



http://app.pan.pl/SOM/app66-Geraads_Zouhri_SOM.pdf

SUPPLEMENTARY ONLINE MATERIAL FOR

A new late Miocene elasmotheriine rhinoceros from Morocco

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Supplementary Online Material

SOM 1. TNT file used in the parsimony analysis of all taxa

available at http://app.pan.pl/SOM/app66-Geraads_Zouhri_SOM/SOM_1.tnt

SOM 2. TNT file used in the parsimony analysis restricted to taxa that have at least 50% of the characters scored

available at http://app.pan.pl/SOM/app66-Geraads_Zouhri_SOM/SOM_2.tnt.

SOM 3. Majority rule consensus tree of the 87 most parsimonious trees obtained by TNT on the data matrix of 75

taxa; the 87 shortest trees; majority rule consensus tree of the 16 most parsimonious trees obtained by TNT on the data matrix of the 59 taxa that have at least 50% of their characters scored; the same tree in parenthetical notation; the apomorphies at each node; the 16 shortest trees in parenthetical notation.

SOM 3. Majority rule consensus tree of the 87 most parsimonious trees obtained by TNT on the data matrix of 75 taxa (file Eoazara.tnt). Length = 1784 ; ci = 16 ; ri = 57:



The same tree in parenthetical notation:

```
tread 'majority rule consensus tree, from the complete data matrix Eoazara.tnt'  
  
(0 ((51 (54 (21 (39 (61 ((((((1 45 )(31 (8 9 )))(44 (48 (47 55 ))))((10 12  
)((37 (34 ((59 ((13 (52 (57 ((27 (28 (29 (14 ((11 62 )(70 (30 (33 (25 (41  
((72 (24 66 ))(40 (42 69 )))))))))(63 68 )))))(65 (64 (35 67 )))))(16 (58 74  
))))))((22 (23 (15 19 )))(49 50 )))(26 38 )))(46 71 )))(20 36 ))(73 (43 ((4  
7 (5 (2 3 )))(60 (6 (53 (17 18 )))))))))))((32 56 )));
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The 87 shortest trees in parenthetical notation:

```
tread '87 shortest trees, from the complete data matrix Eoazara.tnt'
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(0 ((51 ((39 (61 ((((((1 45 )(31 (8 9 )))(44 (48 (47 55 ))))((10 12 ))((37 (34  
((59 ((13 (52 (57 ((14 ((27 (28 (29 ((11 62 )(70 (30 (33 (25 (41 ((72 (24 66  
) (40 (42 69 )))))))))(63 68 )))))(65 (64 (35 67 )))))(16 (58 74 )))))))((22 (23  
(15 19 )))(49 50 )))(26 38 )))(46 71 )))(20 36 ))(73 (43 ((5 (2 3 ))(4 7  
) (60 (6 (53 (17 18 )))))))))))((21 54 ))(32 56 )))*
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(0 ((51 ((39 (61 ((((((1 45 )(31 (8 9 )))(44 (48 (47 55 ))))((10 12 ))((37 (34  
((59 ((13 (52 (57 ((14 ((27 (28 (29 ((11 62 )(70 (30 (33 (25 (41 ((72 (24 66  
) (40 (42 69 )))))))))(63 68 )))))(65 (64 (35 67 )))))(16 (58 74 )))))))((22 (23  
(15 19 )))(49 50 )))(26 38 )))(46 71 )))(20 36 ))(73 (43 ((7 (4 (5 (2 3  
) (60 (6 (53 (17 18 )))))))))))((21 54 ))(32 56 )))*
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(0 ((51 ((39 (61 ((((((1 45 )(31 (8 9 )))(44 (48 (47 55 ))))((10 12 ))((37 (34  
((59 ((13 (52 (57 ((27 (28 (29 (14 ((11 62 )(70 (30 (33 (25 (41 ((72 (24 66  
) (40 (42 69 )))))))))(63 68 )))))(65 (64 (35 67 )))))(16 (58 74 )))))))((22 (23  
(15 19 )))(49 50 )))(26 38 )))(46 71 )))(20 36 ))(73 (43 ((5 (2 3 ))(4 7  
) (60 (6 (53 (17 18 )))))))))))((21 54 ))(32 56 )))*
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(0 ((51 ((39 (61 ((((((1 45 )(31 (8 9 )))(44 (48 (47 55 ))))((10 12 ))((37 (34  
((59 ((13 (52 (57 ((27 (28 (29 ((14 ((11 62 )(70 (30 (33 (25 (41 ((72 (24 66  
) (40 (42 69 )))))))))(63 68 )))))(65 (64 (35 67 )))))(16 (58 74 )))))))((22 (23  
(15 19 )))(49 50 )))(26 38 )))(46 71 )))(20 36 ))(73 (43 ((5 (2 3 ))(4 7  
) (60 (6 (53 (17 18 )))))))))))((21 54 ))(32 56 )))*
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(0 ((51 (54 (21 (39 (61 ((((((1 45 )(31 (8 9 )))(44 (48 (47 55 ))))((10 12  
)((37 (34 ((59 ((13 (52 (57 ((14 ((27 (28 (29 ((11 62 )(70 (30 (33 (25 (41  
((72 (24 66 ))(40 (42 69 )))))))))(63 68 )))))(65 (64 (35 67 )))))(16 (58 74  
))))))((22 (23 (15 19 )))(49 50 )))(26 38 )))(46 71 )))(20 36 ))(73 (43 ((5  
(2 3 ))(4 7 ))(60 (6 (53 (17 18 )))))))))))((32 56 )))*
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(0 ((51 ((39 (61 ((((((1 45 )(31 (8 9 )))(44 (48 (47 55 ))))((10 12 ))((37 (34  
((59 ((13 (52 (57 ((14 ((27 (28 (29 ((11 62 )(70 (30 (33 (25 (41 ((72 (24 66  
) (40 (42 69 )))))))))(63 68 )))))(65 (64 (35 67 )))))(16 (58 74 )))))))((22 (23  
(15 19 )))(49 50 )))(26 38 )))(46 71 )))(20 36 ))(73 (43 (60 ((5 (2 3 ))(4  
7 ))(6 (53 (17 18 )))))))))))((21 54 ))(32 56 )))*
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(0 ((51 ((39 (61 ((((((1 45 )(31 (8 9 )))(44 (48 (47 55 ))))((10 12 ))((37 (34  
((59 ((13 (52 (57 ((14 ((27 (28 (29 ((11 62 )(70 (30 (33 (25 (41 ((72 (24 66  
) (40 (42 69 )))))))))(63 68 )))))(65 (64 (35 67 )))))(16 (58 74 )))))))((22 (23  
(15 19 )))(49 50 )))(26 38 )))(46 71 )))(20 36 ))(73 (43 ((60 (5 (2 3 ))(4  
7 ))(6 (53 (17 18 )))))))))))((21 54 ))(32 56 )))*
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(0 ((54 (21 (39 (61 ((((((1 45 )(31 (8 9 )))(44 (48 (47 55 ))))((10 12 ))((37  
(34 ((59 ((13 (52 (57 ((14 ((27 (28 (29 ((11 62 )(70 (30 (33 (25 (41 ((72 (24  
66 ))(40 (42 69 )))))))))(63 68 )))))(65 (64 (35 67 )))))(16 (58 74 )))))))((22  
(23 (15 19 )))(49 50 )))(26 38 )))(46 71 )))(20 36 ))(73 (43 ((5 (2 3 ))(4  
7 ))(60 (6 (53 (17 18 )))))))))))((51 (32 56 ))))*
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(0 ((54 (21 (39 (61 ((((((1 45)(31 (8 9)))(44 (48 (47 55))))((10 12))((37 (34 ((59 ((13 (52 (57 ((27 (28 (29 ((14 ((11 62))(70 (30 (33 (25 (41 ((72 (24 66))(40 (42 69)))))))))))((63 68)))))(65 (64 (35 67)))))(16 (58 74))))((22 (23 (15 19)))(49 50)))))(26 38)))))(46 71)))))(20 36))(73 (43 ((7 (4 (5 (2 3)))))(60 (6 (53 (17 18)))))))))))((51 (32 56)))))*

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(0 ((51 (54 (21 (39 (61 ((((((1 45)(31 (8 9)))(44 (48 (47 55))))((10 12))((37 (34 ((59 ((13 (52 (57 ((14 ((27 (28 (29 (((11 62))(70 (30 (33 (25 (41 ((72 (24 66))(40 (42 69)))))))))))((63 68)))))(65 (64 (35 67)))))(16 (58 74))))((22 (23 (15 19)))(49 50)))))(26 38)))))(46 71)))))(20 36))(73 (43 ((7 (4 (60 (5 (2 3)))))(6 (53 (17 18)))))))))))((32 56)))*

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(0 ((54 (21 (39 (61 ((((((1 45)(31 (8 9)))(44 (48 (47 55))))((10 12))((37 (34 ((59 ((13 (52 (57 ((14 ((27 (28 (29 (((11 62))(70 (30 (33 (25 (41 ((72 (24 66))(40 (42 69)))))))))))((63 68)))))(65 (64 (35 67)))))(16 (58 74))))((22 (23 (15 19)))(49 50)))))(26 38)))))(46 71)))))(20 36))(73 (43 ((7 (4 (60 (5 (2 3)))))(6 (53 (17 18)))))))))))((51 (32 56)))))*

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(0 (32 (56 (51 ((39 (61 ((((((1 45)(31 (8 9)))(44 (48 (47 55)))))(20 36))((10 12))((37 (34 ((59 ((13 (52 (57 ((14 ((27 (28 (29 ((11 62)(70 (30 (33 (25 (41 ((72 (24 66))(40 (42 69)))))))))))((63 68)))))((65 (64 (35 67)))))(16 (58 74))))))))((22 (23 (15 19)))(49 50)))(26 38)))(46 71)))(73 (43 ((7 (4 (2 (3 5)))))(60 (6 (53 (17 18)))))))))(21 54)))))*

(0 ((51 (54 (21 (39 (61 ((((((1 45)(31 (8 9)))(44 (48 (47 55)))))(10 12))((37 (34 ((59 ((13 (52 (57 ((27 (28 (29 (14 ((11 62)(70 (30 (33 (25 (41 ((72 (24 66))(40 (42 69)))))))))))((63 68)))))((65 (64 (35 67)))))(16 (58 74))))))))((22 (23 (15 19)))(49 50)))(26 38)))(46 71)))(20 36))(73 (43 ((7 (4 (60 (5 (2 3)))))(6 (53 (17 18)))))))))(32 56)))*

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(0 (32 (56 (51 ((39 (61 ((((((1 45)(31 (8 9)))(44 (48 (47 55)))))(20 36))((10 12))((37 (34 ((59 ((13 (52 (57 (((27 (28 (29 (14 (((11 62)(70 (30 (33 (25 (41 ((72 (24 66))(40 (42 69)))))))))))((63 68)))))(65 (64 (35 67)))))(16 (58 74)))))))((22 (23 (15 19)))(49 50)))))(26 38)))))(46 71)))))(73 (43 ((7 (4 (2 (3 5)))))(60 (6 (53 (17 18)))))))))))((21 54)))))*

Majority rule consensus tree of the 16 most parsimonious trees obtained by TNT on the data matrix of the 59 taxa that have at least 50% of their characters scored (file Eoazara-16.tnt); the same tree in parenthetical notation; the apomorphies at each node; the 16 shortest trees in parenthetical notation:



(0 (51 (54 (39 (21 ((48 (44 (((31 (1 45)) (8 9)) (20 36)) (47 55)) ((10 12)) (46 (37 (34 (((13 52 (57 ((14 (27 28 (29 (11 (30 (33 (25 (42 (40 (24 41))))))))))) (16 58)))) ((22 (23 (15 19)) (49 50)) (26 38)))))))) (35 (43 ((2 (3 5)) (7 (4 (6 (53 (17 18))))))))))) (32 56)));

Tapirus terrestris :

- No autapomorphies
- Aceratherium incisivum :**
- Upper molars medifossette (143): always absent → usually absent
- Lower molars labial cingulum (191): always present → usually absent
- Humerus fossa olecrani (215): high → low
- Trapezoid proximal border in anterior view (217): symmetric → asymmetric

Acerorhinus fuguensis :

- Maxillary anterior base of the processus zygomaticus maxillari (16): high → low
- Basioccipital foramen nervi hypoglossi (59): in the middle of the fossa → shifted antero-externally
- Squamosal processus posttympanicus (63): well developed → huge
- Corpus mandibulae base (80): straight → convex
- Upper molars labial cingulum (138): always present → usually present

Acerorhinus hezhengensis :

Frontal-parietal (49): sagittal crest → close frontoparietal crests
Symphysis (71): upraised → very upraised
Upper molars lingual cingulum (144): usually present → usually absent
di1 (202): present → absent

Acerorhinus palaeosinensis :

Zygomatic arch processus postorbitalis (22): absent → present
Symphysis (71): upraised → nearly horizontal
P2 protocone and hypocone (123): separated → lingual bridge
P3-4 constriction of the protocone (130): usually absent, or usually present → always absent
M1-2 paracone fold (148): strong → weak

Acerorhinus tsaidamensis :

Occipital ventral end of the paraoccipital process relative to the postglenoid process (30): above → nearly equal

Zygomatic width/frontal width (48): less than 1.5 → more than 1.5
Ramus processus coronoideus (83): well developed → little developed
P3-4 protocone and hypocone (131): separated → lingual bridge
P3 crista (134): always present → usually present
Lower premolars labial cingulum (182): continuous → reduced

Acerorhinus yuanmouensis :

Nasal dorsal profile (2): straight → undulated
Maxillary foramen infraorbitalis (4): above premolars → above molars
Basioccipital foramen nervi hypoglossi (59): in the middle of the fossa → shifted antero-externally
Upper cheek teeth crista (110): one → always doubled
Upper premolars labial cingulum (112): usually absent → usually present
P3-4 medifossette (129): usually present, or always present → always absent
P3 crista (134): always present → usually present

Acerorhinus zernowi :

Nasal notch (8): V-shaped → U-shaped
P3 crista (134): always present → usually present
Upper molars medifossette (143): always absent → usually present

Alicornops complanatum :

I1 (93): present → absent
Lower cheekteeth paralophid (172): away from the lingual rim → nearly reach the lingual rim

Alicornops simorrense :

P2-4 crochet (114): usually simple → always simple
Upper molars lingual cingulum (144): usually present → usually absent
Lower premolars labial cingulum (182): reduced → continuous
D2 mesostyle (197): present → absent
d2 paralophid (211): simple → double

Aprotodon fatehjangense :

Maxillary anterior base of the processus zygomaticus maxillari (16): high → low
External auditory pseudo-meatus (28): partially closed → closed
Cheekteeth cement (87): absent → present
Cheekteeth shape of enamel (89): wrinkled and corrugated → wrinkled
Cheekteeth roots (92): joined → distinct
P2-4 crochet (114): usually simple → usually multiple
P3-4 constriction of the protocone (130): always absent → usually absent
Lower premolars lingual cingulum (179): usually present → always present
d1/p1 (in adults) (183): usually absent → always absent
Lower molars lingual cingulum (189): usually present → always present
Lower molars hypolophid (193): oblique → transverse
Lower milk teeth constriction of the metaconid (204): present → absent
d3 paralophid (213): double → simple
d3 lingual groove on the entoconid (214): always absent → always present
Humerus fossa olecrani (215): high → low

Begertherium grimmi :

- Frontal-parietal (49): close frontoparietal crests → sagittal crest
- Foramen mandibulare (84): above the teeth neck → below the teeth neck
- Upper cheek teeth crista (110): one → always doubled
- P3-4 medifossette (129): always absent → usually absent
- M1-2 posterior part of the ectoloph (152): straight → concave
- Lower cheekteeth paralophid (172): nearly reach the lingual rim → away from the lingual rim
- Lower cheek teeth occlusal outline of the trigonid basin (173): U-shaped → V-shaped
- Lower cheekteeth metaconid (176): constricted → joined to the metalophid
- Lower milk teeth constriction of the metaconid (204): present → absent

Brachypotherium brachypus :

- Foramen magnum (67): circular → subtriangular
- Basioccipital median ridge on the condyle (68): present → absent
- Upper premolars labial cingulum (112): usually absent, or always absent → usually present
- P2 protocone and hypocone (123): lingual bridge → separated
- P2 protoloph (128): joined to the ectoloph → interrupted
- Upper molars labial cingulum (138): usually absent → usually present
- Upper molars antecrochet (139): always present → usually present
- M1-2 constriction of the protocone (145): always present → usually present
- M1-2 paracone fold (148): strong → weak
- M1-2 metacone fold (149): absent → present
- M1-2 posterior part of the ectoloph (152): concave → straight
- M3 constriction of the protocone (165): always present → always absent
- Lower cheekteeth metaconid (176): joined to the metalophid → constricted
- Lower premolars lingual opening of the posterior valley (178): narrow V-shape → U-shape
- Lower premolars lingual cingulum (179): usually present → always absent
- Lower molars lingual cingulum (189): usually present → usually absent
- Lower molars labial cingulum (192): reduced → continuous
- McII magnum-facet (218): curved → straight
- McII posterior McIII-facet (220): always present → always absent

Brachypotherium minor :

- Nasal dorsal profile (2): dorsally arched → straight
- Skull dorsal profile (25): concave → flat
- Skull narrowing of dorsal surface anterior to the orbit (36): gradual → abrupt
- Nasal bones (39): anteriorly separated → fused
- Median nasal horn (41): present → absent
- Occipital processus paraoccipitalis (64): well developed → little developed
- Upper premolars labial cingulum (112): usually absent → usually present
- P2-4 lingual cingulum (117): reduced → continuous
- P2 protocone (126): less strong than the hypocone → equal or stronger than the hypocone
- P3-4 protocone and hypocone (131): lingual bridge → separated
- Upper molars labial cingulum (138): usually absent → always present
- Upper molars lingual cingulum (144): usually absent → always absent
- M1-2 paracone fold (148): strong → weak
- M3 protoloph (167): transverse → lingually elongated
- Lower cheekteeth paralophid (172): nearly reach the lingual rim → away from the lingual rim
- Lower molars labial cingulum (191): usually absent → usually present

Caementodon caucasicum :

- Nasal lateral apophysis (1): absent → present
- Maxillary anterior base of the processus zygomaticus maxillari (16): low → high
- Upper cheek teeth crista (110): one → always doubled
- P2-4 lingual cingulum (116): usually absent → always absent
- P2 metaloph (124): transverse → hypocone anterior to metacone
- P4 hypocone and metacone (137): joined → separated
- Upper molars labial cingulum (138): usually absent → always absent

Upper molars lingual cingulum (144): usually absent → always absent

M1-2 constriction of the protocone (146): strong → weak

M1-2 posterior part of the ectoloph (152): straight → concave

Ceratotherium simum :

Jugal/squamosal suture (24): rough → smooth

Occipital crest (52): straight → forked

Cheekteeth cement (88): weak or variable → abundant

P1 (in adults) (120): usually present → always absent

P2 protocone and hypocone (123): separated → lingual wall

P3-4 protocone and hypocone (131): separated → lingual bridge

M1-2 paracone fold (147): present → absent

M3 protoloph (167): transverse → lingually elongated

Lower cheekteeth external groove (170): developed → smooth U-shaped

Lower molars hypolophid (193): oblique → almost sagittal

Chilotheridium pattersoni :

Nasal notch (7): above P1-3 → above P4-M1

Zygomatic arch (17): high → low

P2-4 postfossette (118): wide → narrow

P2 protocone (126): less strong than the hypocone → equal or stronger than the hypocone

P4 antecrochet (136): usually present → always present

Upper molars lingual cingulum (144): usually absent → usually present

M1-2 posterior part of the ectoloph (152): straight → concave

McII anterior and posterior McIII-facets (221): separated → fused

Chilotherium anderssoni :

Nasal notch (8): V-shaped → U-shaped

Zygomatic arch processus postorbitalis (22): absent → present

External auditory pseudo-meatus (28): closed → partially closed

Frontal-parietal (49): close frontoparietal crests → distant crests

Chilotherium wimani :

Corpus mandibulae base (80): straight → convex

M1-2 cristella (153): always present → usually present

M1 antecrochet-hypocone (156): always separated → sometimes joined

Coelodonta antiquitatis :

Maxillary foramen infraorbitalis (4): above premolars → above molars

Nasal notch (7): above P1-3 → above P4-M1

External auditory pseudo-meatus (28): open → closed

Occipital ventral end of the paraoccipital process relative to the postglenoid process (30): above → nearly equal

Occipital nuchal tubercle (32): developed, or very developed → little developed

Skull widest part of the dorsal surface (37): at level of supraorbital process → at level of postorbital process area

Nasal bones (39): anteriorly separated → fused

Squamosal processus postglenoidalis (58): convex → dihedral

Squamosal processus posttympanicus (63): well developed → little developed

Symphysis (71): very upraised, or upraised → nearly horizontal

Foramen mentale (77): level of p2-4 → in front of p2

Premolar/molar row index (85): $(100 \times LP3-4/LM1-3) > 50 \rightarrow 42 < (100 \times LP3-4/LM1-3) < 50$

Cheekteeth crown (91): high → partial hypsodonty

P2-4 crochet (114): usually simple → always simple

P2-3 antecrochet (119): always absent → usually absent

P2 protocone (126): less strong than the hypocone → equal or stronger than the hypocone

P3-4 medifossette (129): usually present → always present

P3-4 constriction of the protocone (130): usually absent → always absent

P3 crista (134): usually present → always present

P4 antecrochet (136): always absent → usually absent

Upper molars crista (142): usually present → always present
M1-2 metaloph (151): short → long
M1 metaloph (155): continuous → hypocone isolated
M2 metaloph (159): continuous → hypocone isolated
M3 constriction of the protocone (165): always absent → usually absent
d2 posterior valley (212): always open → usually open
Trapezoid proximal border in anterior view (217): asymmetric → symmetric
McII posterior McIII-facet (220): always present → always absent
McII trapezium-facet (222): always absent → always present

Diaceratherium aginense :

M2 metaloph (159): hypocone isolated → continuous
Lower cheekteeth trigonid (174): rounded → angular
Lower premolars lingual opening of the posterior valley (178): narrow V-shape → U-shape
d1/p1 (in adults) (183): usually present, or usually absent → always absent

Diceratherium armatum :

Nasal notch distance to the the orbit/length of the skull (9): short(<17%) → long(>17%)
Lacrymal processus lacrymalis (14): present → absent
Maxillary anterior base of the processus zygomaticus maxillari (16): high → low
Squamosal area between temporal and nuchal crests (27): flat → depression
External auditory pseudo-meatus (28): partially closed → closed
Occipital side (29): vertical → inclined forward
Occipital ventral end of the paraoccipital process relative to the postglenoid process (30): above → nearly equal
Paired nasal horns (43): absent → present
Paired nasal horns (44): terminal bumps → lateral crests
Squamosal articular tubercle (55): smooth → high
Symphysis (71): upraised → nearly horizontal
M1-2 paracone fold (148): strong → weak
Lower premolars lingual opening of the posterior valley (178): narrow V-shape → U-shape
d2 posterior valley (212): always open, or usually open → usually closed

Dicerorhinus sumatrensis :

Occipital ventral end of the paraoccipital process relative to the postglenoid process (30): above → nearly equal
Occipital crest (52): straight → concave
Basioccipital sagittal crest on the basilar process (60): present → absent
Foramen mentale (77): level of p2-4 → in front of p2
P2-4 metaloph constriction (115): absent → present
M1-2 constriction of the protocone (145): usually present → always present
p2 paralophid (186): curved without constriction → isolated spur-like
Humerus fossa olecrani (215): low → high

Diceros bicornis :

Squamosal area between temporal and nuchal crests (27): depression → flat
Squamosal transversal profile of articular tubercle (56): concave → straight
Occipital processus paraoccipitalis (64): well developed → little developed
P2-4 lingual cingulum (116): usually present → always present
P2-4 lingual cingulum (117): reduced → continuous
Upper molars lingual cingulum (144): usually absent → always present

Elasmotherium sibiricum :

Nasal dorsal profile (2): dorsally arched → straight
Nasal anterior end (3): before premaxillae → before DP1
Nasal notch distance to the the orbit/length of the skull (9): long(>17%) → short(<17%)
Nasal septum ossified (11): partially → totally
Orbit anterior border (13): behind M3 → above M3
Occipital ventral end of the paraoccipital process relative to the postglenoid process (30): nearly equal → under

Nasal bones rostral end (38): broad, or very broad → narrow
Median nasal horn (41): present → absent
Frontal horn (45): absent → present
Occipital crest (52): straight → forked
Maxillary processus zygomaticus maxilla anterior tip (53): progressive → steep
Squamosal processus postglenoidalis (58): convex → dihedron
Nuchal face outline (65): trapezoidal → square
Cheekteeth enamel foldings (86): weak → intense
P2-4 crochet (113): always present → always absent
P2-4 metaloph constriction (115): present → absent
P2 (122): present → absent
P3-4 protocone and hypocone (131): lingual wall → separated
P4 antecrochet (136): always absent → always present
M1 antecrochet-hypocone (156): sometimes joined, or always joined → always separated

Eoazara xerrii :

Frontal processus postorbitalis (15): present → absent
External auditory pseudo-meatus (28): open → partially closed
Pterygoid posterior margin (34): nearly horizontal → nearly vertical
Squamosal foramen postglenoideum (57): distant from the processus postglenoidalis → close to it
Squamosal occipital processus posttympanicus and processus paraoccipitalis (62): fused → distant
Squamosal processus posttympanicus (63): well developed → little developed
Symphysis (71): upraised → nearly horizontal
Foramen mentale (77): level of p2-4 → in front of p2
Corpus mandibulae base (80): convex → straight
Cheekteeth cement (88): abundant → weak or variable
i2 (100): absent → present
P1 (in adults) (120): always present → always absent
M2 antecrochet and hypocone (162): separated → joined
Lower molars labial cingulum (191): usually absent → always absent
McII trapezium-facet (222): always present → always absent

Gaioatherium browni :

Upper cheek teeth protocone constricted (108): anteroposteriorly → just anteriorly
Lower molars lingual cingulum (189): usually absent → always absent
Lower molars labial cingulum (191): usually absent → always absent

Hispanotherium beonense :

Maxillary processus zygomaticus maxilla anterior tip (53): progressive → steep
Symphysis posterior margin (76): level of p2-4 → in front of p2
Foramen mentale (77): level of p2-4 → in front of p2
i1 crown (99): developed with a pronounced neck → reduced
P2 protocone (126): less strong than the hypocone → equal or stronger than the hypocone
P2 protoloph (127): present → absent
P3 protoloph (133): joined to the ectoloph → interrupted
M1-2 posterior part of the ectoloph (152): straight → concave
M2 protocone lingual groove (158): always absent → always present
McII posterior McIII-facet (220): always absent → usually absent

Hispanotherium corcolense :

Upper premolars labial cingulum (112): usually absent → usually present
P4 antecrochet (136): always absent → usually present
Lower cheek teeth occlusal outline of the trigonid basin (173): U-shaped → V-shaped
d2 posterior valley (212): always open → usually open

Hispanotherium matritense :

Infraorbital foramen (5): behind the nasal notch → below the nasal notch
Nasal notch (8): U-shaped → V-shaped
P2-4 crochet (114): usually simple → usually multiple
M2 protocone lingual groove (158): always absent → usually absent

d3 paralophid (213): double → simple

Hispanotherium tungurense :

Maxillary anterior base of the processus zygomaticus maxillari (16): low → high

P3-4 metaloph (132): hypocone posterior to metacone → transverse

P4 hypocone and metacone (137): joined → separated

M2 mesostyle (161): weak → strong

Hoploaceratherium tetradactylum :

Maxillary foramen infraorbitalis (4): above premolars → above molars

Nuchal face outline (65): square → bell-shaped

Symphysis (71): upraised → nearly horizontal

Symphysis posterior margin (76): level of p2-4 → in front of p2

I1 (93): present → absent

Upper premolars labial cingulum (112): usually absent → usually present

P3 crista (134): always absent, or usually absent → usually present

D3-4 mesostyle (198): absent → present

d2-3 vertical external roughnesses (208): absent → present

Hyrachyus eximius :

Maxillary anterior base of the processus zygomaticus maxillari (16): high → low

Occipital ventral end of the paraoccipital process relative to the postglenoid process (30): above → under

Symphysis posterior margin (76): level of p2-4 → in front of p2

Ramus (82): vertical → inclined forward

i2 shape (101): tusk-like → incisor-like

i3 present (104): 1 → absent

c1 (105): absent → present

Upper premolars labial cingulum (112): always present → usually present

P2 protocone and hypocone (123): separated → fused

P2 protoloph (127): present → absent

P3 protoloph (133): joined to the ectoloph → interrupted

Upper molars labial cingulum (138): always present → usually absent

Upper molars antecrochet (139): usually absent → always absent

M1-2 metaloph (151): long → short

Lower premolars lingual cingulum (179): usually absent → always absent

p2 paralophid (186): isolated spur-like → curved without constriction

Semilunate anterior side (216): keeled → smooth

Iranotherium morgani :

Zygomatic arch (17): high → very high

Occipital ventral end of the paraoccipital process relative to the postglenoid process (30): above → nearly equal

Occipital crest (52): straight → forked

Squamosal processus posttympanicus (63): well developed → huge

Upper cheek teeth crista (110): one → always doubled

P2-4 crochet (114): usually simple → always simple

Upper molars base of the antecrochet expanded toward the entrance of the median valley (140): absent → present

M1 postfossette (157): present → usually absent

McII posterior McIII-facet (220): always absent → always present

Lartetotherium sansaniense :

P3 crista (134): always absent → usually absent

Lower cheek teeth occlusal outline of the trigonid basin (173): V-shaped → U-shaped

Lower cheekteeth metaconid (176): joined to the metalophid → constricted

Lower molars lingual cingulum (189): usually absent → always absent

Menoceras arikareense :

Nasal notch distance to the the orbit/length of the skull (9): short(<17%) → long(>17%)

Maxillary anterior base of the processus zygomaticus maxillari (16): high → low

External auditory pseudo-meatus (28): partially closed → open
Paired nasal horns (43): absent → present
Occipital processus paraoccipitalis (64): well developed → little developed
Nuchal face outline (65): bell-shaped → trapezoidal
Corpus mandibulae base (80): straight → convex
Cheekteeth roots (92): joined → fused
C1 (97): absent → present
P2-4 lingual cingulum (117): continuous → reduced
P3-4 constriction of the protocone (130): usually absent, or usually present → always present
Upper molars crista (142): usually absent → usually present
M2 metaloph (159): hypocone isolated → continuous
M2 mesostyle (160): absent → present
Lower cheekteeth external groove (170): developed → angular shaped
p2 paralophid (186): isolated spur-like → curved without constriction
Lower molars labial cingulum (191): always present → usually absent
D2 mesoloph (201): absent → present
McII posterior McIII-facet (220): always absent → always present

Mesaceraotherium gaimersheimense :

P3-4 protocone and hypocone (131): separated → lingual bridge
Upper molars labial cingulum (138): usually absent → always present
Upper molars crochet (141): always present → usually absent
M1-2 paracone fold (148): strong → weak
M3 constriction of the protocone (165): always present → usually absent
Lower cheekteeth external groove (170): developed → angular shaped
d1/p1 (in adults) (183): usually present, or usually absent → always present
Lower molars labial cingulum (191): always present → usually absent
Lower molars hypolophid (193): oblique → transverse

Mesaceraotherium paulhiacense :

M1-2 paracone fold (148): strong → weak
M2 mesostyle (160): absent → present
Trapezoid proximal border in anterior view (217): symmetric → asymmetric
McII magnum-facet (218): curved → straight
McII anterior and posterior McIII-facets (221): separated → fused

Mesaceraotherium welcommi :

Symphysis constriction before the lower cheek teeth row (74): absent → present
P3-4 constriction of the protocone (130): always absent, or usually absent → always present
Upper molars labial cingulum (138): always absent → always present
Upper molars antecrochet (139): always absent, or usually absent, or usually present → always present
Upper molars lingual cingulum (144): usually absent → always present
M1-2 constriction of the protocone (145): usually present → always present
M1-2 constriction of the protocone (146): weak → strong
M1-2 paracone fold (148): strong → weak
M1-2 posterior part of the ectoloph (152): straight → concave
M2 metaloph (159): continuous → hypocone isolated
M3 shape (164): triangular → quadrangular
p2-3 vertical external rugosities (169): absent → present
Lower cheekteeth external groove (170): developed → angular shaped
Lower cheekteeth entoconid (177): joined to the hypolophid → constricted

Molassitherium albigense :

Zygomatic arch processus postorbitalis (23): on jugal → on squamosal
Occipital side (29): vertical → inclined backward
Skull back of tooth row (33): in the posterior half → restricted to the anterior half
Nasal bones (40): short → long
Occipital crest (52): concave, or straight → forked

Squamosal foramen postglenoideum (57): distant from the processus postglenoidalis → close to it
Squamosal processus posttympanicus (63): well developed → little developed
Foramen magnum (67): circular → subtriangular
Cheekteeth enamel foldings (86): absent → weak
M1-2 metacone fold (149): present → absent
M1 metaloph (155): continuous → hypocone isolated
M1 postfossette (157): present → usually absent
M2 mesostyle (160): absent → present
M3 constriction of the protocone (165): always absent → always present
Lower cheekteeth external groove (171): vanishing before the neck → developed until the neck
D3-4 mesostyle (198): absent → present
Lower milk teeth protoconid fold (206): present → absent

Ningxiatherium euryrhinus :

Nasal lateral apophysis (1): absent → present
Frontal processus postorbitalis (15): present → absent
Occipital nuchal tubercle (32): very developed → little developed
Pterygoid posterior margin (34): nearly horizontal → nearly vertical
Squamosal articular tubercle (55): smooth → high
Basioccipital sagittal crest on the basilar process (60): present → absent
Upper premolars labial cingulum (112): usually absent, or always absent → always present
P2-4 crochet (114): usually simple → always simple
P3-4 constriction of the protocone (130): usually present, or always present → always absent
P3 crista (134): usually present → always absent
Upper molars labial cingulum (138): always absent → always present
M1-2 posterior part of the ectoloph (152): straight → concave
M1 metaloph (155): hypocone isolated → continuous
M2 metaloph (159): hypocone isolated → continuous
M3 ectoloph and metaloph (163): fused(ectometaloph) → distinct
M3 protoloph (167): lingually elongated → transverse

Ningxiatherium longirhinus :

Zygomatic arch processus postorbitalis (22): absent → present
Squamosal area between temporal and nuchal crests (27): flat → depression
Occipital crest (52): straight → concave
Cheekteeth crown (91): subhypsodonty, or hypsodonty → partial hypsodonty
Upper molars base of the antecrochet expanded toward the entrance of the median valley (140):
absent → present
Upper molars crista (142): always present → usually present
M1-2 cristella (153): usually present → always present
M2 antecrochet and hypocone (162): separated → joined

Parelasmotherium lingxiaense :

Maxillary processus zygomaticus maxilla anterior tip (53): progressive → steep
Premolar/molar row index (85): $100 \times LP3-4/LM1-3 < 42$ → $(100 \times LP3-4/LM1-3) > 50$
P2-4 crochet (113): always present → usually present
P3-4 medifossette (129): always absent → usually present
Upper molars base of the antecrochet expanded toward the entrance of the median valley (140):
absent → present
M3 constriction of the protocone (165): always present → always absent
Lower cheekteeth entoconid (177): constricted → joined to the hypolophid

Plesiaceratherium gracile :

Nasal notch (8): V-shaped → U-shaped
Occipital side (29): vertical → inclined forward
Occipital ventral end of the paraoccipital process relative to the postglenoid process (30): above →
under
Nasal bones (40): short → very long
Ramus (82): vertical → inclined forward

Upper cheek teeth crista (110): one → always doubled
Upper premolars labial cingulum (112): usually absent → always present
P3-4 protocone and hypocone (131): separated → lingual bridge
d1/p1 (in adults) (183): usually present, or usually absent, or always absent → always present

Plesiaceratherium mirallesi :

Squamosal area between temporal and nuchal crests (27): flat → depression
Occipital crest (52): concave → straight
Squamosal foramen postglenoideum (57): distant from the processus postglenoidalis → close to it
Squamosal occipital processus posttympanicus and processus paraoccipitalis (62): distant → fused
Basioccipital medial truncation on the condyle (69): absent → present
Cheekteeth shape of enamel (89): wrinkled and corrugated → wrinkled
Cheekteeth roots (92): joined → distinct
P2-3 antecrochet (119): always absent → usually absent
P3-4 medifossette (129): usually absent → usually present
M2 metaloph (159): hypocone isolated → continuous
p2-3 vertical external rugosities (169): absent → present
d1 (184): always one-rooted → usually two-rooted
Lower molars hypolophid (193): oblique → transverse
d2-3 vertical external roughnesses (208): absent → present
McII anterior McIII-facet (219): present → sometimes absent
McII trapezium-facet (222): always present → always absent

Pleuroceros blanfordi :

P3-4 protocone and hypocone (131): separated → lingual bridge
P4 antecrochet (136): usually absent, or usually present → always present
M1-2 constriction of the protocone (146): weak → strong
M1-2 metacone fold (149): absent → present
M1-2 posterior cingulum (154): continuous → low and reduced
M2 mesostyle (160): absent → present
M3 shape (164): triangular → quadrangular
Lower cheekteeth trigonid (174): rounded → angular
Lower cheekteeth metaconid (176): joined to the metalophid → constricted
Lower premolars lingual cingulum (179): usually absent → always present
Lower premolars lingual cingulum (180): reduced → continuous
Lower premolars labial cingulum (182): reduced → continuous
Lower molars lingual cingulum (189): usually present → always present
McII magnum-facet (218): straight → curved
McII posterior McIII-facet (220): always present → always absent

Pleuroceros pleuroceros :

Zygomatic arch (17): low → high
Zygomatic arch processus postorbitalis (22): absent → present
Occipital side (29): inclined forward → vertical
Skull (35): brachycephalic → dolichocephalic
Paired nasal horns (43): absent → present
Maxillary processus zygomaticus maxilla anterior tip (53): progressive → steep
Cheekteeth cement (87): absent → present
Cheekteeth shape of enamel (89): wrinkled and corrugated → wrinkled
P2-4 crochet (113): always present → usually present
P2-4 crochet (114): usually simple → usually multiple
P2-4 metaloph constriction (115): absent → present
P4 hypocone and metacone (137): joined → separated
M1-2 posterior cingulum (154): continuous → low and reduced
p2-3 vertical external rugosities (169): absent → present
Lower cheekteeth trigonid (174): rounded → angular
d1/p1 (in adults) (183): usually present → always present

Prosantorhinus douvillei :

Nasal lateral apophysis (1): absent → present
Nasal notch (7): above P4-M1 → above P1-3
Jugal/squamosal suture (24): smooth → rough
Paired nasal horns (43): absent → present
Occipital crest (52): concave → straight
Cheekteeth roots (92): joined → distinct
i1 (98): present → absent
P2-4 crochet (113): always present → usually present
Upper molars antecrochet (139): always present → usually present
M1-2 metacone fold (149): absent → present
M1 metaloph (155): hypocone isolated → continuous
M2 metaloph (159): hypocone isolated → continuous
M3 constriction of the protocone (165): always present → always absent
Lower premolars lingual opening of the posterior valley (178): narrow V-shape → U-shape
p2 posterior valley (188): lingually open → always closed
Lower molars lingual cingulum (189): usually present → always present
m2-3 lingual groove of the entoconid (194): absent → present
d3 lingual groove on the entoconid (214): usually absent → always present
McII posterior McIII-facet (220): always present → usually absent
McII trapezium-facet (222): always present → usually present

Protaceratherium minutum :

Nasal dorsal profile (2): straight → undulated
External auditory pseudo-meatus (28): partially closed → open
Corpus mandibulae base (80): straight → convex
i1 crown (99): developed with a pronounced neck → reduced
P2 protocone and hypocone (123): lingual bridge → separated
P4 antecrochet (136): usually absent → usually present
Lower cheekteeth external groove (170): developed → angular shaped
Lower cheekteeth metaconid (176): joined to the metalophid → constricted
d1/p1 (in adults) (183): usually present, or usually absent → always present
Lower molars labial cingulum (191): always present → usually present

Rhinoceros sondaicus :

Nasal notch (8): V-shaped → U-shaped
Occipital ventral end of the paraoccipital process relative to the postglenoid process (30): above → nearly equal
Occipital crest transverse expansion (50): wide → narrow
P2-4 crochet (114): usually simple → usually multiple
P1 antero-lingual cingulum (121): present → absent
M1-2 constriction of the protocone (145): usually present → always absent
Lower cheekteeth paralophid (172): nearly reach the lingual rim → away from the lingual rim
p2 posterior valley (188): lingually open → usually closed

Rhinoceros unicornis :

Zygomatic arch processus postorbitalis (22): absent → present
Skull dorsal profile (25): concave → very concave
Occipital crest (52): straight → concave
i2 orientation (102): parallel → divergent
P2-4 lingual cingulum (116): usually present → always absent
P3-4 constriction of the protocone (130): usually absent → usually present
P3 crista (134): usually absent → usually present
Upper molars crista (142): always absent, or usually absent → usually present
Upper molars medifossette (143): always absent → usually present
Upper molars lingual cingulum (144): usually absent → always absent
M1-2 paracone fold (148): strong → weak
M1-2 metaloph (151): short → long
Lower cheekteeth metaconid (176): joined to the metalophid → constricted

m2-3 lingual groove of the entoconid (194): absent → present

Ronzotherium filholi :

Maxillary foramen infraorbitalis (4): above premolars → above molars

Zygomatic arch processus postorbitalis (22): present → absent

Skull dorsal profile (25): flat → concave

Skull widest part of the dorsal surface (37): at level of postorbital process area → at level of supraorbital process

Frontal-parietal (49): sagittal crest → close frontoparietal crests

Maxillary processus zygomaticus maxilla anterior tip (53): progressive → steep

Symphysis posterior margin (76): level of p2-4 → in front of p2

Corpus mandibulae lingual groove (79): still present at adult stage → present at juvenile stage only

Ramus processus coronoideus (83): well developed → little developed

P2-4 postfossette (118): narrow → wide

P2 protocone and hypocone (123): separated → lingual bridge

P3 crista (134): always absent → usually present

P4 antecrochet (136): always absent → usually absent

Upper molars labial cingulum (138): always present → usually present

Upper molars antecrochet (139): usually absent → usually present

Upper molars crochet (141): always absent, or usually absent → usually present

Upper molars crista (142): always absent → usually present

M1-2 metacone fold (149): present → absent

M1-2 metastyle (150): short → long

McII trapezium-facet (222): always present → always absent

Rusingaceros leakeyi :

Frontal horn (45): absent → present

Corpus mandibulae base (80): straight → convex

M1-2 constriction of the protocone (145): usually present → usually absent

p2 paralophid (186): curved without constriction → isolated spur-like

Shansirhinus ringstromi :

Nasal dorsal profile (2): straight → upturned

Median nasal horn (41): absent → present

P2-4 crochet (114): always simple → usually multiple

Upper molars crista (142): usually present → always present

Upper molars medifossette (143): always absent → usually present

Lower cheekteeth paralophid (172): away from the lingual rim → nearly reach the lingual rim

Lower cheek teeth occlusal outline of the trigonid basin (173): V-shaped → U-shaped

Lower molars hypolophid (193): oblique → transverse

Subhyracodon occidentalis :

Nasal notch distance to the the orbit/length of the skull (9): short(<17%) → long(>17%)

Squamosal area between temporal and nuchal crests (27): flat → depression

Paired nasal horns (43): absent → present

Zygomatic width/frontal width (48): less than 1.5 → more than 1.5

Symphysis (71): upraised → nearly horizontal

Symphysis (72): slender → massive

Premolar/molar row index (85): $(100 \times LP3-4/LM1-3) > 50$ → $42 < (100 \times LP3-4/LM1-3) < 50$

P2-4 metaloph constriction (115): absent → present

P2-4 postfossette (118): narrow → wide

P2 metaloph (124): hypocone posterior to metacone → transverse

P4 hypocone and metacone (137): joined → separated

M1-2 metastyle (150): short → long

M1-2 metaloph (151): long → short

p2 posterior valley (188): lingually open → usually closed

Teleoceras fossiger :

Occipital side (29): inclined forward → vertical

Nasal bones (39): totally separated → anteriorly separated

Frontal-parietal (49): sagittal crest → close frontoparietal crests
 Squamosal posterior groove on the processus zygomaticus (61): present → absent
 Squamosal processus posttympanicus (63): well developed → little developed
 Occipital processus paraoccipitalis (64): well developed → little developed
 Foramen mentale (77): level of p2-4 → in front of p2
 Corpus mandibulae base (80): straight → convex
 Premolar/molar row index (85): $(100 \times LP3-4/LM1-3) > 50 \rightarrow 42 < (100 \times LP3-4/LM1-3) < 50$
 Cheekteeth crown (90): low → high
 i2 orientation (102): parallel → divergent
 P2-4 lingual cingulum (116): always present → usually absent
 P2-4 lingual cingulum (117): continuous → reduced
 P1 (in adults) (120): always present → always absent
 P3-4 constriction of the protocone (130): always absent → usually absent
 P3-4 protocone and hypocone (131): separated → lingual bridge
 Upper molars lingual cingulum (144): usually absent → always absent
 M1-2 constriction of the protocone (146): weak → strong
 M1-2 paracone fold (147): present → absent
 M1-2 metaloph (151): long → short
 M1 antecrochet-hypocone (156): always separated → sometimes joined
 M2 protocone lingual groove (158): always absent → usually absent
 Lower cheekteeth paralophid (172): away from the lingual rim → nearly reach the lingual rim
 Lower cheek teeth occlusal outline of the trigonid basin (173): V-shaped → U-shaped
 d1/p1 (in adults) (183): usually absent → always absent
 p2 (185): always present → usually present
 Lower molars lingual cingulum (189): usually present → usually absent
 Lower molars labial cingulum (191): always present → usually absent
 D2 mesostyle (197): present → absent
 Lower milk teeth constriction of the entoconid (205): absent → present
 d1(in juveniles) (207): present → absent
 d2-3 ectolophid fold (209): present → absent
 Semilunate anterior side (216): smooth → keeled

Trigonias osborni :

Nasal lateral apophysis (1): absent → present
 Occipital crest transverse expansion (50): narrow → wide
 Squamosal processus posttympanicus (63): well developed → little developed
 Nuchal face outline (65): bell-shaped → square
 Foramen magnum (67): circular → subtriangular
 Symphysis (71): very upraised → nearly horizontal
 I1 shape of the crown cross section (94): almond → oval
 M1-2 paracone fold (148): strong → weak
 Lower premolars labial cingulum (181): present → absent
 Lower molars labial cingulum (191): always present → usually absent

Turkanatherium acutirostratum :

Squamosal processus posttympanicus (63): well developed → little developed
 P3-4 metaloph (132): hypocone posterior to metacone → transverse
 M1 metaloph (155): continuous → hypocone isolated

Victoriaceros kenyensis :

Nasal notch distance to the the orbit/length of the skull (9): long(>17%) → short(<17%)
 Occipital ventral end of the paraoccipital process relative to the postglenoid process (30): above → nearly equal
 Nasal bones rostral end (38): narrow → very broad
 Median nasal horn (42): small → developed
 Orbit lateral projection (47): absent → present
 Frontal-parietal (49): close frontoparietal crests → distant crests
 Ramus (82): vertical → inclined forward

P2 metaloph (124): hypocone posterior to metacone, or transverse → hypocone anterior to metacone
P3 crista (134): always absent → usually absent
Upper molars labial cingulum (138): usually absent → usually present
Upper molars crochet (141): always present → usually absent
Upper molars crista (142): always absent → usually absent
M1-2 posterior cingulum (154): low and reduced → continuous
M2 protocone lingual groove (158): always absent → usually absent
Lower cheekteeth entoconid (177): joined to the hypolophid → constricted

Node 60 :

Nasal notch (7): above P4-M1 → above P1-3
Maxillary anterior base of the processus zygomaticus maxillari (16): high → low
External auditory pseudo-meatus (28): partially closed → open
Occipital side (29): inclined forward → vertical
Nasal bones (40): short → long
P2-4 crochet (113): always present → usually present
P2-4 crochet (114): usually simple → always simple
P2 protocone (126): less strong than the hypocone → equal or stronger than the hypocone
P3-4 constriction of the protocone (130): usually absent → usually present
Lower cheekteeth external groove (170): developed → smooth U-shaped

Node 61 :

Cheekteeth shape of enamel (89): wrinkled and corrugated → wrinkled
P1 (in adults) (120): always present → usually present
P3-4 constriction of the protocone (130): always absent → usually absent
M1-2 paracone fold (148): strong → weak
McII trapezium-facet (222): always present → usually present

Node 62 :

Zygomatic arch processus postorbitalis (22): absent → present
Maxillary processus zygomaticus maxilla anterior tip (53): progressive → steep
Squamosal posterior groove on the processus zygomaticus (61): present → absent
Squamosal processus posttympanicus (63): well developed → little developed
Foramen mandibulare (84): below the teeth neck → above the teeth neck
i2 orientation (102): parallel → divergent
P2-4 metaloph constriction (115): absent → present
Lower premolars lingual cingulum (179): usually present → usually absent

Node 63 :

Infraorbital foramen (5): behind the nasal notch → below the nasal notch
Zygomatic width/frontal width (48): less than 1.5 → more than 1.5
Foramen magnum (67): circular → subtriangular
P2 protocone (126): equal or stronger than the hypocone → less strong than the hypocone
McII magnum-facet (218): curved → straight
McII anterior and posterior McIII-facets (221): separated → fused

Node 64 :

P2 protoloph (128): interrupted → joined to the ectoloph
P3-4 medifossette (129): usually absent → always absent
P3 crista (134): usually absent → always absent
M1-2 metacone fold (149): present → absent
M1-2 metaloph (151): short → long
M1 metaloph (155): continuous → hypocone isolated
M3 constriction of the protocone (165): always absent → always present
Lower premolars lingual cingulum (179): always present → usually present
Lower molars lingual cingulum (189): always present → usually present
McII posterior McIII-facet (220): usually absent → always present

Node 65 :

Zygomatic arch (17): high → low
Occipital side (29): vertical → inclined forward

Squamosal articular tubercle (55): smooth → high
Symphysis (72): slender → massive
M3 shape (164): quadrangular → triangular
Lower cheekteeth trigonid (174): angular → rounded
Lower premolars labial cingulum (182): continuous → reduced
D2 secondary folds (200): absent → present
McII posterior McIII-facet (220): always absent → usually absent

Node 66 :

P4 antecrochet (136): always absent → usually absent
Upper molars labial cingulum (138): always present → usually absent

Node 67 :

Squamosal posterior groove on the processus zygomaticus (61): absent → present
P2-4 crochet (113): always absent → always present
P3-4 medifossette (129): always absent → usually absent
P3 crista (134): always absent → usually absent, or usually present
Upper molars crochet (141): usually absent → always present
M1-2 metastyle (150): short → long
M1-2 metaloph (151): long → short

Node 68 :

Cheekteeth shape of enamel (89): wrinkled → wrinkled and corrugated
Cheekteeth roots (92): distinct → joined
Upper premolars labial cingulum (112): always present → usually absent, or always absent
P2 protocone and hypocone (123): separated → lingual bridge

Node 69 :

External auditory pseudo-meatus (28): open → partially closed
I1 shape of the crown cross section (94): almond → oval
P3-4 metaloph (132): transverse → hypocone posterior to metacone
Upper molars antecrochet (139): usually absent → always present
M1-2 constriction of the protocone (145): always absent → usually present, or always present
M2 metaloph (159): continuous → hypocone isolated

Node 70 :

Symphysis (71): very upraised → upraised
M1-2 posterior part of the ectoloph (152): straight → concave
M3 ectoloph and metaloph (163): distinct → fused(ectometaloph)
Lower premolars lingual opening of the posterior valley (178): U-shape → narrow V-shape
Lower premolars lingual cingulum (180): reduced → continuous
d1 (184): always two-rooted → always one-rooted

Node 71 :

No synapomorphies

Node 72 :

Maxillary foramen infraorbitalis (4): above premolars → above molars
Upper molars crista (142): usually absent → always absent
Upper molars lingual cingulum (144): always present → usually present

Node 73 :

Infraorbital foramen (6): one → two-three
Skull narrowing of dorsal surface anterior to the orbit (36): gradual → abrupt
Symphysis constriction before the lower cheek teeth row (74): absent → present
Cheekteeth crown (90): low → high
I1 (93): present → absent
P2 protocone and hypocone (123): lingual bridge → separated

Node 74 :

Infraorbital foramen (5): behind the nasal notch → below the nasal notch
External auditory pseudo-meatus (28): partially closed → closed
Cheekteeth shape of enamel (89): wrinkled and corrugated → wrinkled
Cheekteeth roots (92): joined → distinct

i2 orientation (102): parallel → divergent
P2-4 crochet (114): usually simple, or usually multiple → always simple
P2-4 postfossette (118): narrow → posterior wall
P1 (in adults) (120): always present → always absent
P2 protocone (126): equal or stronger than the hypocone → less strong than the hypocone
P2 protoloph (128): interrupted → joined to the ectoloph
M1-2 metacone fold (149): present → absent
M1 metaloph (155): continuous → hypocone isolated
M3 shape (164): quadrangular → triangular
M3 constriction of the protocone (165): always absent → always present
p2-3 vertical external rugosities (169): absent → present

Node 75 :

Squamosal transversal profile of articular tubercle (56): straight → concave
i1 (98): present → absent
P3-4 medifossette (129): usually absent → usually present
P3-4 constriction of the protocone (130): always absent → usually absent, or usually present
P3 crista (134): usually absent, or usually present → always present
Upper molars crista (142): always absent → usually absent
M1-2 posterior cingulum (154): continuous → low and reduced
D2 mesostyle (197): present → absent
d2-3 vertical external roughnesses (208): absent → present

Node 76 :

P3-4 constriction of the protocone (130): usually absent, or usually present → always absent
M1-2 paracone fold (148): strong → weak
Lower molars lingual cingulum (189): always present → usually absent

Node 77 :

Zygomatic width/frontal width (48): less than 1.5 → more than 1.5
Frontal-parietal (49): sagittal crest → close frontoparietal crests

Node 78 :

Upper molars crista (142): usually absent → usually present
M1-2 cristella (153): always absent → usually present
Lower premolars labial cingulum (182): continuous → reduced

Node 79 :

Upper molars lingual cingulum (144): always present → usually present
M1-2 cristella (153): usually present → always present

Node 80 :

Corpus mandibulae base (80): straight → convex
Cheekteeth cement (87): absent → present
i1 (98): present → absent
M2 metaloph (159): hypocone isolated → continuous
Lower cheekteeth trigonid (174): rounded → angular
Lower cheekteeth trigonid (175): obtuse or right dihedron → acute dihedron
Lower molars lingual cingulum (189): usually present, or usually absent → always absent
Lower molars labial cingulum (191): always present → usually present

Node 81 :

Squamosal processus posttympanicus (63): well developed → little developed
Occipital processus paraoccipitalis (64): well developed → little developed
Symphysis (72): massive → very massive
Corpus mandibulae lingual groove (78): present → absent
I1 shape of the crown cross section (94): oval → almond
Lower cheek teeth occlusal outline of the trigonid basin (173): V-shaped → U-shaped
p2 paraconid (187): developed → reduced

Node 82 :

Frontal-parietal (49): sagittal crest → distant crests
Vomer (54): rounded → acute

Symphysis (71): upraised → nearly horizontal
d2-3 ectolophid fold (209): present → absent

Node 83 :

i1 crown (99): developed with a pronounced neck → reduced
i2 (100): present → absent
P3 crista (134): usually absent → usually present, or always present
Upper molars lingual cingulum (144): usually absent → always absent

Node 84 :

P3 crista (134): always absent → usually absent
D2 lingual wall (199): absent → present

Node 85 :

P3-4 constriction of the protocone (130): usually absent, or usually present → always present
Upper molars labial cingulum (138): usually absent → usually present
M1 metaloph (155): continuous → hypocone isolated

Node 86 :

Symphysis (72): massive → slender
P2-4 crochet (113): usually present → always present
P2 protocone and hypocone (123): lingual bridge → lingual wall
P3-4 protocone and hypocone (131): lingual bridge → lingual wall
M1-2 metacone fold (149): absent → present
M2 mesostyle (160): absent → present
M3 shape (164): triangular → quadrangular
Trapezoid proximal border in anterior view (217): symmetric → asymmetric
McII posterior McIII-facet (220): always present → always absent

Node 87 :

Nasal dorsal profile (2): dorsally arched → undulated
Zygomatic arch processus postorbitalis (22): absent → present
Occipital crest (52): straight → concave
Squamosal posterior groove on the processus zygomaticus (61): absent → present
Premolar/molar row index (85): $(100 \times LP3-4/LM1-3) > 50 \rightarrow 42 < (100 \times LP3-4/LM1-3) < 50$

Node 88 :

Skull (35): brachycephalic → dolichocephalic
P2-4 lingual cingulum (116): usually present → usually absent
P2-4 postfossette (118): narrow → wide
Upper molars antecrochet (139): usually absent, or usually present → always present
Upper molars crochet (141): usually present → always present
M1-2 constriction of the protocone (145): usually present → always present
M1-2 constriction of the protocone (146): weak → strong
M3 constriction of the protocone (165): always absent → always present
Lower cheekteeth external groove (170): developed → angular shaped

Node 89 :

Nasal notch (8): V-shaped → U-shaped
Median nasal horn (42): developed → small
Occipital crest transverse expansion (50): wide → narrow
Squamosal articular tubercle (55): high → smooth
I1 shape of the crown cross section (94): oval → almond
Upper premolars labial cingulum (112): always absent → usually absent
P2-4 crochet (113): always present → usually present
Upper molars labial cingulum (138): always absent → usually absent
M1-2 posterior cingulum (154): continuous → low and reduced
M3 posterior groove on the ectometaloph (168): absent → present
Lower cheekteeth trigonid (174): rounded → angular
Lower cheekteeth metaconid (176): joined to the metalophid → constricted

Node 90 :

P2-4 lingual cingulum (116): usually absent → usually present

Upper molars crochet (141): always present → usually present
M1-2 metaloph (151): long → short
M1 metaloph (155): hypocone isolated → continuous
M3 constriction of the protocone (165): always present → always absent
d1 (184): always one-rooted → always two-rooted, or usually two-rooted

Node 91 :

Zygomatic width/frontal width (48): less than 1.5 → more than 1.5
Occipital crest (52): concave → straight
Squamosal posterior groove on the processus zygomaticus (61): present → absent
Cheekteeth cement (87): absent → present
P2 protocone (126): equal or stronger than the hypocone → less strong than the hypocone

Node 92 :

Upper molars antecrochet (139): always present → always absent, or usually absent, or usually present

Upper molars lingual cingulum (144): always present → usually absent
M1-2 constriction of the protocone (145): always present → usually present
M1-2 posterior part of the ectoloph (152): concave → straight
M2 metaloph (159): hypocone isolated → continuous
Lower premolars labial cingulum (181): present → absent

Node 93 :

Nasal bones rostral end (38): narrow → broad, or very broad
Median nasal horn (41): absent → present
P2-4 lingual cingulum (116): always present → usually absent

Node 94 :

Nasal notch (7): above P4-M1 → above P1-3
P2-4 lingual cingulum (117): continuous → reduced
Upper molars labial cingulum (138): usually absent → always absent
p2 paralophid (186): isolated spur-like → curved without constriction
Lower molars labial cingulum (191): always present → usually present

Node 95 :

Nasal notch (8): V-shaped → U-shaped
Orbit anterior border (13): above P4-M2 → above M3
Occipital side (29): vertical → inclined backward
P2-4 lingual cingulum (116): usually present → usually absent
P2-4 postfossette (118): narrow → wide
P3 crista (134): usually absent → usually present
Upper molars crochet (141): usually present → always present
Upper molars crista (142): usually absent → usually present
Upper molars medifossette (143): usually absent → usually present
M1 antecrochet-hypocone (156): always separated → sometimes joined
M3 shape (164): triangular → quadrangular
M3 posterior groove on the ectometaloph (168): absent → present
Lower cheekteeth trigonid (174): rounded → angular
Lower cheekteeth metaconid (176): joined to the metalophid → constricted
Lower cheekteeth entoconid (177): joined to the hypolophid → constricted
d1/p1 (in adults) (183): usually absent → always absent
p2 posterior valley (188): lingually open → usually closed
dI1 (195): present → absent

Node 96 :

Nasal/lacrymal contact (12): long → punctual or absent
Frontal processus postorbitalis (15): present → absent
Nasal bones rostral end (38): broad → very broad
Basioccipital median ridge on the condyle (68): present → absent
Symphysis (72): massive → slender
Corpus mandibulae base (80): straight → very convex

Ramus (82): vertical → inclined backward
Cheekteeth shape of enamel (89): wrinkled and corrugated → corrugated and arborescent
I1 (93): present → absent
i1 (98): present → absent
i2 (100): present → absent
P3-4 medifossette (129): usually absent → usually present
Upper molars medifossette (143): always absent → usually absent
M1-2 constriction of the protocone (145): usually present → usually absent
M1-2 paracone fold (148): strong → weak
McII anterior and posterior McIII-facets (221): separated → fused

Node 97 :

Jugal/squamosal suture (24): smooth → rough
Frontal horn (45): absent → present
Zygomatic width/frontal width (48): more than 1.5 → less than 1.5
Vomer (54): acute → rounded
Symphysis (71): nearly horizontal → upraised
McII trapezium-facet (222): always present → always absent

Node 98 :

i1 crown (99): developed with a pronounced neck → reduced
Upper cheek teeth protocone constricted (108): anteroposteriorly → just anteriorly
P2 protoloph (128): joined to the ectoloph → interrupted
P3-4 protocone and hypocone (131): lingual bridge → separated
P3 crista (134): always absent → usually absent
Trapezoid proximal border in anterior view (217): symmetric → asymmetric

Node 99 :

Skull narrowing of dorsal surface anterior to the orbit (36): gradual → abrupt
P2-3 antecrochet (119): always absent, or usually absent → usually present
P3-4 medifossette (129): always absent → usually absent
P4 antecrochet (136): always absent, or usually absent → usually present
M1-2 paracone fold (148): strong → weak
Lower premolars lingual opening of the posterior valley (178): narrow V-shape → U-shape

Node 100 :

Skull narrowing of dorsal surface anterior to the orbit (36): abrupt → gradual
Symphysis (72): massive → very massive
P3 pseudometaloph (135): always absent → sometimes present
M1-2 paracone fold (148): strong → weak
Lower premolars lingual cingulum (179): always present → always absent
Lower premolars labial cingulum (181): present → absent
d1/p1 (in adults) (183): usually absent → usually present
Lower molars labial cingulum (191): always present → always absent

Node 101 :

Maxillary anterior base of the processus zygomaticus maxillari (16): high → low
Occipital ventral end of the paraoccipital process relative to the postglenoid process (30): above → under

Skull widest part of the dorsal surface (37): at level of supraorbital process → at level of postorbital process area

Occipital crest transverse expansion (50): narrow → wide
P2-3 antecrochet (119): always absent → always present
P3-4 constriction of the protocone (130): usually present → always present
P4 antecrochet (136): always absent → always present
Upper molars lingual cingulum (144): usually present → usually absent

Node 102 :

Nasal lateral apophysis (1): absent → present
Nasal notch (7): above P4-M1 → above P1-3
Squamosal area between temporal and nuchal crests (27): flat → depression

External auditory pseudo-meatus (28): partially closed → closed
Occipital nuchal tubercle (32): developed → very developed
Nasal bones (39): totally separated → anteriorly separated
Occipital processus paraoccipitalis (64): well developed → little developed
Foramen mentale (77): level of p2-4 → in front of p2
P2-4 crochet (113): always present → usually present
P4 antecrochet (136): usually absent, or usually present → always absent
M3 shape (164): triangular → quadrangular

Node 103 :

Occipital ventral end of the paraoccipital process relative to the postglenoid process (30): above → nearly equal

Nasal bones (40): very long → short
Occipital crest transverse expansion (50): narrow → wide
Squamosal occipital processus posttympanicus and processus paraoccipitalis (62): fused → distant
Upper cheek teeth crista (110): one → always doubled
P1 (in adults) (120): always present → always absent
M1-2 metastyle (150): long → short
M3 protocone (166): trefoil-shape → indented

Node 104 :

Nasal septum (10): never ossified → ossified (even sometimes)
Squamosal processus posttympanicus (63): well developed → huge
P2-4 postfossette (118): wide → posterior wall
P2-3 antecrochet (119): always absent → always present
M1 postfossette (157): present → usually absent

Node 105 :

Nasal notch (7): above P1-3 → above P4-M1
Orbit anterior border (13): above P4-M2, or above M3 → behind M3
Lacrymal processus lacrymalis (14): present → absent
Maxillary anterior base of the processus zygomaticus maxillari (16): low → high
Upper molars crochet (141): always present → usually present
Upper molars crista (142): usually present → always present
M1-2 metaloph (151): short → long

Node 106 :

Nasal bones (39): anteriorly separated → fused
Nasal bones (40): short → very long
Squamosal posterior groove on the processus zygomaticus (61): present → absent
Symphysis constriction before the lower cheek teeth row (74): absent → present
M2 mesostyle (160): present → absent
M3 protoloph (167): transverse → lingually elongated
Lower cheekteeth trigonid (175): acute dihedron → obtuse or right dihedron

Node 107 :

Zygomatic arch processus postorbitalis (22): present → absent
Nasal bones (39): totally separated → anteriorly separated
Occipital crest (52): concave → straight
Ramus (82): vertical → inclined backward
Premolar/molar row index (85): $42 < (100 \times LP3-4/LM1-3) < 50 \rightarrow 100 \times LP3-4/LM1-3 < 42$
Cheekteeth enamel foldings (86): absent → weak
Cheekteeth crown (91): high → partial hypsodonty
i1 (98): present → absent
P2-4 lingual cingulum (116): usually absent → always absent
P2 lingual groove (125): present → absent
Upper molars labial cingulum (138): usually absent → always absent
Upper molars crista (142): usually absent → usually present
M1-2 metacone fold (149): present → absent
M2 protocone lingual groove (158): always absent → usually absent, or always present

Node 108 :

Nasal dorsal profile (2): straight → dorsally arched
Nasal bones rostral end (38): narrow → broad
Median nasal horn (42): small → developed
Frontal-parietal (49): close frontoparietal crests → distant crests
Cheekteeth cement (88): weak or variable → abundant
P2 protoloph (128): interrupted → joined to the ectoloph
Upper molars labial cingulum (138): usually present → usually absent
M1 antecrochet-hypocone (156): always separated → sometimes joined, or always joined
Lower cheekteeth external groove (171): vanishing before the neck → developed until the neck
Lower cheekteeth trigonid (174): angular → rounded
Lower cheekteeth entoconid (177): joined to the hypolophid → constricted
D3-4 mesostyle (198): absent → present

Node 109 :

External auditory pseudo-meatus (28): partially closed → closed
Occipital nuchal tubercle (32): developed → little developed
Basioccipital sagittal crest on the basilar process (60): present → absent
I2 (95): absent → present
i2 orientation (102): parallel → divergent
P2-4 lingual cingulum (116): usually absent → always absent

Node 110 :

Nasal notch (8): V-shaped → U-shaped
Nasal notch distance to the the orbit/length of the skull (9): short(<17%) → long(>17%)
External auditory pseudo-meatus (28): open → partially closed
Occipital nuchal tubercle (32): little developed, or developed → very developed
Premolar/molar row index (85): (100xLP3-4/LM1-3>50 → 42<(100xLP3-4/LM1-3<50
P4 hypocone and metacone (137): joined → separated
Lower cheekteeth metaconid (176): joined to the metalophid → constricted
Lower premolars lingual cingulum (179): always present, or usually present → usually absent
Lower molars lingual cingulum (189): always present → usually absent

Node 111 :

Maxillary anterior base of the processus zygomaticus maxillari (16): high → low
Squamosal transversal profile of articular tubercle (56): straight → concave
Corpus mandibulae lingual groove (78): present → absent
I1 shape of the crown cross section (94): oval → almond
P2-4 crochet (114): usually simple → usually multiple
P2 protoloph (128): joined to the ectoloph → interrupted
P4 antecrochet (136): usually absent, or usually present → always present
Upper molars labial cingulum (138): usually absent → always absent
Upper molars lingual cingulum (144): always present, or usually present → usually absent
M2 mesostyle (160): absent → present
Lower cheekteeth metaconid (176): joined to the metalophid → constricted
Lower premolars lingual cingulum (179): usually present → always present
Lower premolars labial cingulum (181): present → absent
d2 posterior valley (212): always open → always closed
d3 lingual groove on the entoconid (214): always absent → usually absent
Humerus fossa olecrani (215): high → low

Node 112 :

External auditory pseudo-meatus (28): open, or partially closed → closed
Pterygoid posterior margin (34): nearly horizontal → nearly vertical
Ramus (82): vertical → inclined forward
D2 secondary folds (200): absent → present

The 16 shortest trees obtained by TNT on Eoazara-16.tnt (taxa that have at least 50% of their characters scored):

tread '16 shortest trees, from the data matrix Eoazara-16.tnt'

(0 ((51 (54 (39 (21 ((48 (44 (((((31 (1 45))(8 9))(47 55))(20 36))((10 12
) (46 (37 (34 (((52 (13 (57 ((14 (27 (28 (29 (11 (30 (33 (25 (42 (40 (24 41
))))))))) (16 58)))) ((22 (23 (15 19)) (49 50)) (26 38))))))) (35 (43 ((2
(3 5)) (7 (4 (6 (53 (17 18))))))) (32 56)))*
(0 ((54 (39 (21 ((48 (44 (((((31 (1 45))(8 9))(47 55))(20 36))((10 12))(46
(37 (34 (((52 (13 (57 ((14 (27 (28 (29 (11 (30 (33 (25 (42 (40 (24 41
))))))))) (16 58)))) ((22 (23 (15 19)) (49 50)) (26 38))))))) (35 (43 ((2
(3 5)) (7 (4 (6 (53 (17 18))))))) (51 (32 56)))*
(0 ((51 (54 (39 (21 ((48 (44 (((((31 (1 45))(8 9))(20 36))(47 55))((10 12
) (46 (37 (34 (((52 (13 (57 ((14 (27 (28 (29 (11 (30 (33 (25 (42 (40 (24 41
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) (46 (37 (34 (((13 (52 (57 ((14 (27 (28 (29 (11 (30 (33 (25 (42 (40 (24 41
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28)))(16 58)))))(22 (23 (15 19)))(49 50)))(26 38))))))) (35 (43 ((2 (3 5
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(37 (34 (((13 (52 (57 ((14 ((29 (11 (30 (33 (25 (42 (40 (24 41)))))))))(27 28
) (16 58)))))(22 (23 (15 19)))(49 50)))(26 38))))))) (35 (43 ((2 (3 5
) (7 (4 (6 (53 (17 18))))))))))) (51 (32 56)));