	5	0.500	0.750	0.375	0.500	0.750
59 (P3/ lingual cingulum extension)		1	1	1	2	1.000	1.000	1.000	0.000	1.000
60 (P4/ paraconule)	1	1	2	4	0.500	0.667	0.333	0.500	0.750	
61 (P4/ metacone)	3	3	4	6	0.750	0.667	0.500	0.250	0.750	
62 (P4/ hypocone)	1	1	2	5	0.500	0.750	0.375	0.500	0.750	
63 (P4/ lingual cingulum)	1	1	3	5	0.333	0.500	0.167	0.667	0.600	
64 (P4/ lingual cingulum extension)		1	1	1	2	1.000	1.000	1.000	0.000	1.000
65 (P4/ mesial cingulum extension)		1	1	2	3	0.500	0.500	0.250	0.500	0.750
66 (M1-2/ parastyle)	1	1	3	4	0.333	0.333	0.111	0.667	0.600	
67 (M1-2-3/ paraconule)	1	1	3	5	0.333	0.500	0.167	0.667	0.600	
68 (M1-2/ paraconule shape)		1	1	1	3	1.000	1.000	1.000	0.000	1.000
69 (M1-2/ metaconule)	1	1	3	5	0.333	0.500	0.167	0.667	0.600	
70 (M1-2/ metaconule)	2	2	2	3	1.000	1.000	1.000	0.000	1.000	
71 (M1-2/ mesostyle)	1	1	2	4	0.500	0.667	0.333	0.500	0.750	
72 (M1-2-3/ post-paracrista II)		1	1	1	2	1.000	1.000	1.000	0.000	1.000
73 (M1-2/ convolute)	1	1	1	4	1.000	1.000	1.000	0.000	1.000	
74 (M1-2/ lingual cingulum)		1	1	6	7	0.167	0.167	0.028	0.833	0.375
75 (M1/ postentoconule)	1	1	2	4	0.500	0.667	0.333	0.500	0.750	
76 (M1/ postentoconule shape)		2	2	2	3	1.000	1.000	1.000	0.000	1.000

77 (M1/ centrocrista)	1	1	1	4	1.000	1.000	1.000	0.000	1.000
78 (M1/ tritoloph)	1	1	1	3	1.000	1.000	1.000	0.000	1.000
79 (M1/ mesial cingulum)		1	1	3	5	0.333	0.500	0.167	0.667
80 (M2-3/ centrocrista)		1	1	3	3	0.333	0.000	0.000	0.667
81 (M2-3/ tritoloph)		1	1	1	3	1.000	1.000	1.000	0.000
82 (M2-3/ mesial cingulum)			1	1	3	6	0.333	0.600	0.200
83 (M2/ postentoconule)			1	1	3	5	0.333	0.500	0.167
84 (M2/ postentoconule shape)			2	2	3	4	0.667	0.500	0.333
85 (M3/ parastyle)		1	1	4	4	0.250	0.000	0.000	0.750
86 (M3/ paraconule)			1	1	2	2	0.500	0.000	0.000
87 (M3/ metaconule)			1	1	3	3	0.333	0.000	0.000
88 (M3/ mesostyle)			1	1	2	3	0.500	0.500	0.250
89 (M3/ metaloph)			1	1	2	3	0.500	0.500	0.250
90 (M3/ lingual cingulum)				1	2	4	5	0.500	0.333
91 (P/1)	1	1	2	6	0.500	0.800	0.400	0.500	0.750
92 (P/2)	1	1	1	3	1.000	1.000	1.000	0.000	1.000
93 (P/2 occlusal)		1	1	2	2	0.500	0.000	0.000	0.500
94 (P/2 metaconid)			1	1	2	2	0.500	0.000	0.000
95 (P/2 hypoconid)			1	1	2	3	0.500	0.500	0.250
96 (P/2-3-4 mesial cingulid)				1	1	2	4	0.500	0.667
97 (P/3-4 protostylid)			1	1	2	3	0.500	0.500	0.250
98 (P/3 occlusal)		1	1	2	2	0.500	0.000	0.000	0.500
99 (P/3 paraconid)			1	1	2	4	0.500	0.667	0.333
100 (P/3 metaconid)			3	3	4	5	0.750	0.500	0.375
101 (P/3 premetacristid)			1	1	2	2	0.500	0.000	0.000
102 (P/4 occlusal)			1	1	2	2	0.500	0.000	0.000
103 (P/4 paraconid)				1	1	3	3	0.333	0.000
104 (P/4 paraconid size)				1	1	2	4	0.500	0.667
105 (P/4 accessory cusp in front of the metaconid)					1	1	2	2	0.500
106 (P/4 entoconid)				1	1	2	4	0.500	0.667
107 (P/4 premetacristid)				1	1	2	2	0.500	0.000
108 (P/4 metalophid)				1	1	1	3	1.000	1.000
109 (M/1-2 accessory cusp in front of the metaconid)					1	2	4	4	0.500
110 (M/1-2-3 preprotocristid)				1	2	4	6	0.500	0.500
111 (M/1-2 postmetacristid)				1	1	3	8	0.333	0.714
112 (M/1-2 preentocristid)				2	2	3	9	0.667	0.857
113 (M/2-3 buccal cingulid)				1	1	2	4	0.500	0.667
114 (M/1-2 mesoconid)				1	1	1	4	1.000	1.000
115 (M/1-2 cristid obliqua)				1	1	2	4	0.500	0.667
116 (M/1-2 postentoconulid)				3	4	4	7	1.000	1.000
117 (M/1-2 hypoconulid)				1	2	2	5	1.000	1.000
118 (M/1-2 molar pattern)				3	3	4	10	0.750	0.857
119 (M/3 accessory cusp on the premetacristid)					1	2	4	5	0.500
120 (M/3 postmetacristid)				1	1	2	7	0.500	0.833
121 (M/3 preentocristid)				1	1	2	6	0.500	0.800
122 (M/3 preentocristid shape)					1	1	1	4	1.000
123 (M/3 talonid)	1	2	2	5	1.000	1.000	1.000	0.500	0.750
124 (M/3 talonid position)		1	1	1	2	1.000	1.000	1.000	0.000
125 (Enamel microstructure Radial Enamel)				2	2	5	6	0.400	0.250
126 (Enamel microstructure HSB 3DE)					2	3	5	6	0.600
127 (Atlas distal articular facet)		1	1	2	3	0.500	0.500	0.250	0.500
128 (Atlas proximodistal flattening)			1	1	3	4	0.333	0.333	0.111
129 (Atlas dorsoventral flattening)			1	1	2	4	0.500	0.667	0.333
130 (Scapula supraglenoidal tubercle)			2	2	3	4	0.667	0.500	0.333

131 (Scapula scapular spine)	2	2	2	3	1.000	1.000	1.000	0.000	1.000			
132 (Scapula coracoid process)	1	1	2	3	0.500	0.500	0.250	0.500	0.750			
133 (Scapula glenoid cavity)	1	1	2	3	0.500	0.500	0.250	0.500	0.750			
134 (Humerus humeral crest)	2	2	3	4	0.667	0.500	0.333	0.333	0.750			
135 (Humerus deltoid process)	1	1	2	2	0.500	0.000	0.000	0.500	0.750			
136 (Humerus medial supracondylar crest)		1	1	1	3	1.000	1.000	1.000	0.000	1.000		
137 (Humerus entepicondylar foramen)		1	1	2	3	0.500	0.500	0.250	0.500	0.750		
138 (Humerus lateral supracondylar crest)		1	1	2	4	0.500	0.667	0.333	0.500	0.750		
139 (Humerus lateral supracondylar crest lateral extension)			2	2	2	5	1.000	1.000	1.000	0.000	1.000	
140 (Humerus humeral trochlea)	1	1	1	4	1.000	1.000	1.000	0.000	1.000			
141 (Humerus medial condyle of the trochlea)		1	1	1	3	1.000	1.000	1.000	0.000	1.000		
142 (Humerus olecranon fossa)		1	1	1	3	1.000	1.000	1.000	0.000	1.000		
143 (Humerus trochiter)	1	1	1	2	1.000	1.000	1.000	0.000	1.000			
144 (Ulna diaphysis)	1	1	1	2	1.000	1.000	1.000	0.000	1.000			
145 (Ulna synovial groove)	1	1	2	3	0.500	0.500	0.250	0.500	0.750			
146 (Ulna proximal surface for the radius)		1	1	1	2	1.000	1.000	1.000	0.000	1.000		
147 (Ulna olecranon)	2	2	3	4	0.667	0.500	0.333	0.333	0.750			
148 (Ulna proximal extension)		2	2	3	5	0.667	0.667	0.444	0.333	0.750		
149 (Ulna lateral sigmoid facet)	1	1	1	4	1.000	1.000	1.000	0.000	1.000			
150 (Radius size)	1	1	1	2	1.000	1.000	1.000	0.000	1.000			
151 (Radius proximal extremity)		1	1	1	2	1.000	1.000	1.000	0.000	1.000		
152 (Lunar shape in proximal view)		1	1	1	3	1.000	1.000	1.000	0.000	1.000		
153 (Lunar contact facet for the ulna)		1	1	1	2	1.000	1.000	1.000	0.000	1.000		
154 (Lunar contact facet for a free central bone)			1	1	1	2	1.000	1.000	1.000	0.000	1.000	
155 (Lunar contact facet for the unciform)		1	1	1	2	1.000	1.000	1.000	0.000	1.000		
156 (Lunar contact for the scaphoid)		1	1	1	2	1.000	1.000	1.000	0.000	1.000		
157 (Lunar contact for the scaphoid position)			1	1	1	2	1.000	1.000	1.000	0.000	1.000	
158 (Cuneiform in occlusal view)		1	1	1	2	1.000	1.000	1.000	0.000	1.000		
159 (Cuneiform contact for the lunar)		1	1	1	2	1.000	1.000	1.000	0.000	1.000		
160 (Cuneiform ulnar facet shape)		1	1	1	2	1.000	1.000	1.000	0.000	1.000		
161 (Cuneiform contact facet for the Mc V)			1	1	1	2	1.000	1.000	1.000	0.000	1.000	
162 (Cuneiform contact facet for the pisiform)			1	1	1	2	1.000	1.000	1.000	0.000	1.000	
163 (Cuneiform contact facet for the pisiform shape)				1	1	2	3	0.500	0.500	0.250	0.500	0.750
164 (Magnum facet for the Mc II)			1	1	1	2	1.000	1.000	1.000	0.000	1.000	
165 (Magnum facet for the lunar)			1	1	1	2	1.000	1.000	1.000	0.000	1.000	
166 (Ilion)	1	1	2	3	0.500	0.500	0.250	0.500	0.750			
167 (Femur diaphysis)		1	1	1	2	1.000	1.000	1.000	0.000	1.000		
168 (Femur neck)	1	1	2	2	0.500	0.000	0.000	0.500	0.750			
169 (Femur head)	2	2	3	3	0.667	0.000	0.000	0.333	0.750			
170 (Femur greater trochanter)		2	2	3	5	0.667	0.667	0.444	0.333	0.750		
171 (Femur neck size)	1	1	1	3	1.000	1.000	1.000	0.000	1.000			
172 (Femur small trochanter)		2	2	2	4	1.000	1.000	1.000	0.000	1.000		
173 (Femur third trochanter)	1	1	2	2	0.500	0.000	0.000	0.500	0.750			
174 (Femur third trochanter size)		1	1	1	2	1.000	1.000	1.000	0.000	1.000		
175 (Femur distal extremity)		1	1	1	4	1.000	1.000	1.000	0.000	1.000		
176 (Femur trochlea)	1	1	2	3	0.500	0.500	0.250	0.500	0.750			
177 (Femur head orientation)		1	1	3	3	0.333	0.000	0.000	0.667	0.600		
178 (Femur medial condyle)		1	1	1	2	1.000	1.000	1.000	0.000	1.000		
179 (Femur size)	1	1	1	2	1.000	1.000	1.000	0.000	1.000			
180 (Tibia diaphysis)	1	1	1	3	1.000	1.000	1.000	0.000	1.000			
181 (Tibia tuberuculum intercondylare)			1	1	1	3	1.000	1.000	1.000	0.000	1.000	
182 (Tibia area intercondylaris cranialis)		2	2	2	4	1.000	1.000	1.000	0.000	1.000		
183 (Tibia anterior tuberosity)		2	2	3	3	0.667	0.000	0.000	0.333	0.750		
184 (Tibia diaphysis shape)		2	2	2	4	1.000	1.000	1.000	0.000	1.000		

185 (Tibia tibial cochlea)	1	1	1	2	1.000	1.000	1.000	0.000	1.000
186 (Fibula)	1	1	2	2	0.500	0.000	0.000	0.500	0.750
187 (Astragalus tuberculum mediale)		1	1	1	2	1.000	1.000	1.000	0.000
188 (Astragalus sustentacular facet)		1	1	2	2	0.500	0.000	0.000	0.500
189 (Astragalus ectal facet)	2	2	2	3	1.000	1.000	1.000	0.000	1.000
190 (Astragalus fibular facet)	1	1	1	2	1.000	1.000	1.000	0.000	1.000
191 (Astragalus foramen astragali)		1	1	1	2	1.000	1.000	1.000	0.000
192 (Astragalus fibular facet orientation)		1	1	1	2	1.000	1.000	1.000	0.000
193 (Astragalus in lateral view)		1	1	1	2	1.000	1.000	1.000	0.000
194 (Astragalus in anterior view)		1	1	1	2	1.000	1.000	1.000	0.000
195 (Astragalus neck)	1	1	1	2	1.000	1.000	1.000	0.000	1.000
196 (Astragalus crista capitatis)	1	1	1	2	1.000	1.000	1.000	0.000	1.000
197 (Astragalus tibial facet)	2	2	2	3	1.000	1.000	1.000	0.000	1.000
198 (Calcaneum ectal and sustentacular facets)			1	1	1	3	1.000	1.000	1.000
199 (Calcaneum tuber calcanei)		1	1	2	3	0.500	0.500	0.250	0.500
200 (Calcaneum sustentacular facet shape)			1	1	1	3	1.000	1.000	1.000

DELTRAN
#####

paup> pset opt=delTran;

paup> hsearch addseq=random nreps=10000 hold=100;

Heuristic search settings:

Optimality criterion = parsimony

Character-status summary:

Of 200 total characters:

All characters are of type 'unord'

All characters have equal weight

All characters are parsimony-informative

Gaps are treated as "missing"

Multistate taxa interpreted as polymorphism

Starting tree(s) obtained via stepwise addition

Addition sequence: random

Number of replicates = 10000

Starting seed = generated automatically

Number of trees held at each step = 100

Branch-swapping algorithm: tree-bisection-reconnection (TBR) with reconnection limit = 8

Steepest descent option not in effect

Initial 'Maxtrees' setting = 4100 (will be auto-increased by 1000)

Branches collapsed (creating polytomies) if maximum branch length is zero

'MulTrees' option in effect

No topological constraints in effect

Trees are unrooted

Heuristic search completed

Total number of rearrangements tried = 34504391

Score of best tree(s) found = 390

Number of trees retained = 4

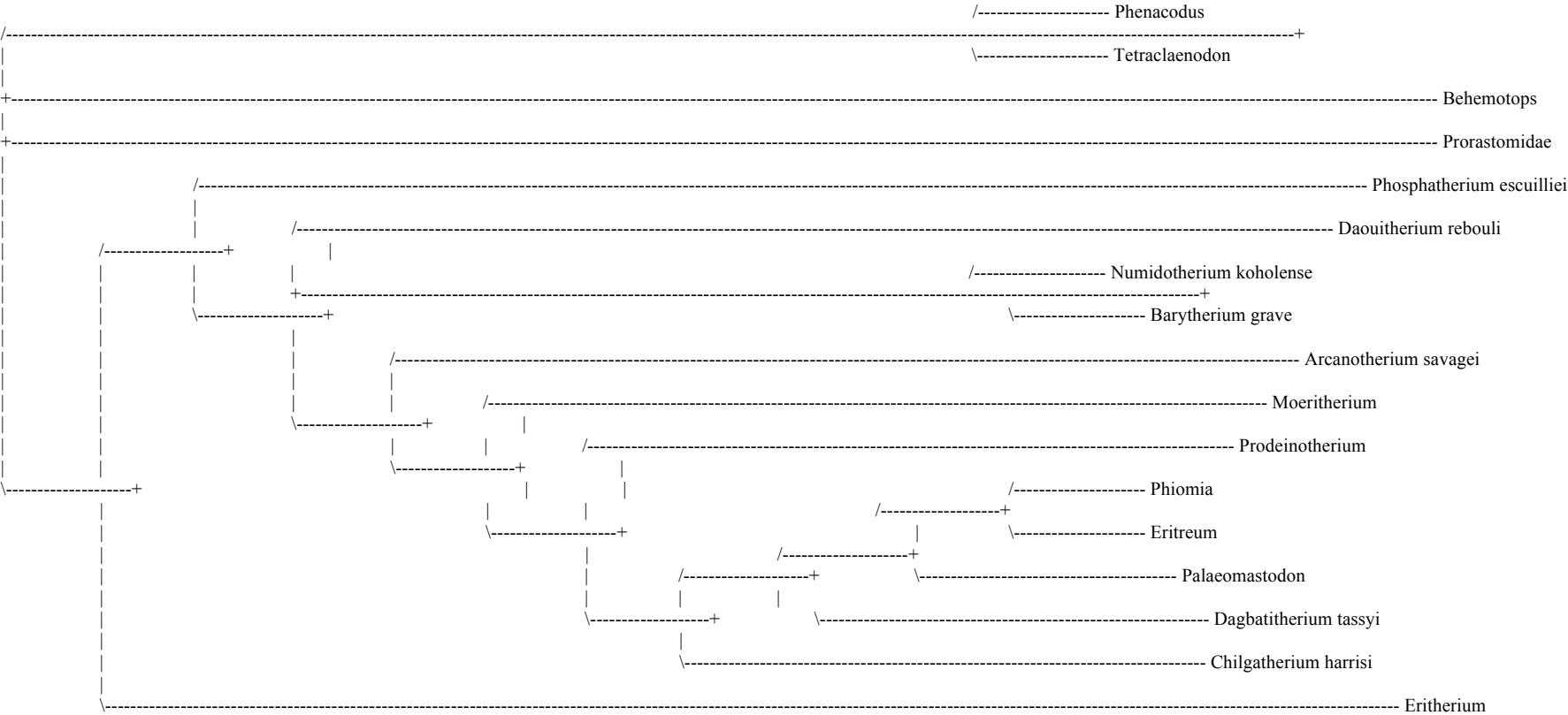
Time used = 00:07:41 (CPU time = 00:07:38.8)

Tree-island profile:

Island	Size	First tree	Last tree	First Score	Times replicate	hit
1	4	1	4	390	1	10000

paup> Contre all/treefile=DagbatitheriumConsDEL.tre;

Strict consensus of 4 trees:



Consensus tree(s) written to treefile: C:\Users\Mourl\Desktop\Dagbatitherium_Manuscript_Figures_Matrix\DagbatitheriumConsDEL.tre

paup> execute DagbatitheriumConsDEL.tre;

Processing of file "C:\Users\Mourl\Desktop\Dagbatitherium_Manuscript_Figures_Matrix\DagbatitheriumConsDEL.tre" begins...

1 tree read from TREES block; time used = 0.00 sec (CPU time = 0.00 sec)

Processing of input file "DagbatitheriumConsDEL.tre" completed.

paup> describeTrees / plot=Both apoList diagnose;

Tree description:

Unrooted tree(s) rooted using outgroup method

Optimality criterion = parsimony

Character-status summary:

Of 200 total characters:

All characters are of type 'unord'

All characters have equal weight

All characters are parsimony-informative

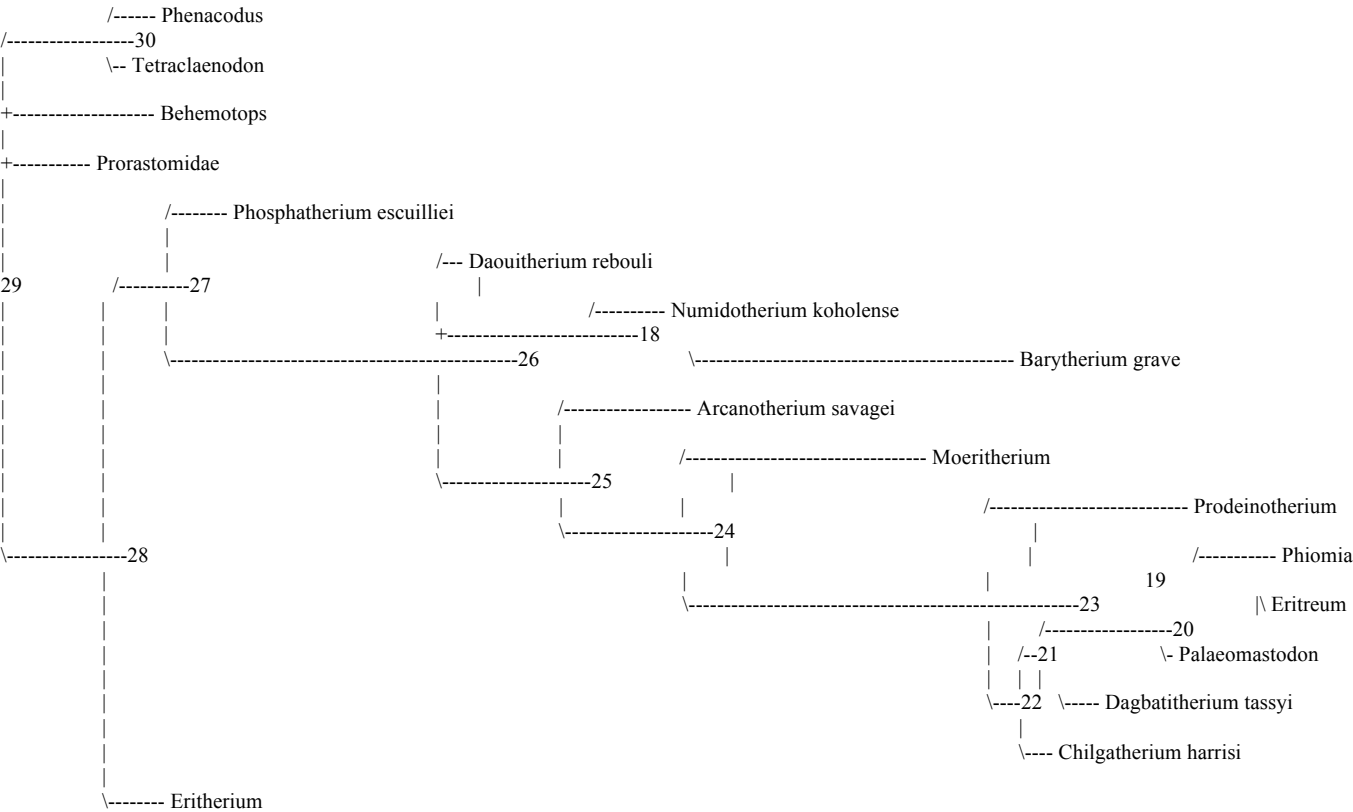
Gaps are treated as "missing"

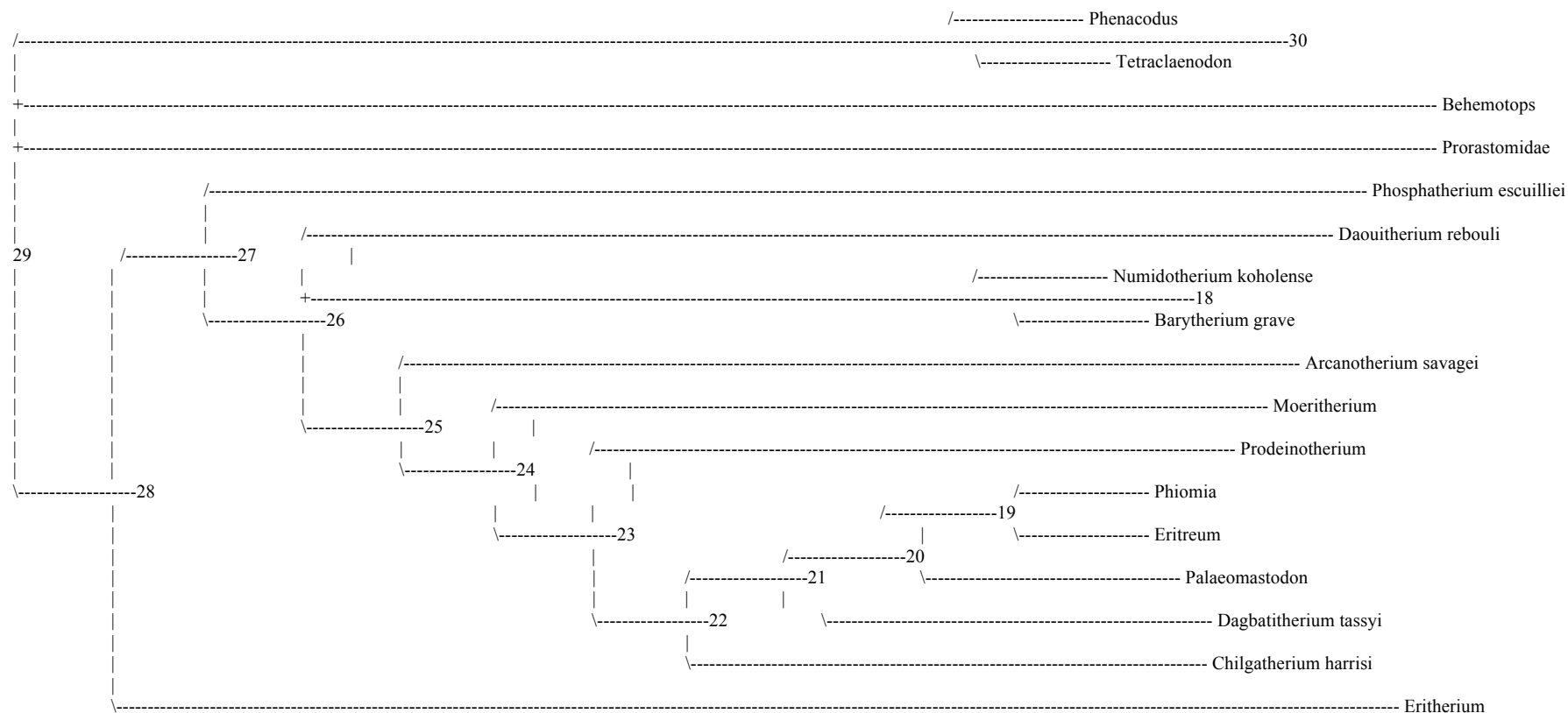
Multistate taxa interpreted as polymorphism ("min" values for CI, RI, and RC are minimum-possible character lengths)

Character-state optimization: Delayed transformation (DELTRAN)

Tree 1 ("Strict") (rooted using user-specified outgroup)

Tree length = 393
Consistency index (CI) = 0.6387
Homoplasy index (HI) = 0.3817
Retention index (RI) = 0.6966
Rescaled consistency index (RC) = 0.4449





Apomorphy lists:

Branch	Character	Steps	CI	Change
node_29 --> node_30	23 (Angle between vertical and horizontal rami)	1	0.667	1 ==> 0
	30 (Coronoid foramen)	1	1.000	1 ==> 0
	32 (M1/1 size)	1	0.500	0 ==> 2
	64 (P4/ lingual cingulum extension)	1	1.000	1 ==> 0
	65 (P4/ mesial cingulum extension)	1	0.500	1 ==> 0
	66 (M1-2/ parastyle)	1	0.333	1 ==> 0
	83 (M2/ postentoconule)	1	0.333	1 ==> 0
	97 (P/3-4 protostylid)	1	0.500	1 ==> 0
	104 (P/4 paraconid size)	1	0.500	1 ==> 0
	118 (M/1-2 molar pattern)	1	0.750	1 ==> 0
	125 (Enamel microstructure Radial Enamel)	1	0.400	0 --> 1
	167 (Femur diaphysis)	1	1.000	1 ==> 0
	174 (Femur third trochanter size)	1	1.000	1 ==> 0
	176 (Femur trochlea)	1	0.500	1 ==> 0
	179 (Femur size)	1	1.000	1 ==> 0
	184 (Tibia diaphysis shape)	1	1.000	2 ==> 0

node_30 --> Phenacodus	54 (P3/ parastyle)	1 0.333 0 ==> 1
	55 (P3/ metacone)	1 0.333 0 ==> 1
	56 (P3/ metastyle)	1 0.333 0 ==> 1
	74 (M1-2/ lingual cingulum)	1 0.167 0 --> 1
	85 (M3/ parastyle)	1 0.250 0 --> 1
node_30 --> Tetracaelonodon	47 (Shape of P2/ in occlusal view)	1 0.500 1 ==> 0
	87 (M3/ metaconule)	1 0.333 1 ==> 0
node_29 --> Behemotops	26 (Angular process)	1 0.500 0 ==> 1
	27 (Symphysis fusion)	1 0.333 0 --> 1
	28 (Posterior extension of the symphysis)	1 0.667 1 ==> 2
	31 (Diastema between the jugal and anterior teeth)	1 0.500 0 ==> 1
	38 (Lower incisors)	1 0.667 0 --> 1
	71 (M1-2/ mesostyle)	1 0.500 0 ==> 1
	74 (M1-2/ lingual cingulum)	1 0.167 0 --> 1
	80 (M2-3/ centrocrista)	1 0.333 0 ==> 1
	84 (M2/ postentoconule shape)	1 0.667 0 --> 1
	88 (M3/ mesostyle)	1 0.500 0 --> 1
	100 (P3 metaconid)	1 0.750 0 ==> 2
	106 (P4 entoconid)	1 0.500 0 ==> 1
	111 (M1-2 postmetacristid)	1 0.333 0 ==> 1
	115 (M1-2 cristid obliqua)	1 0.500 0 ==> 1
	120 (M3 postmetacristid)	1 0.500 0 ==> 1
	121 (M3 preentocristid)	1 0.500 0 ==> 1
node_29 --> Prorastomidae	1 (Frontal)	1 0.500 0 ==> 1
	2 (Posterior extension of the nares)	1 0.500 0 ==> 1
	15 (Maxillary processus pyramidalis - anterior extension)	1 0.400 0 --> 1
	27 (Symphysis fusion)	1 0.333 0 --> 1
	28 (Posterior extension of the symphysis)	1 0.667 1 ==> 3
	79 (M1/ mesial cingulum)	1 0.333 0 ==> 1
	82 (M2-3/ mesial cingulum)	1 0.333 0 ==> 1
	90 (M3/ lingual cingulum)	1 0.500 0 ==> 1
	170 (Femur greater trochanter)	1 0.667 0 --> 1
node_29 --> node_28	3 (Opening of the orbit)	1 1.000 0 ==> 1
	16 (Maxillary processus pyramidalis - posterior extension)	1 0.667 0 ==> 1
	17 (Zygomatic arches)	1 1.000 0 ==> 1
	38 (Lower incisors)	1 0.667 0 --> 1
	46 (P2/ parastyle)	1 0.500 0 --> 1
	49 (P2/ metacone)	1 0.333 0 --> 1
	51 (P2/ lingual cingulum)	1 0.500 0 --> 1
	58 (P3/ lingual cingulum)	1 0.500 0 --> 1
	60 (P4/ paraconule)	1 0.500 0 ==> 1
	63 (P4/ lingual cingulum)	1 0.333 0 ==> 1
	67 (M1-2-3/ paraconule)	1 0.333 0 ==> 1
	69 (M1-2/ metaconule)	1 0.333 0 ==> 1
	75 (M1/ postentoconule)	1 0.500 0 --> 1
	99 (P3 paraconid)	1 0.500 0 ==> 1
	113 (M2-3 buccal cingulid)	1 0.500 0 ==> 1
node_28 --> node_27	4 (Position of the orbit)	1 0.400 0 --> 1

10 (Parietal)	1	1.000	0 --> 1
11 (Petrosal bone)	1	1.000	0 --> 1
41 (I/3)	1	1.000	0 ==> 1
42 (Lower incisors size)	1	1.000	0 ==> 1
43 (Lower canine)	1	1.000	0 ==> 1
88 (M3/ mesostyle)	1	0.500	0 --> 1
110 (M/1-2-3 preprotocrisid)	1	0.500	0 --> 1
118 (M/1-2 molar pattern)	1	0.750	1 ==> 2
119 (M/3 accessory cusp on the premetacristid)	1	0.500	0 --> 1

node_27 --> Phosphatherium escuilliei 15 (Maxillary processus pyramidalis - anterior extension) 1 0.400 0 --> 1

18 (Position of the postglenoid foramen)	1	1.000	0 --> 1
66 (M1-2/ parastyle)	1	0.333	1 ==> 0
85 (M3/ parastyle)	1	0.250	0 --> 1
90 (M3/ lingual cingulum)	1	0.500	0 --> (01)
109 (M/1-2 accessory cusp in front of the metaconid)	1	0.500	0 ==> 1
125 (Enamel microstructure Radial Enamel)	1	0.400	0 --> 1

node_27 --> node_26 5 (Processus orbitalis of the palatine) 1 1.000 0 --> 1

6 (Jugal)	1	1.000	0 --> 1
7 (External auditory meatus)	1	1.000	0 ==> 1
8 (External auditory meatus)	1	1.000	0 ==> 1
9 (Squamosal)	1	1.000	0 ==> 1
15 (Maxillary processus pyramidalis - anterior extension)	1	0.400	0 --> 2
18 (Position of the postglenoid foramen)	1	1.000	0 --> 2
19 (Condylar foramina)	1	1.000	0 ==> 1
20 (Zygomatic extension of the squamosal)	1	1.000	0 ==> 1
27 (Symphysis fusion)	1	0.333	0 --> 1
31 (Diastema between the jugal and anterior teeth)	1	0.500	0 --> 1
36 (Upper incisors)	1	1.000	0 --> 1
44 (P1/)	1	1.000	0 ==> 1
53 (P3-4/ mesial cingulum)	1	0.500	0 ==> 1
71 (M1-2/ mesostyle)	1	0.500	0 ==> 1
79 (M1/ mesial cingulum)	1	0.333	0 ==> 1
82 (M2-3/ mesial cingulum)	1	0.333	0 ==> 1
96 (P/2-3-4 mesial cingulid)	1	0.500	0 --> 1
112 (M/1-2 preentocrisid)	1	0.667	0 ==> 1
122 (M/3 preentocrisid shape)	1	1.000	0 ==> 1
125 (Enamel microstructure Radial Enamel)	1	0.400	0 --> 2
131 (Scapula scapular spine)	1	1.000	0 --> 2
153 (Lunar contact facet for the ulna)	1	1.000	0 --> 1
155 (Lunar contact facet for the unciform)	1	1.000	0 --> 1
158 (Cuneiform in occlusal view)	1	1.000	0 --> 1
160 (Cuneiform ulnar facet shape)	1	1.000	0 --> 1
161 (Cuneiform contact facet for the Mc V)	1	1.000	0 --> 1
164 (Magnum facet for the Mc II)	1	1.000	0 --> 1
171 (Femur neck size)	1	1.000	0 --> 1
172 (Femur small trochanter)	1	1.000	0 --> 1
175 (Femur distal extremity)	1	1.000	0 --> 1
181 (Tibia tuberculum intercondylare)	1	1.000	0 --> 1
184 (Tibia diaphysis shape)	1	1.000	2 --> 1
185 (Tibia tibial cochlea)	1	1.000	0 --> 1
187 (Astragalus tuberculum mediale)	1	1.000	0 --> 1
189 (Astragalus ectal facet)	1	1.000	0 --> 2

191 (Astragalus foramen astragali)	1	1.000	0 --> 1
192 (Astragalus fibular facet orientation)	1	1.000	0 --> 1
195 (Astragalus neck)	1	1.000	0 --> 1
196 (Astragalus crista capitis)	1	1.000	0 --> 1
197 (Astragalus tibial facet)	1	1.000	0 --> 2

node_26 --> Daouitherium rebouli	23 (Angle between vertical and horizontal rami)	1	0.667	1 ==> 2
95 (P/2 hypocond)	1	0.500	0 --> 1	

node_26 --> node_18	13 (Pneumatisation)	1	0.667	0 --> 1
25 (Coronoid process of the vertical ramus)	1	0.500	0 --> 1	
48 (P2/ protocone)	1	1.000	0 ==> 1	
52 (P2/ mesial cingulum)	1	0.500	0 --> 1	
72 (M1-2-3/ post-paracrista II)	1	1.000	0 ==> 1	
75 (M1/ postentoconule)	1	0.500	1 ==> 0	
83 (M2/ postentoconule)	1	0.333	1 ==> 0	
90 (M3/ lingual cingulum)	1	0.500	0 ==> 1	
91 (P/1)	1	0.500	0 --> 1	
95 (P/2 hypocond)	1	0.500	0 --> 1	
126 (Enamel microstructure HSB 3DE)	1	0.600	1 ==> 3	
127 (Atlas distal articular facet)	1	0.500	0 ==> 1	
128 (Atlas proximodistal flattening)	1	0.333	0 --> 1	
134 (Humerus humeral crest)	1	0.667	0 --> 2	
138 (Humerus lateral supracondylar crest)	1	0.500	0 --> 1	
139 (Humerus lateral supracondylar crest lateral extension)	1	1.000	0 ==> 2	
146 (Ulna proximal surface for the radius)	1	1.000	0 ==> 1	
148 (Ulna proximal extension)	1	0.667	0 --> 1	
157 (Lunar contact for the scaphoid position)	1	1.000	0 ==> 1	
165 (Magnum facet for the lunar)	1	1.000	0 ==> 1	
166 (Ilion)	1	0.500	0 --> 1	
170 (Femur greater trochanter)	1	0.667	0 --> 1	
199 (Calcaneum tuber calcanei)	1	0.500	0 --> 1	

node_18 --> Numidotherium koholense	14 (Postorbital process of the frontal)	1	0.500	0 --> 1
49 (P2/ metacone)	1	0.333	1 ==> 0	
66 (M1-2/ parastyle)	1	0.333	1 ==> 0	
85 (M3/ parastyle)	1	0.250	0 --> 1	
119 (M/3 accessory cusp on the premetacristid)	1	0.500	1 ==> 0	
133 (Scapula glenoid cavity)	1	0.500	0 ==> 1	
176 (Femur trochlea)	1	0.500	1 ==> 0	
197 (Astragalus tibial facet)	1	1.000	2 ==> 1	

node_18 --> Barytherium grave	4 (Position of the orbit)	1	0.400	1 --> 2
16 (Maxillary processus pyramidalis - posterior extension)	1	0.667	1 ==> 2	
22 (Origin of the vertical ramus)	1	1.000	0 ==> 3	
24 (Coronoid process of the vertical ramus)	1	0.500	0 ==> 1	
28 (Posterior extension of the symphysis)	1	0.667	1 ==> 4	
29 (Lateral thickening of the horizontal ramus)	1	0.667	0 ==> 1	
35 (I3/)	1	0.500	0 ==> 1	
37 (Upper canine)	1	0.500	0 ==> 1	
39 (I/1)	1	1.000	0 ==> 1	
50 (P2/ metastyle)	1	0.500	0 ==> 1	
54 (P3/ parastyle)	1	0.333	0 ==> 1	
61 (P4/ metacone)	1	0.750	0 ==> 1	

62 (P4/ hypocone)	1	0.500	0 ==> 1
93 (P/2 occlusal)	1	0.500	0 ==> 1
94 (P/2 metaconid)	1	0.500	0 ==> 1
98 (P/3 occlusal)	1	0.500	0 ==> 1
100 (P/3 metaconid)	1	0.750	0 ==> 1
101 (P/3 premetacristid)	1	0.500	0 ==> 1
102 (P/4 occlusal)	1	0.500	0 ==> 1
103 (P/4 paraconid)	1	0.333	0 ==> 1
105 (P/4 accessory cusp in front of the metaconid)	1	0.500	0 ==> 1
107 (P/4 premetacristid)	1	0.500	0 ==> 1
109 (M/1-2 accessory cusp in front of the metaconid)	1	0.500	0 ==> 1
130 (Scapula supraglenoidal tubercle)	1	0.667	0 ==> 1
132 (Scapula coracoid process)	1	0.500	0 --> 1
137 (Humerus entepicondylar foramen)	1	0.500	0 --> 1
145 (Ulna synovial groove)	1	0.500	0 --> 1
147 (Ulna olecranon)	1	0.667	0 --> 1
163 (Cuneiform contact facet for the pisiform shape)	1	0.500	0 --> 1
168 (Femur neck)	1	0.500	0 ==> 1
169 (Femur head)	1	0.667	0 ==> 1
177 (Femur head orientation)	1	0.333	0 --> 1
183 (Tibia anterior tuberosity)	1	0.667	0 --> 1
186 (Fibula)	1	0.500	0 ==> 1
188 (Astragalus sustentacular facet)	1	0.500	0 ==> 1
189 (Astragalus ectal facet)	1	1.000	2 ==> 1

node_26 --> node_25	22 (Origin of the vertical ramus)	1	1.000	0 ==> 2
	29 (Lateral thickening of the horizontal ramus)	1	0.667	0 ==> 1
	67 (M1-2-3/ paraconule)	1	0.333	1 ==> 0
	68 (M1-2/ paraconule shape)	1	1.000	0 --> 1
	69 (M1-2/ metaconule)	1	0.333	1 ==> 0
	77 (M1/ centrocrista)	1	1.000	0 ==> 1
	100 (P/3 metaconid)	1	0.750	0 ==> 1
	110 (M/1-2-3 preprotocristid)	1	0.500	1 ==> 0
	111 (M/1-2 postmetacristid)	1	0.333	0 ==> 1
	112 (M/1-2 preentocristid)	1	0.667	1 ==> 2
	125 (Enamel microstructure Radial Enamel)	1	0.400	2 --> 1
	129 (Atlas dorsoventral flattening)	1	0.500	0 ==> 1
	132 (Scapula coracoid process)	1	0.500	0 --> 1
	145 (Ulna synovial groove)	1	0.500	0 --> 1
	147 (Ulna olecranon)	1	0.667	0 --> 2
	149 (Ulna lateral sigmoid facet)	1	1.000	0 ==> 1
	152 (Lunar shape in proximal view)	1	1.000	0 ==> 1
	163 (Cuneiform contact facet for the pisiform shape)	1	0.500	0 --> 1

node_25 --> Arcanotherium savagei	70 (M1-2/ metaconule)	1	1.000	0 --> 2
	74 (M1-2/ lingual cingulum)	1	0.167	0 --> 1
	86 (M3/ paraconule)	1	0.500	0 --> 1
	93 (P/2 occlusal)	1	0.500	0 ==> 1
	94 (P/2 metaconid)	1	0.500	0 ==> 1
	98 (P/3 occlusal)	1	0.500	0 ==> 1
	101 (P/3 premetacristid)	1	0.500	0 ==> 1
	102 (P/4 occlusal)	1	0.500	0 ==> 1
	103 (P/4 paraconid)	1	0.333	0 ==> 1
	105 (P/4 accessory cusp in front of the metaconid)	1	0.500	0 ==> 1

107 (P/4 premetacristid)	1	0.500	0 ==> 1
109 (M/1-2 accessory cusp in front of the metaconid)	1	0.500	0 ==> 1
126 (Enamel microstructure HSB 3DE)	1	0.600	1 ==> 2
128 (Atlas proximodistal flattening)	1	0.333	0 --> 1
148 (Ulna proximal extension)	1	0.667	0 --> 1

node_25 --> node_24	12 (Foramen ovale)	1	1.000	0 --> 1
	24 (Coronoid process of the vertical ramus)	1	0.500	0 --> 1
	25 (Coronoid process of the vertical ramus)	1	0.500	0 --> 1
	26 (Angular process)	1	0.500	0 --> 1
	51 (P2/ lingual cingulum)	1	0.500	1 --> 0
	55 (P3/ metacone)	1	0.333	0 --> 1
	56 (P3/ metastyle)	1	0.333	0 --> 1
	58 (P3/ lingual cingulum)	1	0.500	1 --> 0
	59 (P3/ lingual cingulum extension)	1	1.000	0 --> 1
	65 (P4/ mesial cingulum extension)	1	0.500	1 --> 0
	73 (M1-2/ convolute)	1	1.000	0 ==> 1
	91 (P/1)	1	0.500	0 --> 1
	119 (M/3 accessory cusp on the premetacristid)	1	0.500	1 ==> 0
	120 (M/3 postmetacristid)	1	0.500	0 ==> 1
	134 (Humerus humeral crest)	1	0.667	0 --> 1
	137 (Humerus entepicondylar foramen)	1	0.500	0 --> 1
	140 (Humerus humeral trochlea)	1	1.000	0 --> 1
	141 (Humerus medial condyle of the trochlea)	1	1.000	0 --> 1
	182 (Tibia area intercondylaris cranialis)	1	1.000	0 --> 2

node_24 --> Moeritherium	4 (Position of the orbit)	1	0.400	1 --> 2
	14 (Postorbital process of the frontal)	1	0.500	0 --> 1
	15 (Maxillary processus pyramidalis - anterior extension)	1	0.400	2 --> 1
	16 (Maxillary processus pyramidalis - posterior extension)	1	0.667	1 ==> 2
	28 (Posterior extension of the symphysis)	1	0.667	1 --> 3
	42 (Lower incisors size)	1	1.000	1 ==> 2
	49 (P2/ metacone)	1	0.333	1 ==> 0
	50 (P2/ metastyle)	1	0.500	0 ==> 1
	63 (P4/ lingual cingulum)	1	0.333	1 --> 0
	74 (M1-2/ lingual cingulum)	1	0.167	0 --> 1
	76 (M1/ postentoconule shape)	1	1.000	0 --> 1
	80 (M2-3/ centrocrista)	1	0.333	0 ==> 1
	84 (M2/ postentoconule shape)	1	0.667	0 --> 1
	86 (M3/ paraconule)	1	0.500	0 --> 1
	87 (M3/ metaconule)	1	0.333	1 --> 0
	97 (P/3-4 protostylid)	1	0.500	1 ==> 0
	113 (M/2-3 buccal cingulid)	1	0.500	1 ==> 0
	118 (M/1-2 molar pattern)	1	0.750	2 --> 3
	130 (Scapula supraglenoidal tubercle)	1	0.667	0 --> 1
	131 (Scapula scapular spine)	1	1.000	2 ==> 1
	135 (Humerus deltoid process)	1	0.500	0 --> 1
	147 (Ulna olecranon)	1	0.667	2 --> 1
	169 (Femur head)	1	0.667	0 ==> 2
	172 (Femur small trochanter)	1	1.000	1 ==> 2
	173 (Femur third trochanter)	1	0.500	0 --> 1
	177 (Femur head orientation)	1	0.333	0 --> 1
	183 (Tibia anterior tuberosity)	1	0.667	0 --> 2

node_24 --> node_23	1 (Frontal)	1 0.500 0 ==> 1
	2 (Posterior extension of the nares)	1 0.500 0 ==> 1
	21 (Mandibular symphysis)	1 1.000 0 ==> 1
	22 (Origin of the vertical ramus)	1 1.000 2 ==> 1
	23 (Angle between vertical and horizontal rami)	1 0.667 1 ==> 2
	29 (Lateral thickening of the horizontal ramus)	1 0.667 1 ==> 2
	33 (Incisor growth)	1 1.000 0 ==> 1
	34 (I1/)	1 1.000 0 ==> 1
	35 (I3/)	1 0.500 0 ==> 1
	37 (Upper canine)	1 0.500 0 ==> 1
	39 (I/1)	1 1.000 0 ==> 2
	40 (I/2)	1 1.000 0 ==> 1
	61 (P4/ metacone)	1 0.750 0 ==> 2
	62 (P4/ hypocone)	1 0.500 0 ==> 1
	76 (M1/ postentoconule shape)	1 1.000 0 --> 2
	78 (M1/ tritoloph)	1 1.000 0 ==> 1
	92 (P/2)	1 1.000 0 ==> 1
	104 (P/4 paraconid size)	1 0.500 1 --> 0
	106 (P/4 entoconid)	1 0.500 0 ==> 1
	108 (P/4 metalophid)	1 1.000 0 ==> 1
	121 (M/3 preentocristid)	1 0.500 0 --> 1
	130 (Scapula supraglenoidal tubercle)	1 0.667 0 --> 2
	133 (Scapula glenoid cavity)	1 0.500 0 ==> 1
	136 (Humerus medial supracondylar crest)	1 1.000 0 ==> 1
	138 (Humerus lateral supracondylar crest)	1 0.500 0 --> 1
	139 (Humerus lateral supracondylar crest lateral extension)	1 1.000 0 ==> 1
	142 (Humerus olecranon fossa)	1 1.000 0 ==> 1
	143 (Humerus trochiter)	1 1.000 0 ==> 1
	144 (Ulna diaphysis)	1 1.000 0 ==> 1
	148 (Ulna proximal extension)	1 0.667 0 --> 2
	150 (Radius size)	1 1.000 0 --> 1
	151 (Radius proximal extremity)	1 1.000 0 --> 1
	154 (Lunar contact facet for a free central bone)	1 1.000 0 --> 1
	156 (Lunar contact for the scaphoid)	1 1.000 0 --> 1
	159 (Cuneiform contact for the lunar)	1 1.000 0 --> 1
	162 (Cuneiform contact facet for the pisiform)	1 1.000 0 --> 1
	170 (Femur greater trochanter)	1 0.667 0 --> 2
	178 (Femur medial condyle)	1 1.000 0 ==> 1
	180 (Tibia diaphysis)	1 1.000 0 ==> 1
	190 (Astragalus fibular facet)	1 1.000 0 ==> 1
	193 (Astragalus in lateral view)	1 1.000 0 ==> 1
	194 (Astragalus in anterior view)	1 1.000 0 ==> 1
	198 (Calcaneum ectal and sustentacular facets)	1 1.000 0 ==> 1
	199 (Calcaneum tuber calcanei)	1 0.500 0 --> 1
	200 (Calcaneum sustentacular facet shape)	1 1.000 0 --> 1
node_23 --> Prodeinotherium	13 (Pneumatisation)	1 0.667 0 --> 2
	28 (Posterior extension of the symphysis)	1 0.667 1 --> 3
	32 (M1/1 size)	1 0.500 0 ==> 2
	38 (Lower incisors)	1 0.667 1 ==> 2
	57 (P3/ hypocone)	1 0.500 0 --> 1
	67 (M1-2-3/ paraconule)	1 0.333 0 ==> 1
	69 (M1-2/ metaconule)	1 0.333 0 ==> 1
	83 (M2/ postentoconule)	1 0.333 1 ==> 0

	89 (M3/ metaloph)	1 0.500 0 --> 1
	90 (M3/ lingual cingulum)	1 0.500 0 ==> 1
	99 (P/3 paraconid)	1 0.500 1 --> 0
	116 (M/1-2 postentoconulid)	1 1.000 0 --> (02)
	117 (M/1-2 hypoconulid)	1 1.000 0 --> (01)
	125 (Enamel microstructure Radial Enamel)	1 0.400 1 ==> 2
	126 (Enamel microstructure HSB 3DE)	1 0.600 1 ==> 3
	127 (Atlas distal articular facet)	1 0.500 0 ==> 1
	128 (Atlas proximodistal flattening)	1 0.333 0 --> 1
	129 (Atlas dorsoventral flattening)	1 0.500 1 ==> 0
	135 (Humerus deltoid process)	1 0.500 0 --> 1
	166 (Ilion)	1 0.500 0 --> 1
	168 (Femur neck)	1 0.500 0 ==> 1
	169 (Femur head)	1 0.667 0 ==> 1
	173 (Femur third trochanter)	1 0.500 0 --> 1
	177 (Femur head orientation)	1 0.333 0 --> 1
	183 (Tibia anterior tuberosity)	1 0.667 0 --> 2
node_23 --> node_22	54 (P3/ parastyle)	1 0.333 0 ==> 1
	63 (P4/ lingual cingulum)	1 0.333 1 --> 0
	81 (M2-3/ tritoloph)	1 1.000 0 ==> 1
	118 (M/1-2 molar pattern)	1 0.750 2 --> 3
	123 (M/3 talonid)	1 1.000 0 ==> 1
node_22 --> node_21	114 (M/1-2 mesoconid)	1 1.000 0 ==> 1
	116 (M/1-2 postentoconulid)	1 1.000 0 --> 3
	117 (M/1-2 hypoconulid)	1 1.000 0 ==> 1
node_21 --> node_20	4 (Position of the orbit)	1 0.400 1 --> 0
	45 (P2/)	1 1.000 0 --> 1
	46 (P2/ parasyle)	1 0.500 1 --> 0
	47 (Shape of P2/ in occlusal view)	1 0.500 1 --> 0
	52 (P2/ mesial cingulum)	1 0.500 0 --> 1
	53 (P3-4/ mesial cingulum)	1 0.500 1 --> 0
	55 (P3/ metacone)	1 0.333 1 --> 0
	56 (P3/ metastyle)	1 0.333 1 --> 0
	70 (M1-2/ metaconule)	1 1.000 0 --> 1
	74 (M1-2/ lingual cingulum)	1 0.167 0 --> 1
	79 (M1/ mesial cingulum)	1 0.333 1 --> 0
	84 (M2/ postentoconule shape)	1 0.667 0 --> 2
	89 (M3/ metaloph)	1 0.500 0 --> 1
	115 (M/1-2 cristid obliqua)	1 0.500 0 ==> 1
	134 (Humerus humeral crest)	1 0.667 1 --> 2
	182 (Tibia area intercondilaris cranialis)	1 1.000 2 --> 1
node_20 --> node_19	124 (M/3 talonid position)	1 1.000 0 ==> 1
node_19 --> Phiomia	13 (Pneumatisation)	1 0.667 0 --> 1
	15 (Maxillary processus pyramidalis - anterior extension)	1 0.400 2 --> 1
	61 (P4/ metacone)	1 0.750 2 --> 3
	80 (M2-3/ centrocrista)	1 0.333 0 --> 1
	82 (M2-3/ mesial cingulum)	1 0.333 1 --> 0
	87 (M3/ metaconule)	1 0.333 1 --> 0
	100 (P/3 metaconid)	1 0.750 1 --> 3

126 (Enamel microstructure HSB 3DE) 1 0.600 1 --> (12)
 186 (Fibula) 1 0.500 0 --> 1
 188 (Astragalus sustentacular facet) 1 0.500 0 --> 1

node_20 --> Palaeomastodon 28 (Posterior extension of the symphysis) 1 0.667 1 --> 5

node_21 --> Dagbatitherium tassyi 110 (M/1-2-3 preprotocristid) 1 0.500 0 ==> 1
 111 (M/1-2 postmetacristid) 1 0.333 1 ==> 0
 112 (M/1-2 preentocristid) 1 0.667 2 ==> 1
 126 (Enamel microstructure HSB 3DE) 1 0.600 1 ==> 2

node_22 --> Chilgatherium harrisi 57 (P3/ hypocone) 1 0.500 0 --> 1
 60 (P4/ paraconule) 1 0.500 1 ==> 0
 116 (M/1-2 postentoconulid) 1 1.000 0 --> 2

node_28 --> Eritherium 4 (Position of the orbit) 1 0.400 0 --> 2
 61 (P4/ metacone) 1 0.750 0 ==> 1
 74 (M1-2/ lingual cingulum) 1 0.167 0 --> 1
 85 (M3/ parastyle) 1 0.250 0 --> 1
 96 (P/2-3-4 mesial cingulid) 1 0.500 0 --> 1
 103 (P/4 paraconid) 1 0.333 0 ==> 1
 109 (M/1-2 accessory cusp in front of the metaconid) 1 0.500 0 --> (01)
 110 (M/1-2-3 preprotocristid) 1 0.500 0 --> (01)
 116 (M/1-2 postentoconulid) 1 1.000 0 ==> 1
 119 (M/3 accessory cusp on the premetacristid) 1 0.500 0 --> (01)
 123 (M/3 talonid) 1 1.000 0 --> (01)

Character diagnostics:

Character	Min Range	Tree steps	Max steps	Max steps	G- CI	RI	RC	HI	fit
1 (Frontal)	1	1	2	3	0.500	0.500	0.250	0.500	0.750
2 (Posterior extension of the nares)			1	1	2	3	0.500	0.500	0.250 0.500 0.750
3 (Opening of the orbit)		1	1	1	3	1.000	1.000	1.000	0.000 1.000
4 (Position of the orbit)		2	2	5	6	0.400	0.250	0.100	0.600 0.500
5 (Processus orbitalis of the palatine)			1	1	1	3	1.000	1.000	1.000 0.000 1.000
6 (Jugal)	1	1	1	3	1.000	1.000	1.000	0.000	1.000
7 (External auditory meatus)			1	1	1	4	1.000	1.000	1.000 0.000 1.000
8 (External auditory meatus)			1	1	1	4	1.000	1.000	1.000 0.000 1.000
9 (Squamosal)		1	1	1	5	1.000	1.000	1.000	0.000 1.000
10 (Parietal)	1	1	1	3	1.000	1.000	1.000	0.000	1.000
11 (Petrosal bone)		1	1	1	3	1.000	1.000	1.000	0.000 1.000
12 (Foramen ovale)		1	1	1	2	1.000	1.000	1.000	0.000 1.000
13 (Pneumatisation)		2	2	3	4	0.667	0.500	0.333	0.333 0.750
14 (Postorbital process of the frontal)			1	1	2	2	0.500	0.000	0.000 0.500 0.750
15 (Maxillary processus pyramidalis - anterior extension)					2	2	5	7	0.400 0.400 0.160 0.600 0.500
16 (Maxillary processus pyramidalis - posterior extension)					2	2	3	5	0.667 0.667 0.444 0.333 0.750
17 (Zygomatic arches)		1	1	1	4	1.000	1.000	1.000	0.000 1.000
18 (Position of the postglenoid foramen)			2	2	2	4	1.000	1.000	1.000 0.000 1.000
19 (Condylar foramina)		1	1	1	4	1.000	1.000	1.000	0.000 1.000
20 (Zygomatic extension of the squamosal)				1	1	5	1.000	1.000	1.000 0.000 1.000
21 (Mandibular symphysis)			1	1	1	3	1.000	1.000	1.000 0.000 1.000
22 (Origin of the vertical ramus)		3	3	3	6	1.000	1.000	1.000	0.000 1.000

23 (Angle between vertical and horizontal rami)		2	2	3	6	0.667	0.750	0.500	0.333	0.750
24 (Coronoid process of the vertical ramus)		1	1	2	5	0.500	0.750	0.375	0.500	0.750
25 (Coronoid process of the vertical ramus)		1	1	2	6	0.500	0.800	0.400	0.500	0.750
26 (Angular process)	1	1	2	5	0.500	0.750	0.375	0.500	0.750	
27 (Symphysis fusion)	1	1	3	4	0.333	0.333	0.111	0.667	0.600	
28 (Posterior extension of the symphysis)		4	4	6	6	0.667	0.000	0.000	0.333	0.600
29 (Lateral thickening of the horizontal ramus)		2	2	3	7	0.667	0.800	0.533	0.333	0.750
30 (Coronoid foramen)	1	1	1	2	1.000	1.000	1.000	0.000	1.000	
31 (Diastema between the jugal and anterior teeth)		1	1	2	4	0.500	0.667	0.333	0.500	0.750
32 (M1/I size)	1	1	2	3	0.500	0.500	0.250	0.500	0.750	
33 (Incisor growth)		1	1	1	3	1.000	1.000	1.000	0.000	1.000
34 (I1/)	1	1	1	3	1.000	1.000	1.000	0.000	1.000	
35 (I3/)	1	1	2	4	0.500	0.667	0.333	0.500	0.750	
36 (Upper incisors)		1	1	1	3	1.000	1.000	1.000	0.000	1.000
37 (Upper canine)		1	1	2	4	0.500	0.667	0.333	0.500	0.750
38 (Lower incisors)		2	2	3	4	0.667	0.500	0.333	0.333	0.750
39 (I/1)	2	2	2	4	1.000	1.000	1.000	0.000	1.000	
40 (I/2)	1	1	1	3	1.000	1.000	1.000	0.000	1.000	
41 (I/3)	1	1	1	5	1.000	1.000	1.000	0.000	1.000	
42 (Lower incisors size)		2	2	2	5	1.000	1.000	1.000	0.000	1.000
43 (Lower canine)		1	1	1	5	1.000	1.000	1.000	0.000	1.000
44 (P1/)	1	1	1	6	1.000	1.000	1.000	0.000	1.000	
45 (P2/)	1	1	1	2	1.000	1.000	1.000	0.000	1.000	
46 (P2/ parasyle)	1	1	2	4	0.500	0.667	0.333	0.500	0.750	
47 (Shape of P2/ in occlusal view)		1	1	2	3	0.500	0.500	0.250	0.500	0.750
48 (P2/ protocone)		1	1	1	2	1.000	1.000	1.000	0.000	1.000
49 (P2/ metacone)		1	1	3	4	0.333	0.333	0.111	0.667	0.600
50 (P2/ metastyle)	1	1	2	2	0.500	0.000	0.000	0.500	0.750	
51 (P2/ lingual cingulum)		1	1	2	4	0.500	0.667	0.333	0.500	0.750
52 (P2/ mesial cingulum)		1	1	2	4	0.500	0.667	0.333	0.500	0.750
53 (P3-4/ mesial cingulum)		1	1	2	4	0.500	0.667	0.333	0.500	0.750
54 (P3/ parastyle)	1	1	3	5	0.333	0.500	0.167	0.667	0.600	
55 (P3/ metacone)	1	1	3	4	0.333	0.333	0.111	0.667	0.600	
56 (P3/ metastyle)	1	1	3	4	0.333	0.333	0.111	0.667	0.600	
57 (P3/ hypocone)	1	1	2	2	0.500	0.000	0.000	0.500	0.750	
58 (P3/ lingual cingulum)		1	1	2	5	0.500	0.750	0.375	0.500	0.750
59 (P3/ lingual cingulum extension)		1	1	1	2	1.000	1.000	1.000	0.000	1.000
60 (P4/ paraconule)	1	1	2	4	0.500	0.667	0.333	0.500	0.750	
61 (P4/ metacone)	3	3	4	6	0.750	0.667	0.500	0.250	0.750	
62 (P4/ hypocone)	1	1	2	5	0.500	0.750	0.375	0.500	0.750	
63 (P4/ lingual cingulum)	1	1	3	5	0.333	0.500	0.167	0.667	0.600	
64 (P4/ lingual cingulum extension)		1	1	1	2	1.000	1.000	1.000	0.000	1.000
65 (P4/ mesial cingulum extension)		1	1	2	3	0.500	0.500	0.250	0.500	0.750
66 (M1-2/ parastyle)	1	1	3	4	0.333	0.333	0.111	0.667	0.600	
67 (M1-2-3/ paraconule)	1	1	3	5	0.333	0.500	0.167	0.667	0.600	
68 (M1-2/ paraconule shape)		1	1	1	3	1.000	1.000	1.000	0.000	1.000
69 (M1-2/ metaconule)	1	1	3	5	0.333	0.500	0.167	0.667	0.600	
70 (M1-2/ metaconule)	2	2	2	3	1.000	1.000	1.000	0.000	1.000	
71 (M1-2/ mesostyle)	1	1	2	4	0.500	0.667	0.333	0.500	0.750	
72 (M1-2-3/ post-paracrista II)		1	1	1	2	1.000	1.000	1.000	0.000	1.000
73 (M1-2/ convolute)	1	1	1	4	1.000	1.000	1.000	0.000	1.000	
74 (M1-2/ lingual cingulum)		1	1	6	7	0.167	0.167	0.028	0.833	0.375
75 (M1/ postentoconule)	1	1	2	4	0.500	0.667	0.333	0.500	0.750	
76 (M1/ postentoconule shape)		2	2	2	3	1.000	1.000	1.000	0.000	1.000

77 (M1/ centrocrista)	1	1	1	4	1.000	1.000	1.000	0.000	1.000
78 (M1/ tritoloph)	1	1	1	3	1.000	1.000	1.000	0.000	1.000
79 (M1/ mesial cingulum)		1	1	3	5	0.333	0.500	0.167	0.667
80 (M2-3/ centrocrista)		1	1	3	3	0.333	0.000	0.000	0.667
81 (M2-3/ tritoloph)		1	1	1	3	1.000	1.000	1.000	0.000
82 (M2-3/ mesial cingulum)			1	1	3	6	0.333	0.600	0.200
83 (M2/ postentoconule)			1	1	3	5	0.333	0.500	0.167
84 (M2/ postentoconule shape)			2	2	3	4	0.667	0.500	0.333
85 (M3/ parastyle)		1	1	4	4	0.250	0.000	0.000	0.750
86 (M3/ paraconule)			1	1	2	2	0.500	0.000	0.000
87 (M3/ metaconule)			1	1	3	3	0.333	0.000	0.000
88 (M3/ mesostyle)			1	1	2	3	0.500	0.500	0.250
89 (M3/ metaloph)			1	1	2	3	0.500	0.500	0.250
90 (M3/ lingual cingulum)				1	2	4	5	0.500	0.333
91 (P/1)	1	1	2	6	0.500	0.800	0.400	0.500	0.750
92 (P/2)	1	1	1	3	1.000	1.000	1.000	0.000	1.000
93 (P/2 occlusal)		1	1	2	2	0.500	0.000	0.000	0.500
94 (P/2 metaconid)			1	1	2	2	0.500	0.000	0.000
95 (P/2 hypoconid)			1	1	2	3	0.500	0.500	0.250
96 (P/2-3-4 mesial cingulid)				1	1	2	4	0.500	0.667
97 (P/3-4 protostylid)				1	1	2	3	0.500	0.500
98 (P/3 occlusal)		1	1	2	2	0.500	0.000	0.000	0.500
99 (P/3 paraconid)			1	1	2	4	0.500	0.667	0.333
100 (P/3 metaconid)			3	3	4	5	0.750	0.500	0.375
101 (P/3 premetacristid)				1	1	2	2	0.500	0.000
102 (P/4 occlusal)			1	1	2	2	0.500	0.000	0.000
103 (P/4 paraconid)				1	1	3	3	0.333	0.000
104 (P/4 paraconid size)				1	1	2	4	0.500	0.667
105 (P/4 accessory cusp in front of the metaconid)					1	1	2	2	0.500
106 (P/4 entoconid)				1	1	2	4	0.500	0.667
107 (P/4 premetacristid)				1	1	2	2	0.500	0.000
108 (P/4 metalophid)				1	1	1	3	1.000	1.000
109 (M/1-2 accessory cusp in front of the metaconid)					1	2	4	4	0.500
110 (M/1-2-3 preprotocristid)				1	2	4	6	0.500	0.500
111 (M/1-2 postmetacristid)				1	1	3	8	0.333	0.714
112 (M/1-2 preentocristid)				2	2	3	9	0.667	0.857
113 (M/2-3 buccal cingulid)				1	1	2	4	0.500	0.667
114 (M/1-2 mesoconid)				1	1	1	4	1.000	1.000
115 (M/1-2 cristid obliqua)				1	1	2	4	0.500	0.667
116 (M/1-2 postentoconulid)				3	4	4	7	1.000	1.000
117 (M/1-2 hypoconulid)				1	2	2	5	1.000	1.000
118 (M/1-2 molar pattern)				3	3	4	10	0.750	0.857
119 (M/3 accessory cusp on the premetacristid)						1	2	4	5
120 (M/3 postmetacristid)				1	1	2	7	0.500	0.833
121 (M/3 preentocristid)				1	1	2	6	0.500	0.800
122 (M/3 preentocristid shape)					1	1	1	4	1.000
123 (M/3 talonid)	1	2	2	5	1.000	1.000	1.000	0.500	0.750
124 (M/3 talonid position)		1	1	1	2	1.000	1.000	1.000	0.000
125 (Enamel microstructure Radial Enamel)				2	2	5	6	0.400	0.250
126 (Enamel microstructure HSB 3DE)					2	3	5	6	0.600
127 (Atlas distal articular facet)		1	1	2	3	0.500	0.500	0.250	0.500
128 (Atlas proximodistal flattening)			1	1	3	4	0.333	0.333	0.111
129 (Atlas dorsoventral flattening)			1	1	2	4	0.500	0.667	0.333
130 (Scapula supraglenoidal tubercle)			2	2	3	4	0.667	0.500	0.333

131 (Scapula scapular spine)	2	2	2	3	1.000	1.000	1.000	0.000	1.000				
132 (Scapula coracoid process)	1	1	2	3	0.500	0.500	0.250	0.500	0.750				
133 (Scapula glenoid cavity)	1	1	2	3	0.500	0.500	0.250	0.500	0.750				
134 (Humerus humeral crest)	2	2	3	4	0.667	0.500	0.333	0.333	0.750				
135 (Humerus deltoid process)	1	1	2	2	0.500	0.000	0.000	0.500	0.750				
136 (Humerus medial supracondylar crest)		1	1	1	3	1.000	1.000	1.000	0.000	1.000			
137 (Humerus entepicondylar foramen)		1	1	2	3	0.500	0.500	0.250	0.500	0.750			
138 (Humerus lateral supracondylar crest)		1	1	2	4	0.500	0.667	0.333	0.500	0.750			
139 (Humerus lateral supracondylar crest lateral extension)			2	2	2	5	1.000	1.000	1.000	0.000	1.000		
140 (Humerus humeral trochlea)		1	1	1	4	1.000	1.000	1.000	0.000	1.000			
141 (Humerus medial condyle of the trochlea)			1	1	1	3	1.000	1.000	1.000	0.000	1.000		
142 (Humerus olecranon fossa)			1	1	1	3	1.000	1.000	1.000	0.000	1.000		
143 (Humerus trochiter)		1	1	1	2	1.000	1.000	1.000	0.000	1.000			
144 (Ulna diaphysis)		1	1	1	2	1.000	1.000	1.000	0.000	1.000			
145 (Ulna synovial groove)		1	1	2	3	0.500	0.500	0.250	0.500	0.750			
146 (Ulna proximal surface for the radius)			1	1	1	2	1.000	1.000	1.000	0.000	1.000		
147 (Ulna olecranon)		2	2	3	4	0.667	0.500	0.333	0.333	0.750			
148 (Ulna proximal extension)			2	2	3	5	0.667	0.667	0.444	0.333	0.750		
149 (Ulna lateral sigmoid facet)			1	1	1	4	1.000	1.000	1.000	0.000	1.000		
150 (Radius size)		1	1	1	2	1.000	1.000	1.000	0.000	1.000			
151 (Radius proximal extremity)			1	1	1	2	1.000	1.000	1.000	0.000	1.000		
152 (Lunar shape in proximal view)			1	1	1	3	1.000	1.000	1.000	0.000	1.000		
153 (Lunar contact facet for the ulna)			1	1	1	2	1.000	1.000	1.000	0.000	1.000		
154 (Lunar contact facet for a free central bone)				1	1	1	2	1.000	1.000	1.000	0.000	1.000	
155 (Lunar contact facet for the unciform)				1	1	1	2	1.000	1.000	1.000	0.000	1.000	
156 (Lunar contact for the scaphoid)			1	1	1	2	1.000	1.000	1.000	0.000	1.000		
157 (Lunar contact for the scaphoid position)				1	1	1	2	1.000	1.000	1.000	0.000	1.000	
158 (Cuneiform in occlusal view)			1	1	1	2	1.000	1.000	1.000	0.000	1.000		
159 (Cuneiform contact for the lunar)			1	1	1	2	1.000	1.000	1.000	0.000	1.000		
160 (Cuneiform ulnar facet shape)			1	1	1	2	1.000	1.000	1.000	0.000	1.000		
161 (Cuneiform contact facet for the Mc V)				1	1	1	2	1.000	1.000	1.000	0.000	1.000	
162 (Cuneiform contact facet for the pisiform)				1	1	1	2	1.000	1.000	1.000	0.000	1.000	
163 (Cuneiform contact facet for the pisiform shape)					1	1	2	3	0.500	0.500	0.250	0.500	0.750
164 (Magnum facet for the Mc II)				1	1	1	2	1.000	1.000	1.000	0.000	1.000	
165 (Magnum facet for the lunar)				1	1	1	2	1.000	1.000	1.000	0.000	1.000	
166 (Ilion)		1	1	2	3	0.500	0.500	0.250	0.500	0.750			
167 (Femur diaphysis)			1	1	1	2	1.000	1.000	1.000	0.000	1.000		
168 (Femur neck)			1	1	2	2	0.500	0.000	0.000	0.500	0.750		
169 (Femur head)			2	2	3	3	0.667	0.000	0.000	0.333	0.750		
170 (Femur greater trochanter)				2	2	3	5	0.667	0.667	0.444	0.333	0.750	
171 (Femur neck size)			1	1	1	3	1.000	1.000	1.000	0.000	1.000		
172 (Femur small trochanter)				2	2	2	4	1.000	1.000	1.000	0.000	1.000	
173 (Femur third trochanter)			1	1	2	2	0.500	0.000	0.000	0.500	0.750		
174 (Femur third trochanter size)				1	1	1	2	1.000	1.000	1.000	0.000	1.000	
175 (Femur distal extremity)			1	1	1	4	1.000	1.000	1.000	0.000	1.000		
176 (Femur trochlea)			1	1	2	3	0.500	0.500	0.250	0.500	0.750		
177 (Femur head orientation)				1	1	3	3	0.333	0.000	0.000	0.667	0.600	
178 (Femur medial condyle)				1	1	1	2	1.000	1.000	1.000	0.000	1.000	
179 (Femur size)			1	1	1	2	1.000	1.000	1.000	0.000	1.000		
180 (Tibia diaphysis)			1	1	1	3	1.000	1.000	1.000	0.000	1.000		
181 (Tibia tuberuculum intercondylare)				1	1	1	3	1.000	1.000	1.000	0.000	1.000	
182 (Tibia area intercondylaris cranialis)				2	2	2	4	1.000	1.000	1.000	0.000	1.000	
183 (Tibia anterior tuberosity)				2	2	3	3	0.667	0.000	0.000	0.333	0.750	
184 (Tibia diaphysis shape)				2	2	2	4	1.000	1.000	1.000	0.000	1.000	

185 (Tibia tibial cochlea)	1	1	1	2	1.000	1.000	1.000	0.000	1.000
186 (Fibula)	1	1	2	2	0.500	0.000	0.000	0.500	0.750
187 (Astragalus tuberculum mediale)		1	1	1	2	1.000	1.000	1.000	0.000
188 (Astragalus sustentacular facet)		1	1	2	2	0.500	0.000	0.000	0.500
189 (Astragalus ectal facet)	2	2	2	3	1.000	1.000	1.000	0.000	1.000
190 (Astragalus fibular facet)	1	1	1	2	1.000	1.000	1.000	0.000	1.000
191 (Astragalus foramen astragali)		1	1	1	2	1.000	1.000	1.000	0.000
192 (Astragalus fibular facet orientation)		1	1	1	2	1.000	1.000	1.000	0.000
193 (Astragalus in lateral view)		1	1	1	2	1.000	1.000	1.000	0.000
194 (Astragalus in anterior view)		1	1	1	2	1.000	1.000	1.000	0.000
195 (Astragalus neck)	1	1	1	2	1.000	1.000	1.000	0.000	1.000
196 (Astragalus crista capitatis)	1	1	1	2	1.000	1.000	1.000	0.000	1.000
197 (Astragalus tibial facet)	2	2	2	3	1.000	1.000	1.000	0.000	1.000
198 (Calcaneum ectal and sustentacular facets)			1	1	1	3	1.000	1.000	1.000
199 (Calcaneum tuber calcanei)		1	1	2	3	0.500	0.500	0.250	0.500
200 (Calcaneum sustentacular facet shape)			1	1	1	3	1.000	1.000	1.000

BREMER
#####

paup> hsearch nreps=100;

Heuristic search settings:

Optimality criterion = parsimony

Character-status summary:

Of 200 total characters:

All characters are of type 'unord'

All characters have equal weight

All characters are parsimony-informative

Gaps are treated as "missing"

Multistate taxa interpreted as polymorphism

Starting tree(s) obtained via stepwise addition

Addition sequence: random

Number of replicates = 100

Starting seed = generated automatically

Number of trees held at each step = 100

Branch-swapping algorithm: tree-bisection-reconnection (TBR) with reconnection limit = 8

Steepest descent option not in effect

Initial 'Maxtrees' setting = 100

Branches collapsed (creating polytomies) if maximum branch length is zero

'MulTrees' option in effect

No topological constraints in effect

Trees are unrooted

Heuristic search completed

Total number of rearrangements tried = 278563

Score of best tree(s) found = 390

Number of trees retained = 4

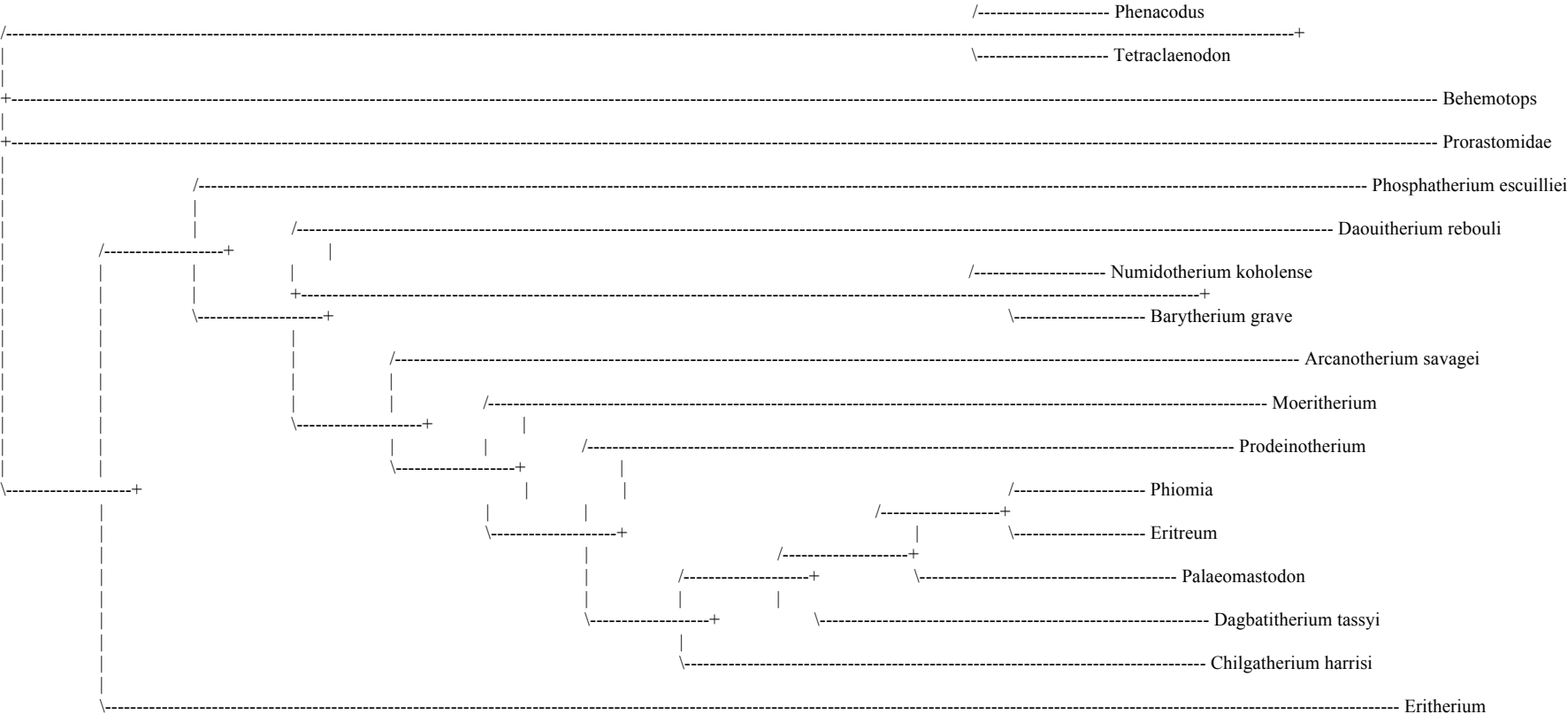
Time used = 4.72 sec (CPU time = 4.72 sec)

Tree-island profile:

Island	First Size	Last tree	tree	First Score	Times replicate	hit
1	4	1	4	390	1	100

paup> contre;

Strict consensus of 4 trees:



paup> hsearch keep=391;

Heuristic search settings:

Optimality criterion = parsimony

Character-status summary:

Of 200 total characters:

All characters are of type 'unord'

All characters have equal weight

All characters are parsimony-informative

Gaps are treated as "missing"
 Multistate taxa interpreted as polymorphism
 Starting tree(s) obtained via stepwise addition
 Addition sequence: random
 Number of replicates = 100
 Starting seed = generated automatically
 Number of trees held at each step = 100
 Branch-swapping algorithm: tree-bisection-reconnection (TBR) with reconnection limit = 8
 Steepest descent option not in effect
 Initial 'Maxtrees' setting = 100
 Branches collapsed (creating polytomies) if maximum branch length is zero
 Keeping all trees less than or equal to score 391
 'MulTrees' option in effect
 No topological constraints in effect
 Trees are unrooted

Heuristic search completed
 Total number of rearrangements tried = 324239
 Score of best tree(s) found = 390
 Number of trees retained = 62
 Time used = 4.89 sec (CPU time = 4.89 sec)

Tree-island profile:

Island	First Size	Last tree	tree	First Score	Times replicate	hit
1	62	1	62	390*	1	100

Note(s):

* Island may contain trees with scores up to KEEP value (391)

paup> contre;

Phylogenetic tree of the order Proboscidea, showing relationships between various genera and families. The tree is rooted at the bottom left and branches out to the right. The taxa listed are: Phenacodus, Tetracaelonodon, Behemotops, Prorastomidae, Phosphatherium escuilliei, Daouitherium rebouli, Numidotherium koholense, Arcanotherium savagei, Barytherium grave, Moeritherium, Prodeinotherium, Phiomia, Palaeomastodon, Chilgatherium harrisi, Dagbatitherium tassyi, Eritreum, and Eritherium.

Heuristic search settings:
 Optimality criterion = parsimony
 Character-status summary:
 Of 200 total characters:
 All characters are of type 'unord'
 All characters have equal weight
 All characters are parsimony-informative
 Gaps are treated as "missing"
 Multistate taxa interpreted as polymorphism
 Starting tree(s) obtained via stepwise addition
 Addition sequence: random
 Number of replicates = 100
 Starting seed = generated automatically
 Number of trees held at each step = 100
 Branch-swapping algorithm: tree-bisection-reconnection (TBR) with reconnection limit = 8
 Steepest descent option not in effect

Initial 'Maxtrees' setting = 100
Branches collapsed (creating polytomies) if maximum branch length is zero
Keeping all trees less than or equal to score 392
'MulTrees' option in effect
No topological constraints in effect
Trees are unrooted

Maxtrees will be automatically increased by 1000 when the limit is hit

Heuristic search completed
Total number of rearrangements tried = 711889
Score of best tree(s) found = 390
Number of trees retained = 376
Time used = 8.64 sec (CPU time = 5.22 sec)

Tree-island profile:

Island	Size	First tree	Last tree	First Score	Times replicate	hit
1	376	1	376	390*	1	100

Note(s):

* Island may contain trees with scores up to KEEP value (392)

paup> contre;

Strict consensus of 376 trees:



```
paup> hsearch keep=393;
```

Heuristic search settings:

Optimality criterion = parsimony

Character-status summary:

Of 200 total characters:

All characters are of type 'unord'

All characters have equal weight

All characters are parsimony-informative

Gaps are treated as "missing"

Multistate taxa interpreted as polymorphism

Starting tree(s) obtained via stepwise addition

Addition sequence: random

Number of replicates = 100

Starting seed = generated automatically

Number of trees held at each step = 100

Branch-swapping algorithm: tree-bisection-reconnection (TBR) with reconnection limit = 8

Steepest descent option not in effect

Initial 'Maxtrees' setting = 1100 (will be auto-increased by 1000)
Branches collapsed (creating polytomies) if maximum branch length is zero
Keeping all trees less than or equal to score 393
'MulTrees' option in effect
No topological constraints in effect
Trees are unrooted

Heuristic search completed
Total number of rearrangements tried = 2341053
Score of best tree(s) found = 390
Number of trees retained = 1348
Time used = 6.14 sec (CPU time = 6.13 sec)

Tree-island profile:

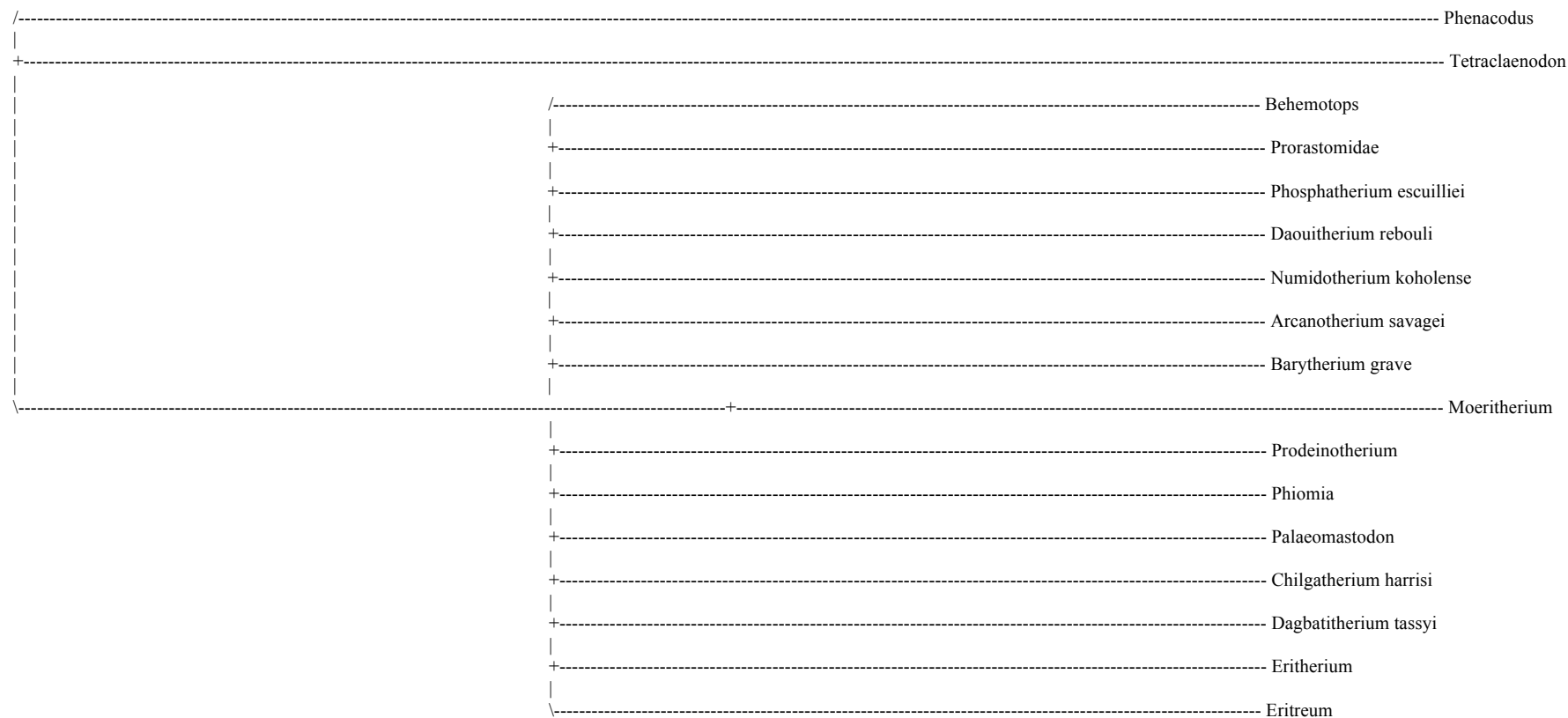
Island	First Size	Last tree	tree	First Score	Times replicate	hit
1	1348	1	1348	390*	1	100

Note(s):

* Island may contain trees with scores up to KEEP value (393)

paup> contre;

Strict consensus of 1348 trees:



paup> hsearch keep=394;

Heuristic search settings:

Optimality criterion = parsimony

Character-status summary:

Of 200 total characters:

All characters are of type 'unord'

All characters have equal weight

All characters are parsimony-informative

Gaps are treated as "missing"

Multistate taxa interpreted as polymorphism

Starting tree(s) obtained via stepwise addition

Addition sequence: random

Number of replicates = 100

Starting seed = generated automatically

Number of trees held at each step = 100

Branch-swapping algorithm: tree-bisection-reconnection (TBR) with reconnection limit = 8

Steepest descent option not in effect

Initial 'Maxtrees' setting = 2100 (will be auto-increased by 1000)
Branches collapsed (creating polytomies) if maximum branch length is zero
Keeping all trees less than or equal to score 394
'MulTrees' option in effect
No topological constraints in effect
Trees are unrooted

Heuristic search completed
Total number of rearrangements tried = 6023655
Score of best tree(s) found = 390
Number of trees retained = 3606
Time used = 8.92 sec (CPU time = 8.92 sec)

Tree-island profile:

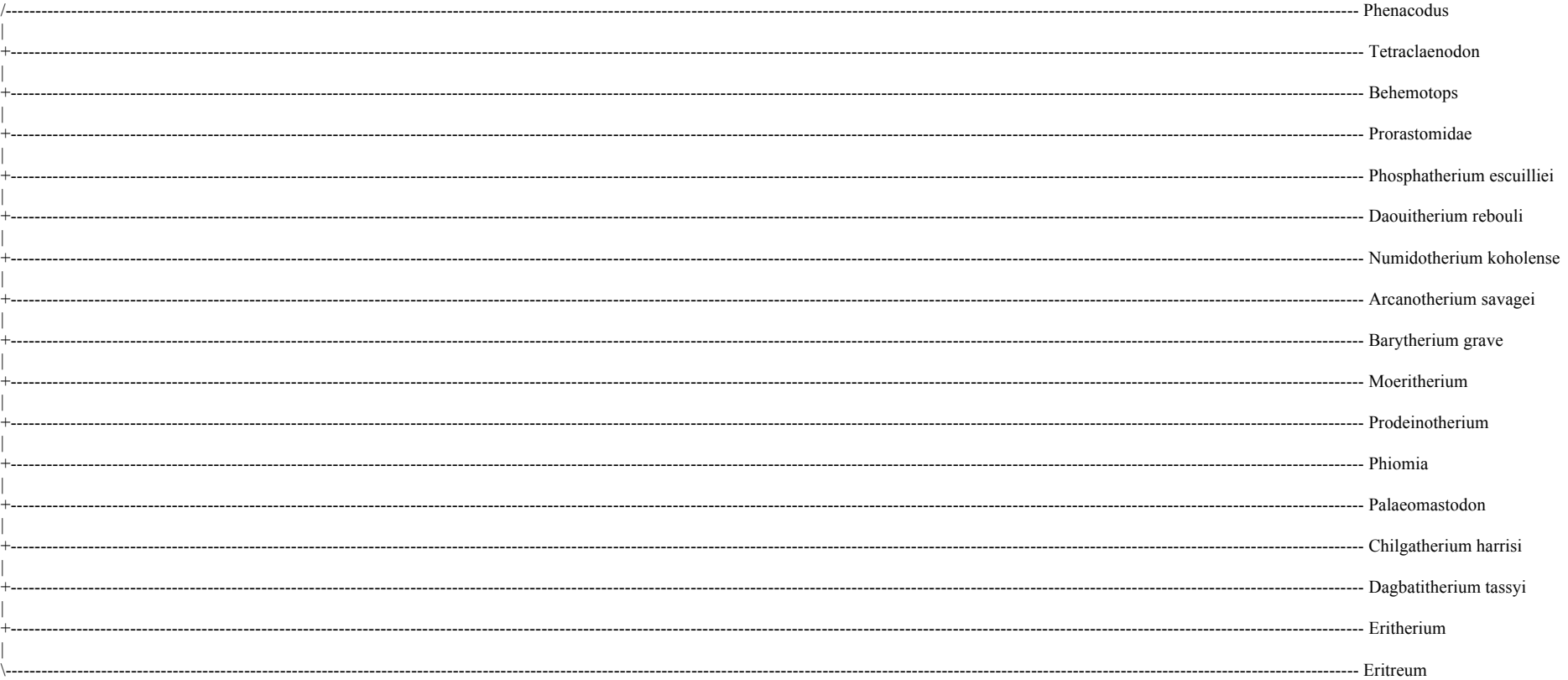
Island	First Size	Last tree	tree	First Score	Times replicate	hit
1	3606	1	3606	390*	1	100

Note(s):

* Island may contain trees with scores up to KEEP value (394)

paup> contre;

Strict consensus of 3606 trees:



3. Anatomical plate of the molar ULDG-DAG1

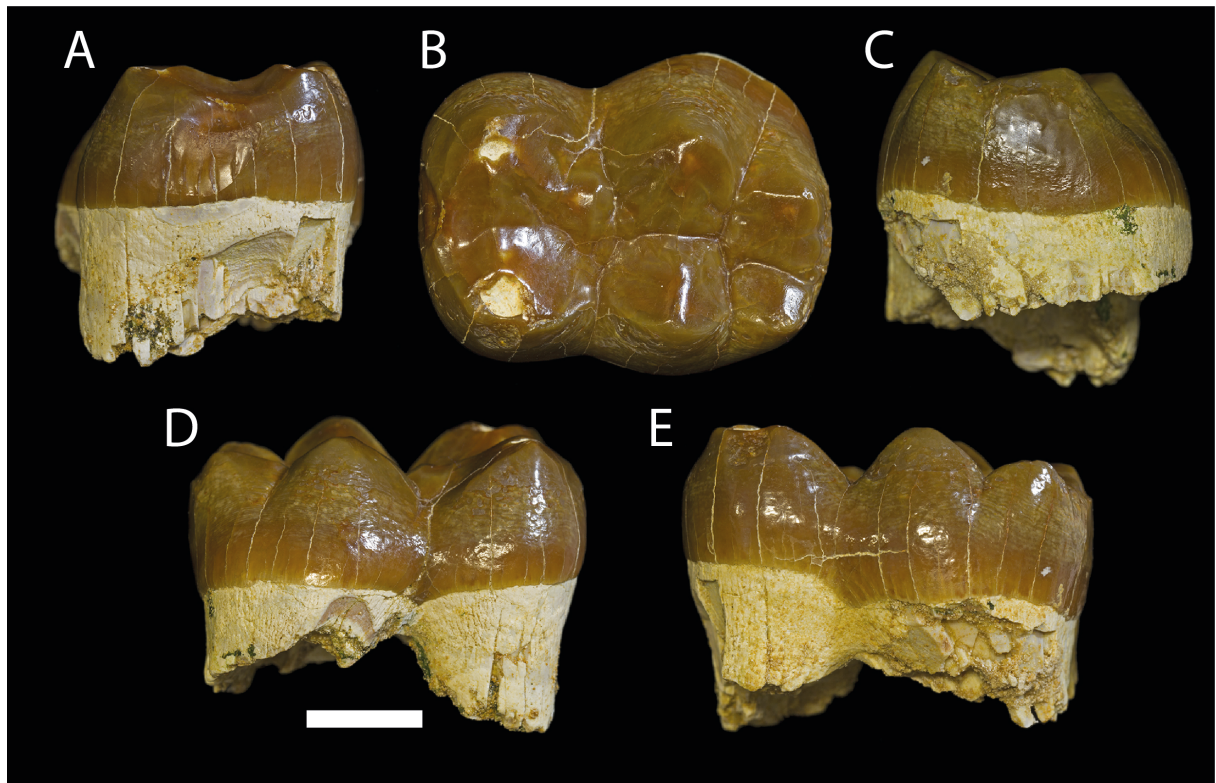


Figure S3 – Anatomical plate of the molar ULDG-DAG1. A, mesial view; B, occlusal view; C, distal view; D, buccal view; and E, lingual view. Scale bar represents 1cm.

4. Enamel microstructure of *Dagbatitherium*

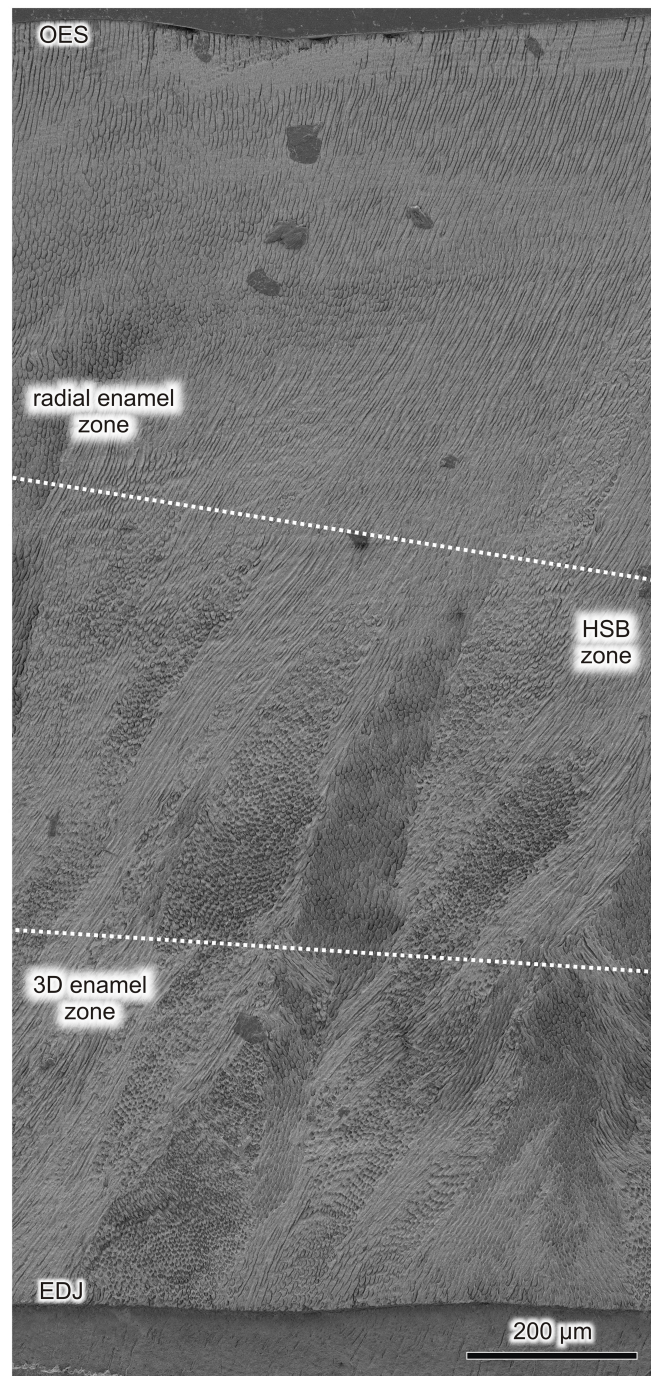


Figure S4 – *Dagbatitherium tassyi* from Dagbati, ULDG-DAG1, vertical enamel section. From the enamel dentine junction (EDJ) to the outer enamel surface (OES), the specimen presents a tree-layered Schmelzmuster formed by 3D enamel on the inner zone, Hunter-Schreger bands (HSB) in the middle zone, and radial enamel in the outer zone.

5. Enamel microstructure of *Palaeomastodon*

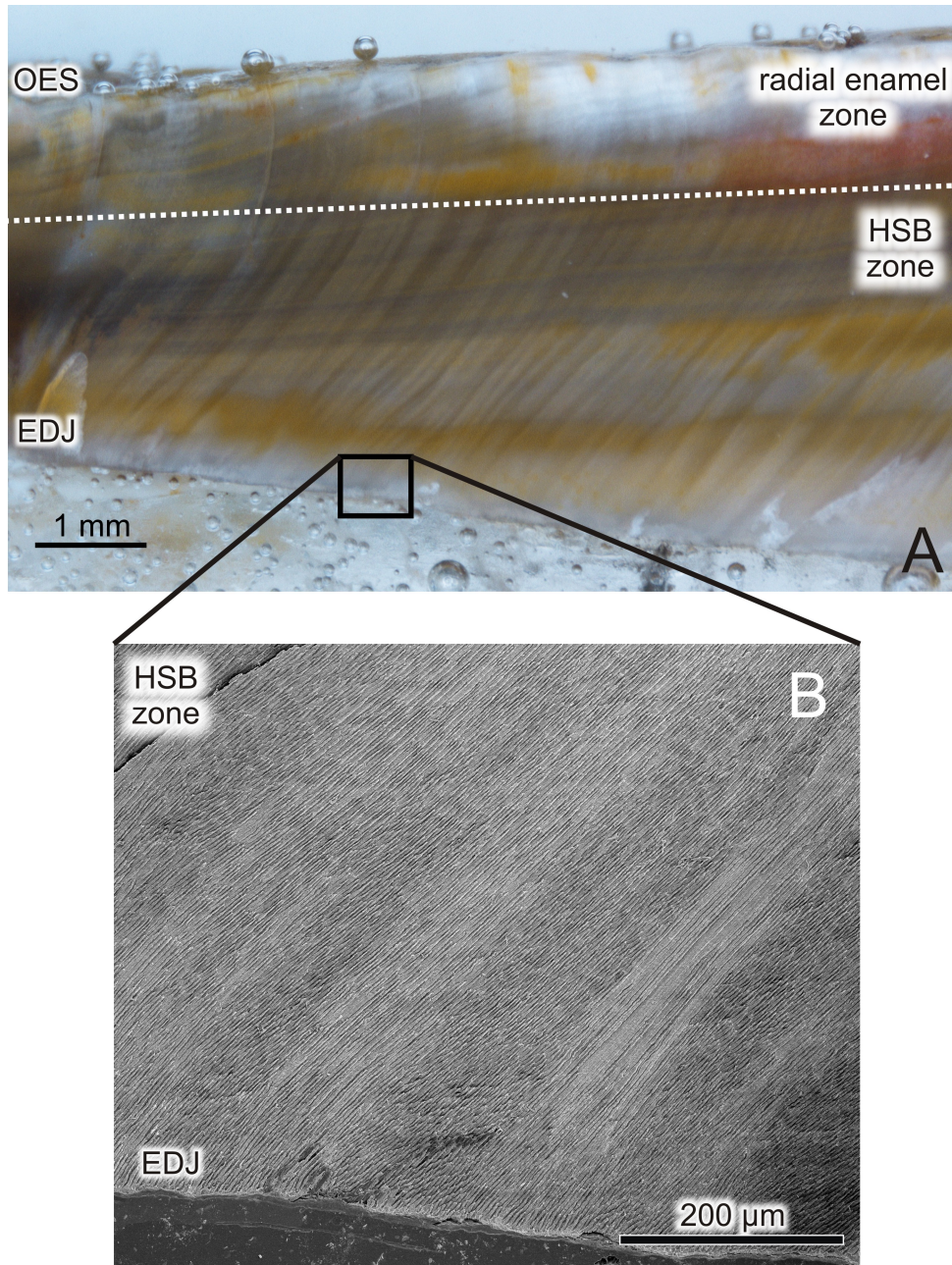


Figure S5 - Vertical enamel section on a lower molar of *Palaeomastodon beadnelli* from the Gebel Qatrani Formation, Fayum, Egypt, Early Oligocene, UCBL-FSL 217965 (Collection de l'Université Lyon 1, France). At low magnification using reflecting light method (RLM), the enamel section reveals that most of the enamel thickness is represented by HSB then by radial enamel (A); SEM image confirms the absence of 3D enamel near the EDJ (B).

6. Distal cingulid of ULDG-DAG1

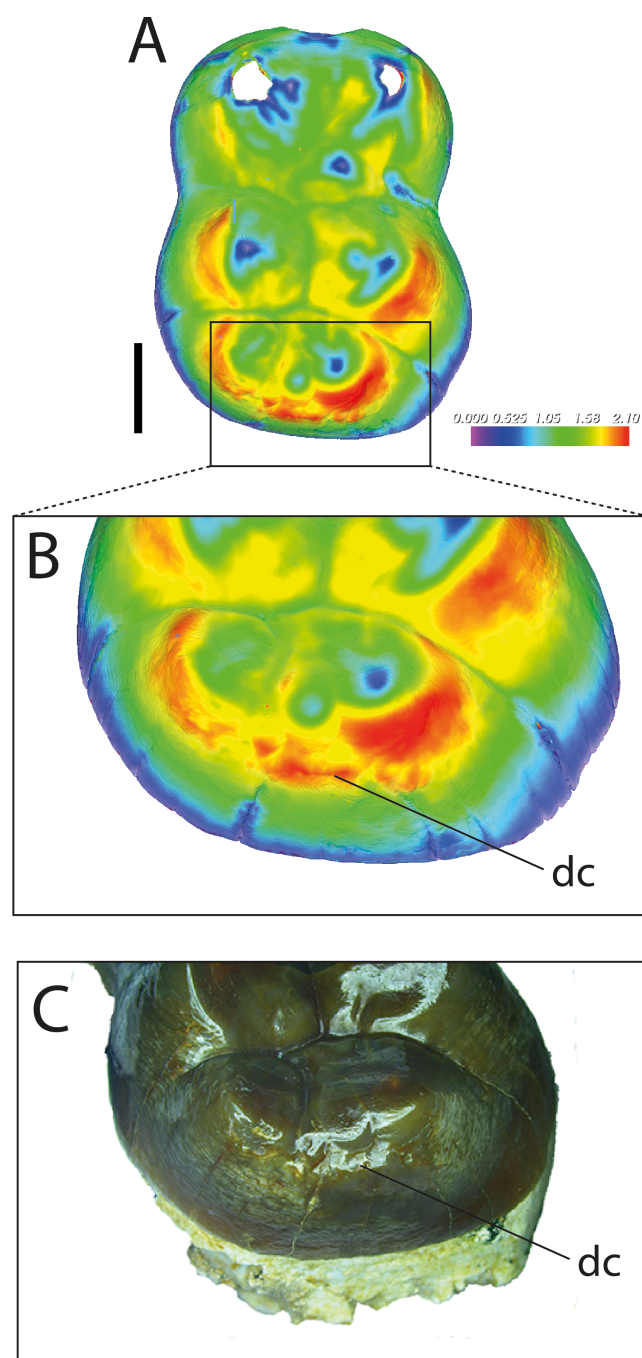


Figure S6 – A, 3D enamel thickness distribution maps with spectral colors of the occlusal view of ULDG-DAG1. The thickest enamel is represented in red, the thinnest enamel is represented in dark blue. Color scale: 0-2.1 mm. B, zoom in the area of the distal cingulid. C, photograph of the distal view of ULDG-DAG1. *Abbreviations:* dc, distal cingulid. Scale bar represents 1cm.

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