Supplementary contents

The holotype of *Macroplacus raeticus*: an historical overview

Macroplacus raeticus is a cyamodontoid placodont first described by Schubert-Klempnauer in 1975 based on a three-dimensionally preserved skull from the Rhaetian of the Bavarian Alps—"Kössener Schichten", now known as the Kössen Formation (Golebiowski 1990)—at Hinterstein (Sonthofen) in Bad Hindelang, Allgäu, Bavaria, Germany. The holotype, and up to now the only known specimen of *Macroplacus raeticus*, is housed in the Palaeontological Collection of the Staatliche Naturwissenschaftliche Sammlungen Bayerns, Bayerische Staatssammlung für Paläontologie und Geologie, München, Germany with the catalogue number SNSB-BSPG 1967 I 324.

The skull does not preserve the portion of premaxillae rostral to the external and internal nares, so it cannot be confirmed whether the premaxillae formed an elongated, edentulous rostrum as in other known cyamodontoids.

Schubert-Klempnauer (1975) noted that the characteristic placodont crushing dentition in the new specimen was remarkable for its hypertrophic size—at that time unknown within this sauropterygian clade—and exhibited a tightly packed pattern, representing the highest degree of specialisation within the cyamodontoid placodonts. He did not interpret the peculiar dentition of the new specimen as the result of the ontogenetic development within one of the previously known placodont species, although ontogenetic changes had been documented in other members of the clade (i.e., *Cyamodus hildegardis*, Kuhn-Schnyder 1959).

Other major features of the new placodont specimen highlighted by Schubert-Klempnauer included: the skull size, which exceeded that of any other (presumably) adult cyamodontoid; the shape, position, and size of the skull openings, which occupied a proportionally larger area of the skull roof than in related taxa; the dorsoventral flattening of the skull, particularly in comparison with *Cyamodus rostratus* and *Placochelys placodonta*; the alignment of the palatal dentition and the articular condyle of the quadrate on the same horizontal plane in lateral view; the presence of a quadrate foramen, and a weakly arched gap separating the quadrate-quadratojugal complex from the squamosal in posterior view; the absence of a true "pterygopalatinum" foramen ("posterior dental lamina foramen" *sensu* Rieppel 2001a), replaced instead by a deep groove running along the tooth margin; the extreme reduction in size of the pterygoid compared to the palatine in ventral view; the upper

dentition formula 0, 2, 2; the premaxillae contributing to the anterior margin of the internal nares; the vomers being restricted to the bridge between the internal nares; the lateral and posterior margins of the latter formed respectively by the maxilla and the palatine; the premaxilla extending beyond the anterior margin of the orbit; the nasal and lacrimal separating the prefrontal from the frontal; the prefrontal forming the entire posterior margin of the external naris, with the maxilla nearly excluded from its margin; the nasals and frontals forming the interorbital bridge; the wide prefrontals meeting medially and thereby separating the frontals from the parietals; the frontals being restricted to the interorbital bridge; the anterior margin of the parietals lying posterior to the posterior margin of the orbits; the dermal ossifications on the posterior portion of the skull being poorly sculptured; the maxilla extending posteriorly only to the midpoint of the orbit; the long, posteriorly extended process of the postorbital excluding the squamosal from the anterolateral margin of the upper temporal fenestra; and the quadratojugal extending broadly along the ventral margin of the temporal arch, reaching the quadrate articular condyle but not contributing to it.

According to Schubert-Klempnauer, the presence of an edentulous (not preserved) rostrum in *Macroplacus*, formed by the premaxillae, was indirectly demonstrated based on functional considerations. He argued that comparison of *Macroplacus* with *Cyamodus* and *Placochelys* (Schubert-Klempnauer 1975, fig. 7) showed that in *Placochelys* the loss of premaxillary dentition is associated with a less anteroposteriorly arched hard palate compared to *Cyamodus*, which retains premaxillary dentition that anteriorly completes the concavity of the crushing surface formed by the tooth-plates. With the reduction of the most anterior dentition, and in association with the (presumed) development of a horny, edentulous beak, a less arched hard palate results into greater efficiency of the anterior tooth-plates still present in the dentition (i.e., maxillary and anterior palatine tooth-plates). In *Macroplacus*, the bony surface bearing the maxillary and palatine dentition is completely flattened relative to that of *Placochelys*, suggesting the presence of an edentulous rostrum that ensured optimal feeding mechanics when associated with the complete flattening of the hard palate. Furthermore, Schubert-Klempnauer emphasised that the preserved portion of the premaxillae is toothless, and that no alveoli can be observed in the broken rostrum; in his view, it could be taken for granted that tooth-plates were also absent in the anterior, pointed part of the rostrum.

Considering whether the differences in palatal dentition and the pattern of skull bones, in comparison with other placodont species, might justify the erection of a new genus and

species, Schubert-Klempnauer (1975) concluded that they did—given the absence of further comparable material—and assessed that the differences observed in the new specimen exceeded those observed within the previously known species.

The new taxon *Macroplacus raeticus* was initially accepted by Pinna (1976a) as a valid genus and species of the Suborder Cyamodontoidea, Family Placochelyidae. However, in comparing *Macroplacus raeticus* with other Rhaetian Placochelyidae (all of which were later synonymised with *Psephoderma alpinum*), he hypothesised that the observed differences in dentition, when considered in relation to increasing size, might have been ontogenetically driven—suggesting the presence of a single placochelyid species in the Rhaetian. At the same time, Pinna noted that the distinct morphology of the orbitofrontal region in *Macroplacus raeticus*, compared to other Rhaetian Placochelyidae, warranted caution; if such differences were not due to pathology or taphonomic distortion, synonymy should be considered only at the generic level.

This may explain why Pinna himself later (1978, 1990 fig. 1, and 1999, *Psephoderma raeticum* sic!)—while confirming that the holotype of *Macroplacus raeticus* represented a later ontogenetic stage than the specimens of *Psephoderma alpinum*—maintained that the observed differences did not justify synonymy at the species level: he ultimately treated *Macroplacus* as a junior synonym of *Psephoderma* (*Psephoderma raeticus*). This interpretation was accepted by Mazin (1989) and by Mazin & Pinna (1993).

Rieppel & Zanon (1997) reported Pinna's opinion on the synonymy of *Macroplacus* and *Psephoderma*, and accordingly treated *Macroplacus* as an invalid genus in their analysis of placodont interrelationships.

However, Rieppel (2000a) subsequently considered *Macroplacus raeticus* a valid genus and species, placing it within the newly proposed family Macroplacidae (Cyamodontoidea > Placochelyida), diagnosed as follows: posterior palatine tooth-plates hypertrophied; posterior (nasal) processes of the premaxillae enlarged and extending posteriorly to reach the frontal, thereby separating the nasals from one another (convergent in *Psephoderma*); post-temporal fossae greatly reduced; a foramen piercing the shaft of the quadrate just above the mandibular condyle.

Based on his analysis of cyamodontoid interrelationships, Rieppel concluded that *Macroplacus*—as the only representative of Macroplacidae—was the sister group to the Protenodontosauridae (*Protenodontosaurus*) + Placochelyidae (*Placochelys* and *Psephoderma*). The families Macroplacidae, Protenodontosauridae, and Placochelyidae

were grouped within a newly defined monophyletic taxon, Placochelyida, diagnosed as a subclade of Cyamodontoidea distinct from the subclade Cyamodontida (new taxon) (see also Rieppel 2001b).

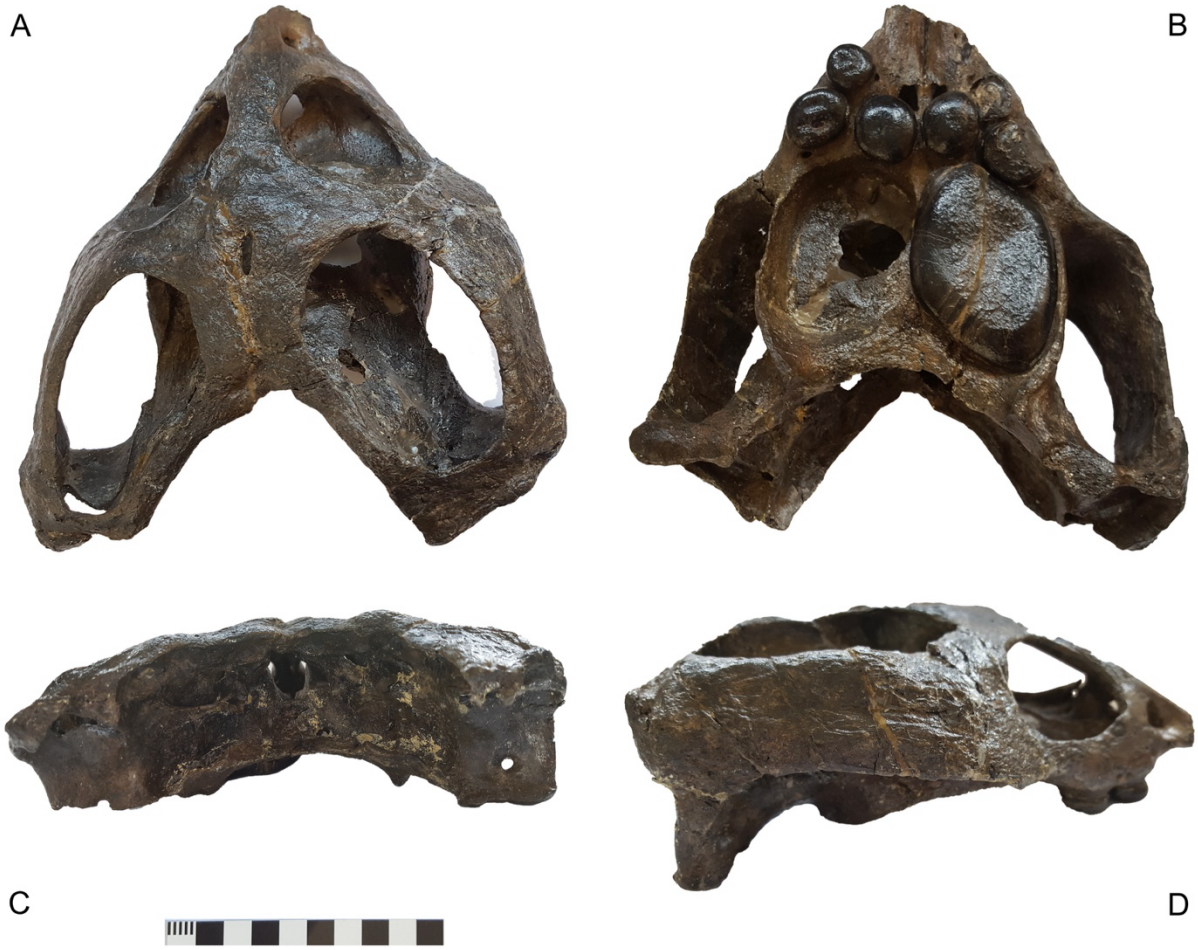
In the same context, Rieppel (2001b) re-described in detail the holotype of *Macroplacus raeticus*—for the first time since Schubert-Klempnauer (1975)—and proposed several important revisions to its interpretation. These included: reinterpreting the prefrontal as the nasal, and the lacrimal (absent in placodonts) as the prefrontal, then the nasals do not meet medially and are excluded from the interorbital bridge; identifying a broad frontal that includes the postfrontal *sensu* Schubert-Klempnauer (1975) and forms most of the interorbital bridge; and hypothesising the presence of a suture within the postorbital *sensu* Schubert-Klempnauer (1975), separating a more lateral postfrontal from the postorbital.

The holotype of *Macroplacus raeticus* was more recently considered by Neenan et al. (2014) in an investigation on tooth replacement patterns in placodonts performed with the help of micro-computed tomography.

Wang et al. (2019b) briefly discussed *Macroplacus raeticus*, classifying it as one of the most derived members of Placochelyidae. However, they did not provide further anatomical information on the skull, stating that it is poorly preserved and that the sutures are obscured due to over-preparation and the application of glue.

Finally, Gere et al. (2024) analysed dental wear in Triassic placodonts and concluded that *Macroplacus raeticus* possesses proportionally the largest posterior crushing teeth among known representatives of the group, associated with the lowest number—but largest size—of wear features, consisting of pits on nearly 100% of the worn surfaces. This pattern may indicate a greater reliance on hard-shelled prey.

To date, no other skulls or postcranial material referable to *Macroplacus raeticus* have been discovered, and the holotype remains the only known specimen of the species. As discussed in the main text based on multiple lines of evidence, MCSNB 13033 represents the second specimen of *Macroplacus raeticus* worldwide, and the first recovered in Italy.



Supplementary Figure 1 – *Macroplacus raeticus*, the holotype skull specimen SNSB-BSPG 1967 I 324 in dorsal (A), ventral (B), posterior (C), and right lateral (D) views. Photos by Stefania Nosotti.

Supplementary Figure 2 – *Psephoderma alpinum*, specimen MSNM V 471 in dorsal (A), anterior (B), ventral (C), right lateral (D), posterior (E), and left lateral (F) views. Photos by Stefania Nosotti.

Commented character list and character coding revision

Character 1 (excluded). Osteoderms absent (0); osteoderms present (1); carapace present (2).

This character is excluded from the analysis, as it is redundant with characters 81 and 82.

Character 2. Ratio of skull total length to skull total height less (0) or greater (1) than 3.

At first glance, the holotype of *Macroplacus* might appear uncodable (?), as the total skull length is unknown due to the incomplete rostrum. However, the preserved portion yields a ratio of 2.88, and even a short rostral extension would clearly increase this ratio above 3. This interpretation remains valid even when accounting for dorsoventral compression. For this reason, we code the holotype of *Macroplacus* as (1). MCSNB 13033 is uncodable(?).

Character 3. Rostrum relatively short and broad (0); relatively narrow and distinctly elongated (1); spatulate (2).

This character would benefit from quantification, as the current wording underrepresents incipient rostral elongation in taxa such as *Protenodontosaurus*. We code MCSNB 13033 as (0+1), and we revise the coding of the holotype of *Macroplacus* from (0) to (0+1), as the base of the rostrum is sufficiently preserved in both specimens to exclude state (2), although the full rostral shape remains unknown.

Character 4. Premaxilla ventral surface level with maxilla (0) or arched, with rostrum distinctly downturned (1).

We revise the coding of *Henodus* from (?) to (1), as the rostrum is clearly downturned in that genus. We suggest that the character be redefined to refer to the ventral surface of the entire mouth in lateral view. The holotype of *Macroplacus* and MCSNB 13033 are uncodable (?), although a condition similar to *Psephoderma* is expected.

Character 5. Premaxilla extends posteriorly along more (0) or less (1) than half of ventral margin of external naris.

The coding for *Paraplacodus* is revised from (0) to (1), following Rieppel (2000b, fig. 3). MCSNB 13033 is uncodable (?).

Character 6. Nasals in contact along midline (0) or separated by large posterior (nasal) processes of premaxillae and/or anterior processes of frontals (1).

In some taxa such as *Placodus* and *Cyamodus kuhnschnyderi*, the nasals are fused, but this does not affect the coding. In the holotype of *Macroplacus*, we code the character as (1), following Rieppel's interpretation rather than that of Schubert-Klempnauer (see "Re-

examination of the holotype of *Macroplacus raeticus*, and comparison with MCSNB 13033 and *Psephoderma alpinum*"). MCSNB 13033 is uncodable (?).

Character 7. Anterior end of maxilla does not expand (0) or expands (1) medially to form most of external naris dermal floor.

We code *Psephoderma* as (1) based on specimen PIMUZ A/III 1491 (Neenan & Scheyer 2014), revised from (?). MCSNB 13033 is coded (0) based on CT imaging, which shows that most of the preserved dermal floor of the external naris is formed by the premaxilla. Its anterior margin is broken, suggesting an anterior extension of the premaxilla itself (see also "Description of the specimen MCSNB 13033").

Character 8. Anterior tip of jugal extends (0) or does not extend (1) anteriorly along ventral margin of orbit beyond midpoint of its longitudinal diameter.

We code *Psephoderma* as (0) based on Pinna & Nosotti (1989) and specimen PIMUZ A/III 1491 (Neenan & Scheyer 2014), revised from (?). *Cyamodus kuhnschnyderi* is revised from (1) to (0), distinguishing it from other Cyamodontida. MCSNB 13033 is coded (1): as in the holotype of *Macroplacus*, the anterior tip of the jugal reaches close to but not beyond, the midpoint of the orbital longitudinal diameter.

Character 9. Jugal does not extend (0) or extends (1) posteriorly along anteromedial margin of subtemporal fossa.

MCSNB 13033 is coded (0) based on CT imaging (Fig. 4I).

Character 10 (ordered). Pineal foramen centred on skull table (0); displaced anteriorly on parietal skull table (1); displaced anteriorly with frontal entering its anterior margin (2).

Neenan et al. (2015) revised the coding for *Psephoderma* from (2) to (1+2) based on specimen PIMUZ A/III 1491. MSNM V 471, as described by Pinna & Nosotti (1989), is coded (1): the pineal foramen is almost entirely on the parietal, although its anterior margin may be slightly incomplete. The frontoparietal suture is faint but more anteriorly positioned, indicating that the small fragment assigned to the frontal by Rieppel more likely pertains to the parietal. MCSNB 13033 is coded (1).

Character 11. Anterolateral process of frontal well developed (0) or reduced (1).

MCSNB 13033 is uncodable (?).

Character 12. Parietal without (0) or with (1) distinct anterolateral process embraced by frontal and/or postfrontal.

We slightly modified state (1) to include "and/or postfrontal", allowing this character to be coded for both the holotype of *Macroplacus* and MCSNB 13033, following our

reinterpretation of postfrontal and frontal shapes and contacts (see also character 89). Both specimens are coded (0). *Placodus gigas* is revised from (1) to (0), following Nosotti & Rieppel (2002) and Rieppel (2000a); the original coding (1) in Rieppel (2000b) was likely a typo, as he explicitly stated that condition (1) is diagnostic for Cyamodontoidea.

Character 13. Frontal does not reach (0) or reaches (1) posteriorly beyond level of anterior margin of upper temporal fossa.

MCSNB 13033 is coded (0).

Character 14. Parietal skull table constricted posteriorly (i.e., with concave lateral margins) (0) or square (i.e., with straight lateral margins posteriorly) (1).

The constriction is not always posteriorly placed (e.g., in *Psephochelys*, it is in the middle portion; in *Sinocyamodus*, in the anterior portion). In *Psephoderma* (and partly *Cyamodus kuhnschnyderi*) the skull table is not only laterally concave but also markedly constricted, resulting in distinctively shaped fenestrae. MCSNB 13033 is coded (0), showing slight posterior constriction.

Character 15. Posterolateral margin of postfrontal weakly concave and evenly curved/nearly straight (0) or deeply concave and angulated (1).

Glyphoderma is revised from (1) to (0) following Neenan et al. (2015, fig. 5). We concur with previous authors' reassignment of the holotype of *Macroplacus* from (?) to (0) based on the sutural configuration illustrated in Fig. 3C, according to our interpretation of the postfrontal. MCSNB 13033 is coded (0).

Character 16 (ordered). Postfrontal enters upper temporal fossa (0); is excluded from upper temporal fossa by narrow (1) or broad (2) postorbital-parietal contact.

Psephochelys is provisionally coded (1) based on Neenan et al. (2015), pending re-examination of the specimen. These authors interpreted the postfrontal as smaller than described by Li & Rieppel (2002), who considered it to enter the upper temporal fossa (0). The holotype of *Macroplacus* is revised from (1) to (2) based on our reinterpretation of the postfrontal and postorbital. MCSNB 13033 is coded (2). See also character 89.

Character 17. Postorbital extends along lateral margin of temporal fossa reaching only to level in front of, or at midpoint of, its longitudinal diameter (0) or extends further posteriorly (1).

Placodus gigas is revised from (1) to (0), as postorbital participation in the lateral margin of the temporal fossa is limited to the anterolateral corner by the squamosal. *Placodus inexpectatus* is coded (0) based on Jiang et al. (2008, fig. 2) and the photograph in Neenan

et al. (2015, fig. 2A), which, as expected, matches the condition in *P. gigas*, contra their line drawing (fig. 2B). *Paraplacodus* is revised from (0) to (1), following Wang et al. (2019a) and Rieppel (2000b). *Glyphoderma* is coded (0), following Neenan et al. (2015, fig. 5). MCSNB 13033 is uncodable (?).

Character 18 (ordered). Vertical part of maxilla–jugal suture behind level of posterior margin of orbit (0); behind level of midpoint of longitudinal diameter of orbit but in front of its posterior margin (1); at level of midpoint of longitudinal diameter of orbit (2).

Paraplacodus is coded (2) rather than uncodable (suture not vertical), as the maxilla–jugal contact point along the orbital rim, and most of the suture, lie close to and anterior to the midpoint of the orbital longitudinal diameter, following Rieppel (2000b). The holotype of *Macroplacus* is revised from (2) to (1). MCSNB 13033 is coded (1), though the vertical suture is short.

Character 19. Dorsal process of epipterygoid narrow (0) or broad (1).

MCSNB 13033 is coded (1).

Character 20. Base of epipterygoid sutured predominantly to pterygoid (0) or predominantly/entirely to palatine (1).

The term “entirely” is added to reflect the condition in the holotype of *Macroplacus*, where the epipterygoid base is fully sutured to the palatine due to its marked posterior development. MCSNB 13033 is coded (1).

Character 21. Postorbital lacks (0) or develops (1) medioventral process abutting lateral surface of epipterygoid at posterodorsal margin of foramen interorbitale.

Psephoderma is coded (1) based on direct observations of specimen MSNM V 471. In *Cyamodus kuhnschnyderi*, the postorbital does not form this process (Rieppel 2001b), so the taxon is coded (0) rather than (?). MCSNB 13033 is uncodable (?).

Character 22. Ratio of basicranial length (snout tip to occipital condyle) to transverse diameter of upper temporal fossa greater (0) or less (1) than 3.

MCSNB 13033 is uncodable (?), as both the rostrum and upper temporal fossa are not preserved.

Character 23. Ratio of longitudinal diameter of upper temporal fossa to longitudinal diameter of orbit less than 2 (0) or equal to/greater than 2 (1) in adult.

Sinocyamodus is coded (0), following Wang et al. (2019c). *Cyamodus hildegardis* is revised from (1) to (0), following Wang et al. (2019a). MCSNB 13033 is uncodable (?), as the upper temporal fossa is incompletely preserved.

Character 24. Epipterygoid lacks (0) or develops (1) posterior dorsal process contacting squamosal at anterodorsal corner of post-temporal fenestra.

Protenodontosaurus is revised from (?) to (0). Neenan & Scheyer (2014) did not observe the contact in *Psephoderma alpinum* specimen PIMUZ A/III 1491, but noted possible taphonomic obscuration; our observations of MSNM V 471 confirm the contact, so *Psephoderma* is coded (1). The holotype of *Macroplacus* is coded (1) based on observation of the right side. MCSNB 13033 is uncodable (?).

Character 25. Epipterygoid fully ossified (0) or incompletely ossified (1) in adult.

MCSNB 13033 is uncodable (?), as the extension and ossification degree of the epipterygoid is unclear, and cannot be reliably assessed in relation to the specimen's juvenile stage.

Character 26 (ordered). Neomorphic otic process of squamosal absent (0); extends to midpoint of ventral margin of post-temporal fossa (1); extends beyond level of midpoint of ventral margin of post-temporal fossa (2) (in lateral view).

Rieppel's (2001b) description of state (2) is here revised, as the published wording ("medial margin") is evidently an inadvertent oversight. MCSNB 13033 is uncodable (?).

Character 27. Palatoquadrate cartilage recess absent (0) or present (1).

MCSNB 13033 is uncodable (?).

Character 28. Basiorbital furrow absent (0) or present (1).

MCSNB 13033 is uncodable (?).

Character 29. Palatine does not contact (0) or contacts (1) quadrate along lateral margin of palatoquadrate cartilage recess.

Cyamodus kuhnschnyderi is revised from (0) to (1), following Nosotti & Pinna (1996). MCSNB 13033 is uncodable (?).

Character 30 (ordered). Pteroccipital foramen absent (0); present, with anterolateral margin lateral to dorsal margin of post-temporal fenestra and posteromedial margin aligned with it, visible within temporal fossa but not in occipital view (1); present, with anterolateral margin aligned with dorsal margin of post-temporal fenestra and posteromedial margin medial to it, visible in occipital view but not within the temporal fossa (2).

We revised the character description and added state (2) to distinguish two spatial configurations of the pteroccipital foramen among cyamodontoids, as clarified by Nosotti & Pinna (1993). Bones delimiting the foramen remain constant across states—squamosal and prootic anterolaterally, paroccipital process posteromedially—but their spatial arrangement differs in respect to the parietal-squamosal bar forming the dorsal margin of the post-

temporal fenestra. This neurovascular passage evolved in parallel with the closure of the cranio-quadrate passage. *Macroplacus*, *Placochelys*, *Protenodontosaurus*, *Psephoderma*, and *Psephochelys* are consistently coded (2). MCSNB 13033 is uncodable (?).

Character 31. Prootic not exposed (0) or exposed (1) in posterior view of skull.

Psephoderma is revised from (?) to (1) based on direct observation. The holotype of *Macroplacus* from (0) to (1); MCSNB 13033 is uncodable (?). Condition (1) is shared by Placochelyida, which also exhibit state (2) of character 30, suggesting that prootic exposure in posterior view is linked to the position of the pteroccipital foramen. The same combination in *Protenodontosaurus* supports this hypothesis. The two characters are retained separately, pending further analyses on the specimens, but may be merged in the future to avoid redundancy.

Character 32 (unordered). Premaxillary teeth present with diastema separating premaxillary and maxillary teeth (0); absent (1); present without diastema (2).

To reduce the number of uncodable entries due to edentulous taxa, characters 32 and 34 are combined and treated as unordered. In *Cyamodus kuhnschnyderi* (e.g., Nosotti & Pinna 1996; Rieppel & Hagdorn 1999), variation in the presence, size, and position of the diastema, as well as in premaxillary tooth number, complicates coding. Specimen MHI 1293, referred to *C. kuhnschnyderi* by Rieppel & Hagdorn (1999) based on the alignment of posterior maxillary and anterior palatine teeth, bears a second premaxillary tooth absent in the holotype. Since both tooth alignment and number vary slightly within Cyamodontidae and within the genus *Cyamodus*, and lack clear diagnostic value, we exclude this specimen from coding. It is best treated as ?*Cyamodontidae* indet., or possibly *Cyamodus* based on the morphology of the pterygoid flange (see character 45). Presence or absence of supernumerary premaxillary and maxillary teeth appears to influence diastema size and may also reflect ontogenetic variation. Kuhn-Schnyder (1959) reported a subadult *Cyamodus hildegardis* specimen with an extra tooth compared to juvenile and adult individuals. In another *C. hildegardis* specimen described by Pinna (1992, figs. 9 and 14), a distinct diastema is not apparent, and the teeth are well-spaced. These examples underscore the need for better definition and quantification of this character. *Henodus* is revised from (?) to (1), as premaxillary teeth are absent. In *Protenodontosaurus*, the diastema is clearly present regardless of differing interpretations concerning a second premaxillary tooth (see Rieppel & Hagdorn 1999). In the holotype of *Macroplacus*, the preserved premaxillae are

edentulous, and the presence of rostral teeth cannot be confirmed; the character is coded (0+1). MCSNB 13033 is uncodable (?).

Character 33. Anterior premaxillary and dentary teeth pointed (0); chisel-shaped (1); bulbous with anterior transverse ridge (2).

MCSNB 13033 is uncodable (?). Character not applicable in edentulous species.

Character 34 (excluded). Diastema separating premaxillary and maxillary teeth absent (0) or present (1).

Character excluded as its content is included in character 32.

Character 35 (ordered). Maxilla bearing four or more teeth (0); three (1); two (2); one tooth (3); no teeth (4).

Following Wang et al. (2019a), *Cyamodus hildegardis* is coded (1), though Kuhn-Schnyder (1959) figured a subadult with four teeth (specimen PIMUZ T 2796). Pending further study of ontogenetic variation and allometric growth of maxilla and its dentition, the condition in the adult is retained as three. MCSNB 13033 is coded (2).

Character 36 (ordered). Palatine bearing more than three teeth (0); three (1); two (2); one tooth (3).

We follow Wang et al. (2019a) in coding *Cyamodus hildegardis* (2). MCSNB 13033 is coded (2).

Character 37. Anterior palatine tooth/teeth rounded (0) or transversely enlarged (1).

Character state (0) wording is revised to remove “small”, which may be misleading. For instance, the anterior palatine tooth-plate in the holotype of *Macroplacus* is similar in size to that of *Placodus*; the distinction lies in shape, not size. MCSNB 13033 is coded (0).

Character 38. Ratio of longitudinal to transverse diameter of posterior palatine tooth less than 1.4 (0) or equal to/greater than 1.4 (1) in adult.

Cyamodus hildegardis is coded (0+1), as two adult skulls yield ratios just below and just above 1.4. MCSNB 13033 is coded (1), identical to the ratio in the holotype of *Macroplacus*, despite differences in size and likely ontogenetic stage.

Character 39. Maxilla without (0) or with (1) anterior process extending into rostrum in ventral view.

MCSNB 13033 is coded (1) based on CT imaging (Fig. 4F).

Character 40. Rostrum ventral surface flat (0) or concave (1) in transverse section.

MCSNB 13033 is coded (1).

Character 41. Rostrum ventral surface without (0) or with distinct grooves leading to internal nares (1).

MCSNB 13033 is coded (0), as is the holotype of *Macroplacus*. Both show a single median concavity at the preserved base of the rostrum, not two grooves leading to the internal nares.

Character 42. Internal nares separated (0) or confluent (1).

Paraplacodus is coded (1), following Wang et al. (2019a). MCSNB 13033 is coded (0).

Character 43. Ectopterygoid present (0) or absent, with palatine-jugal contact (1).

We merged the previous states: (1) ectopterygoid absent, with palatine extending laterally at anterior margin of subtemporal fossa to meet jugal; and (2) ectopterygoid absent, with jugal extending medially to meet palatine. These conditions are overlapping or ambiguous. In some specimens (e.g., the holotype of *Protenodontosaurus*), the condition differs between sides of the skull, while in others (e.g., *Psephoderma* MSNM V471), the jugal extension varies between left and right. Condition (2) is confidently observed only in *Parahenodus*, where it is likely autapomorphic and of limited phylogenetic utility. This character partly overlaps with character 9. MCSNB 13033 is coded (1).

Character 44. Ratio of pterygoid palatal ramus length to palatine length less (0) or greater (1) than 0.3.

The original wording “palatal exposure of pterygoid” in Rieppel 2001b is revised to “pterygoid palatal ramus” for anatomical accuracy. In the holotype of *Macroplacus*, the ratio is 0.17. Based on Rieppel’s measurements (2001b: 53), the correct value is also 0.17—not 1.7 as reported (likely a typo)—although the character was correctly coded. MCSNB 13033 is coded (0), with a measured ratio of 0.22 (8.04 / 36.10, frame 216, 0.4U 70).

Character 45. Pterygoid ventral flange with single (0) or double (1) ventral projection.

Psephoderma is correctly coded (0), as the apparent bifurcation in MSNM V471 is due to a fracture. MCSNB 13033 is uncodable (?).

Character 46. Post-temporal fenestra relatively large (0) or reduced (1) due to expansion of occipital exposure of parietal, squamosal and prootic.

This character should be quantified. In the original description, Rieppel (2000b) mistakenly listed the opisthotic instead of the prootic. In the holotype of *Macroplacus* and in *Psephoderma* (Figs. 7B; 8B), the reduction of the fenestra is caused by dorsal expansion of the occipital exposure of squamosal and prootic. The current definition does not allow reliable coding for some taxa (e.g., *Placodus*), though original coding has been retained. *Psephoderma* is revised from (0) to (1) (Fig. 8B, C); *Cyamodus orientalis* is revised from (0)

to (1), following Wang et al. (2019a), who describe the fossae as small. *Cyamodus rostratus* remains coded (0+1), as the two specimens described by Rieppel (2001b) differ in condition. MCSNB 13033 is uncodable (?).

Character 47. Squamosal buttress for distal tip of paroccipital process absent (0) or present (1).

Parahenodus is revised from (?) to (1) based on the "descending process of the squamosal" described by de Miguel Chaves et al. (2018a). *Protenodontosaurus* is revised from (0) to (1) based on our observations (Nosotti & Pinna 1999). The holotype of *Macroplacus* is coded (0), following our observations and Schubert-Klempnauer (1975). MCSNB 13033 is uncodable (?).

Character 48. Posteroventral tubercle ("lateral tubercle" of Nosotti & Pinna 1996, p. 19) at distal tip of paroccipital process absent (0) or present (1).

Protenodontosaurus is revised from (0) to (1). Coding of *Psephoderma* is confirmed as (1) based on the right side of specimen MSNM V 471 (Fig. 8B). MCSNB 13033 is uncodable (?).

Character 49. Exoccipitals do not meet (0) or meet (1) above occipital condyle (above basioccipital).

MCSNB 13033 is uncodable (?).

Character 50. Basioccipital tuber and ventral opisthotic flange separate (0) or meet ventral to internal carotid passage (1).

The current description does not fully reflect the condition in *Placodus*, but the absence of contact ventral to the internal carotid supports coding as (0). In *Placochelys*, specimen MB.R.1765 (paratype) is clearly coded (1); the holotype FAFI Ob/2323/Vt.3 shows condition (0), possibly due to damage (Rieppel 2001b). Coding (1) is retained based on the paratype. MCSNB 13033 is uncodable (?).

Character 51. Anterior tip of dentary with teeth (0) or edentulous (1).

Protenodontosaurus is uncodable (?), as the mandible is not preserved. MCSNB 13033 is also uncodable (?).

Character 52. Coronoid well separated from (0) or closely approaching (1) ventral margin of mandible.

MCSNB 13033 is uncodable (?).

Character 53. Retroarticular process long and slender (0) or short with sloping surface (1).

Cyamodus kuhnschnyderi is revised from (1) to (?), as the retroarticular process is not preserved in the referred mandible (Nosotti & Pinna 1996). MCSNB 13033 is uncodable (?).

Character 54 (ordered). Tubercular osteoderms secondarily fused to underlying bone absent (0); present along posterior margin of upper temporal fossa only (1); present also on lateral surface of posterior temporal arch (2).

Protenodontosaurus is revised from (?) to (2), following Nosotti & Pinna (1999). *Psephoderma* is revised from (1) to (2), following Pinna & Nosotti (1989) and Neenan & Scheyer (2014). MCSNB 13033 is uncodable (?).

Character 55 (from Rieppel 2000b, character 52). Quadratojugal present (0) or absent (1).

We follow Wang et al. (2019a), who noted that although the character description and polarity were correct in Rieppel (2000b), the coding was inadvertently reversed in the matrix, and they corrected it accordingly. See also Maisch (2020) for an alternative interpretation of quadratojugal presence and evolution, which could affect coding in some basal forms. MCSNB 13033 is uncodable (?).

Character 56 (from Rieppel 2000b, character 53). Jugal–squamosal contact absent (0) or present (1).

Psephoderma and *Protenodontosaurus* are revised from (1) to (0), following the interpretations of Pinna (1976a), Pinna & Nosotti (1999), and Neenan & Scheyer (2014) for the former, and Nosotti & Pinna (1999) for the latter, contra the reconstructions in Rieppel (2000a, 2001b). MCSNB 13033 is uncodable (?).

Character 57 (from Rieppel 2000b, character 54) (ordered). Coronoid process absent (0); distinct but low (1); very high (2).

MCSNB 13033 is uncodable (?).

Character 58 (from Rieppel 2000b, character 63). Crushing tooth-plates absent (0) or present (1).

MCSNB 13033 is coded (1).

Character 59 (from Rieppel 2000b, character 64). Diastema between symphyseal and posterior dentary teeth absent (0) or present (1).

MCSNB 13033 is uncodable (?).

Character 60 (from Rieppel 2000b, character 65). Palatines separated by pterygoids (0) or meeting in medial suture (1).

MCSNB 13033 is coded (1).

Character 61 (from Rieppel 2000b, character 66). Pterygoids (palatal rami) longer (0) or shorter (1) than palatines.

MCSNB 13033 is coded (1).

Character 62 (from Jiang et al. 2008, character 68). External naris is not (0) or is (1) distinctly higher than long.

Protenodontosaurus is revised from (0) to (1). MCSNB 13033 is uncodable (?).

Character 63 (from Jiang et al. 2008, character 69). Chevron morphology simple, y-shaped (0) or complex, as described for *Paraplacodus* by Rieppel (2000b) (1).

MCSNB 13033 is uncodable (?).

Character 64. Preorbital and postorbital regions of skull subequal in length (0) or postorbital region distinctly longer (1).

The state 'preorbital region distinctly longer' was deleted as it does not apply to placodont cranial morphology. The holotype of *Macroplacus* and MCSNB are uncodable (?).

Character 65. External nares not retracted (0); retracted with longitudinal diameter approaching or exceeding half the longitudinal diameter of orbit (1); retracted, narrow, with longitudinal diameter distinctly less than half the longitudinal diameter of orbit (2).

MCSNB 13033 is coded (1+2).

Character 66. Frontal participates in dorsal margin of orbit (0) or is excluded from dorsal margin of orbit by prefrontal–postfrontal contact (1).

MCSNB 13033 is coded (0).

Character 67. Mandibular articulations level with occipital condyle (0) or are displaced distinctly behind occipital condyle (1).

MCSNB 13033 is uncodable (?).

Character 68 (from Neenan et al. 2015, character 102). Scapula broad-bladed (0) or with constriction separating ventral glenoidal portion from posteriorly directed dorsal wing (1).

The state 'rod-like' was excluded, as it does not apply to placodont morphology. MCSNB 13033 is uncodable (?).

Character 69. Deltopectoral crest well developed (0) or reduced (1).

Psephoderma is revised from (0) to (1), following Pinna & Nosotti (1989). MCSNB 13033 is uncodable (?).

Character 70 (from Neenan et al. 2015, character 115). Ectepicondylar groove open and notched anteriorly (0); closed (1); absent (2).

MCSNB 13033 is uncodable (?).

Character 71 (ordered). Carpal ossifications more than three (0); three (1); two (2).
MCSNB 13033 is uncodable (?).

Character 72. Internal trochanter well developed (0) or reduced (1).
Psephoderma is revised from (0) to (1) following Pinna & Nosotti (1989). MCSNB 13033 is uncodable (?).

Character 73. Tarsal ossifications four or more (0); three (1); two or fewer (2).
MCSNB 13033 is uncodable (?).

Character 74. Number of dorsal vertebrae 19 or more (0); 15 or fewer (1).
MCSNB 13033 is uncodable (?).

Character 75. Hyposphene-hypantrum articulation absent (0) or present (1).
Psephoderma is revised from (?) to (0) following Pinna & Nosotti (1989). MCSNB 13033 is uncodable (?).

Character 76. Coracoid elongated, with more or less concave anterior and posterior margins (0) or is a rounded plate of bone (1).
MCSNB 13033 is uncodable (?).

Character 77 (from Rieppel 2000b, character 59). Thyroid fenestra large (0) or reduced by expansion of pubis and ischium to form rounded plates of bone (1).
MCSNB 13033 is uncodable (?).

Character 78. Preaxial margin of humerus curved (0) or rather straight (1).
MCSNB 13033 is uncodable (?).

Character 79. Internal trochanter distinctly set off from proximal end of femur by intertrochanteric fossa (0) or intertrochanteric fossa much reduced/absent (1).
MCSNB 13033 is uncodable (?).

Character 80. Lateral gastral ribs without (0) or with (1) distinct angulation.
MCSNB 13033 is uncodable (?).

Character 81. Dermal armour ("osteoderms") absent (0) or present (1).
MCSNB 13033 is uncodable (?).

Character 82. Carapace (“carapace” means “dorsal carapace” or “main carapace” in this character list) absent (0) or present (1).
MCSNB 13033 is uncodable (?).

Character 83. Proximal portion of forelimbs uncovered (0) or covered under carapace (1).

MCSNB 13033 is uncodable (?).

Character 84. Osteoderms on carapace not uniform (0) or relatively uniform (1).

MCSNB 13033 is uncodable (?).

Character 85. Dorsal carapace surface moderately convex with (0) or without (1) shallow, longitudinal groove along midline.

MCSNB 13033 is uncodable (?).

Character 86. Ratio of carapace length to width around 1 (0); 0.8 or less (1).

MCSNB 13033 is uncodable (?).

Character 87. Fully developed pelvic shield in adult absent (0) or present (1).

MCSNB 13033 is uncodable (?).

Character 88. Plastron absent (0) or present (1).

MCSNB 13033 is uncodable (?).

Character 89 (new). Frontal-parietal contact present (0) or absent (1), with postfrontals meeting at skull midline (see "Re-examination of the holotype of *Macroplacus raeticus*, and comparison with MCSNB 13033 and *Psephoderma alpinum"* and Figs. 2C; 3C; 6A).

The condition in *Psephochelys* is uncertain. In the initial description (Li & Rieppel 2002, fig. 1), postfrontals contact medially as in the holotype of *Macroplacus*, but Neenan et al. (2015) and Wang et al. (2019b) interpreted a frontal–parietal contact typical of most placodonts. The feature remains unclear in photographs; further re-examination is required to assess affinities between the holotype of *Macroplacus* and *Psephochelys.* MCSNB 13033 is coded (1). Taxa are coded for this new character as follows: Ancestor (0), *Palatodonta* (0), *Paraplacodus* (?), *P. gigas* (0), *P. inexpectatus* (0), *C. rostratus* (0), *C. hildegardis* (?), *C. kuhnschnyderi* (0), *Henodus* (0), *Macroplacus* (1), *Placochelys* (0), *Protenodontosaurus* (0), *Psephoderma* (0), *Psephochelys* (?), *Glyphoderma* (0), *Sinocyamodus* (0), MCSNB 13033 (1), *C. orientalis* (0), *Parahenodus* (?).

Character 90 (new, ordered). Ventral opisthotic flange absent (0); present, not contacting pterygoid (1); present, contacting pterygoid (2).

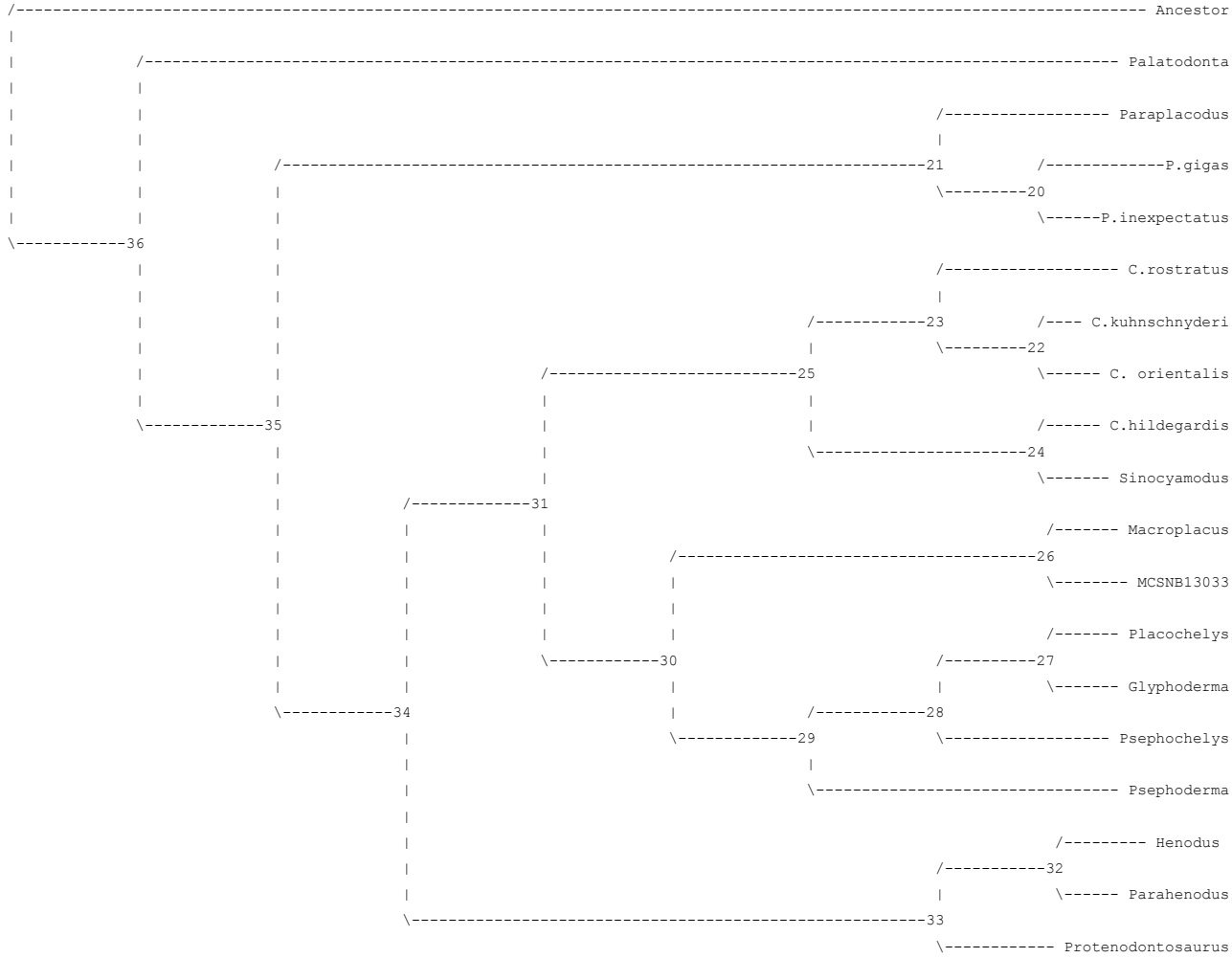
Taxa are coded for this new character as follows: Ancestor (0), *Palatodonta* (?), *Paraplacodus* (?), *P. gigas* (0), *P. inexpectatus* (?), *C. rostratus* (1), *C. hildegardis* (?), *C. kuhnschnyderi* (1), *Henodus* (1), *Macroplacus* (2), indirect evidence (see discussion in the main text and Fig. 7A), *Placochelys* (1), *Protenodontosaurus* (1), *Psephoderma* (2), *Psephochelys* (?), *Glyphoderma* (?), *Sinocyamodus* (?), MCSNB 13033 (?), *C. orientalis* (1), *Parahenodus* (1).

Phylogenetic data output

```
P A U P *
Version 4.0a (build 169) for 32-bit Microsoft Windows (built on Feb 10 2021 at 22:12:44)
Tue Dec 10 16:11:55 2024

Data matrix has 19 taxa, 90 characters
Valid character-state symbols: 01234
Missing data identified by '?'
Gaps identified by '-'

Character types changed:
  Of 90 total characters:
    10 characters are of type 'ord' (Wagner)
    80 characters are of type 'unord'
    All characters have equal weight

*** Skipping "NOTES" block

Processing of input file "matrice placo 29082023.nex.txt" completed.

paup> outgroup 1;

Outgroup status changed:
  1 taxon transferred to outgroup
  Total number of taxa now in outgroup = 1
  Number of ingroup taxa = 18

Character-exclusion status changed:
  2 characters excluded
  Total number of characters now excluded = 2
  Number of included characters = 88

paup> exclude 1 34;

paup> cstatus;

Character-status summary:
  Current optimality criterion = parsimony
  2 characters are excluded
  Of the remaining 88 included characters:
    10 characters are of type 'ord' (Wagner)
    78 characters are of type 'unord'
    All characters have equal weight
    5 characters are parsimony-uninformative
    Number of (included) parsimony-informative characters = 83

Input data matrix:

                          1         2         3         4         5         6         7         8         9
Taxon              234567890123456789012345678901235678901234567890123456789012345678901234567890123456789012345678901234567890
-------------------------------------------------------------------------------------------------------------------------------------
Ancestor           000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
Palatodonta        00?00?010?000000?????????0?????2100??0???????????????00?001100??1?0?????????????????????????????0?
Paraplacodus       00010?0????0??0120?0?00?0?0??0000010??01??0?????000010111??0102101O?00101000010000???00??
                                                                                                                  1
P.gigas            000000000000000010000000000000010110000100000000000011211111001100102020111101100???0000
                          1                   1
P.inexpectatus     000?0?0?1000?0102????0????????010110????????????0?0011211??1101100122120????1?1100???000?
C.rostratus        000001111011012?011011101100102221000000101001100l1?1?211110?1101?????????????????????01
                                            1           1
C.hildegardis      ?00?????1???1???????00????????021200???0?0??????01120021111O?11010??11?1?01110111O?010??
                                              1
C.kuhnschnyderi    000001011111011?111011?11111100222000000101101100l?200?11110?1101?1?????????????1?????01
Henodus            0210101?1010?1???11000?0?11?1?1?43?1?000?10001101012011l?01001000?1????1???1101110110101
Macroplacus        10?11010100000211111?0101100210?220111001O?10??????201?1?110??201?????????????????????12
                    1          1                 1
Placochelys        1110010010001111111100102101211?120011101100100111120121?110?1200??????????11011?0????01
                           1
```

```
Protenodontosaurus  00110000100010202l1?0000210121013200110010001111???200?1?111?1200??????????????????????01
                                      1
Psephoderma         11011100100000211111001011012l1?220111101101110011120021?1100120101l?111011110111l011002
                           2
Psephochelys        01011110110000011211?00000100?1?22001110?10?10??11110021?110?1201?00?121?1111011?11000??
Glyphoderma         ?1000100110010101????0????0???1?????????????????1???1??100?1???001201?100?01???11?1101100?0?
Sinocyamodus        ?00?01001?1001201???00????10???2212011002?10?????0?120021111001?0101021111???11?1100000000?
MCSNB13033          ?0????0101?00002?111?????1?????????220111001O?????????????1?11???10?????????????????????1?
                     1                                                                  2
C. orientalis       0000011111110l1?11??111011101002220O?000?01101??0112002111100110l????121????1?11?0000?01
Parahenodus         ??????1?1??01120????00???1??1???43?1????1?0111?????201?1?0???1??0????????????????????????1

paup> set maxtrees=10000 increase=no;

Maxtrees reset to 10000

paup> hsearch;

Heuristic search settings:
  Optimality criterion = parsimony
    Character-status summary:
      2 characters are excluded
      Of the remaining 88 included characters:
        10 characters are of type 'ord' (Wagner)
        78 characters are of type 'unord'
        All characters have equal weight
        5 characters are parsimony-uninformative
        Number of (included) parsimony-informative characters = 83
    Gaps are treated as "missing"
    Multistate taxa interpreted as uncertainty
  Starting tree(s) obtained via stepwise addition
    Addition sequence: simple (reference taxon = Ancestor)
    Number of trees held at each step = 1
  Branch-swapping algorithm: tree-bisection-reconnection (TBR) with reconnection limit = 8
    Steepest descent option not in effect
  'Maxtrees' setting = 10000 (will not be increased)
  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 = 5672
  Score of best tree(s) found = 200
  Number of trees retained = 1
  Time used = 0.00 sec (CPU time = 0.00 sec)

paup> describeTrees / apoList chgList;

Tree description:

  Unrooted tree(s) rooted using outgroup method
  Optimality criterion = parsimony
    Character-status summary:
      2 characters are excluded
      Of the remaining 88 included characters:
        10 characters are of type 'ord' (Wagner)
        78 characters are of type 'unord'
        All characters have equal weight
        5 characters are parsimony-uninformative
        Number of (included) parsimony-informative characters = 83
    Gaps are treated as "missing"
    Multistate taxa interpreted as uncertainty
    Character-state optimisation: Accelerated transformation (ACCTRAN)

Tree 1 (rooted using user-specified outgroup)

Tree length = 200
Consistency index (CI) = 0.5350
Homoplasy index (HI) = 0.4650
```

CI excluding uninformative characters = 0.5206
HI excluding uninformative characters = 0.4794
Retention index (RI) = 0.6477
Rescaled consistency index (RC) = 0.3465



Character change lists:

Character	CI	Steps	Changes
2 ( )	0.500	1	node_31 0 ==> 1 node_30
		1	node_28 1 ==> 0 Psephochelys
3 ( )	1.000	1	node_31 0 --> 1 node_30
		1	node_33 0 --> 2 node_32
4 ( )	0.500	1	node_27 0 ==> 1 Placochelys
		1	node_34 0 ==> 1 node_33
5 ( )	0.250	1	node_21 0 ==> 1 Paraplacodus
		1	node_31 0 ==> 1 node_30
		1	node_28 1 ==> 0 node_27
		1	node_33 0 ==> 1 Protenodontosaurus
6 ( )	0.333	1	node_31 0 ==> 1 node_30
		1	node_28 1 ==> 0 node_27
		1	node_33 0 --> 1 node_32
7 ( )	0.500	1	node_34 0 --> 1 node_31
		1	node_30 1 --> 0 node_26
8 ( )	0.200	1	node_25 0 --> 1 node_23
		1	node_22 1 --> 0 C.kuhnschnyderi
		1	node_30 0 ==> 1 node_26
		1	node_28 0 ==> 1 Psephochelys
		1	node_33 0 ==> 1 node_32
9 ( )	0.500	1	node_36 0 ==> 1 Palatodonta
		1	node_25 0 ==> 1 node_23
10 ( )	1.000	1	node_36 0 ==> 1 node_35

11 ( )	0.500	1	node_23 0 ==> 1 node_22
		1	node_29 0 ==> 1 node_28
12 ( )	0.500	1	node_31 0 ==> 1 node_25
		1	node_33 0 --> 1 node_32
13 ( )	1.000	1	node_25 0 ==> 1 node_23
14 ( )	0.333	1	node_24 0 ==> 1 C.hildegardis
		1	node_28 0 ==> 1 node_27
		1	node_34 0 ==> 1 node_33
15 ( )	0.333	1	node_31 0 ==> 1 node_25
		1	node_27 0 ==> 1 Placochelys
		1	node_33 0 ==> 1 node_32
16 ( )	0.400	1	node_20 0 ==> 1 P.inexpectatus
		2	node_35 0 ==> 2 node_34
		1	node_23 2 ==> 1 node_22
		1	node_29 2 ==> 1 node_28
17 ( )	0.333	1	node_21 0 ==> 1 Paraplacodus
		1	node_31 0 ==> 1 node_30
		1	node_27 1 ==> 0 Glyphoderma
18 ( )	0.333	2	Ancesto 0 <-> 2 node_36
		1	node_20 2 --> 1 P.gigas
		1	node_34 2 --> 1 node_31
		1	node_23 1 ==> 0 C.rostratus
		1	node_28 1 ==> 2 Psephochelys
19 ( )	1.000	1	node_35 0 ==> 1 node_34
20 ( )	1.000	1	node_35 0 ==> 1 node_34
21 ( )	1.000	1	node_31 0 ==> 1 node_30
22 ( )	1.000	1	node_25 0 ==> 1 node_23
23 ( )	1.000	1	node_25 0 ==> 1 node_23
24 ( )	0.500	1	node_34 0 ==> 1 node_31
		1	node_28 1 ==> 0 Psephochelys
25 ( )	1.000	1	node_22 0 ==> 1 C.kuhnschnyderi
26 ( )	0.500	1	node_35 0 ==> 1 node_34
		1	node_28 1 --> 2 node_27
		1	node_28 1 ==> 0 Psephochelys
		1	node_34 1 --> 2 node_33
27 ( )	1.000	1	node_35 0 ==> 1 node_34
28 ( )	0.500	1	node_23 0 ==> 1 node_22
		1	node_33 0 --> 1 node_32
29 ( )	0.250	1	node_22 0 ==> 1 C.kuhnschnyderi
		1	node_30 0 --> 1 node_29
		1	node_28 1 --> 0 Psephochelys
		1	node_34 0 --> 1 node_33
30 ( )	0.667	1	node_35 0 ==> 1 node_34
		1	node_31 1 ==> 2 node_30
		1	node_33 1 ==> 2 Protenodontosaurus
31 ( )	0.500	1	node_35 0 --> 1 node_34
		1	node_31 1 --> 0 node_25
32 ( )	0.400	1	node_36 0 ==> 2 Palatodonta
		1	node_23 0 ==> 2 C.rostratus
		1	node_24 0 ==> 2 Sinocyamodus
		1	node_31 0 --> 1 node_30
		1	node_33 0 --> 1 node_32
33 ( )	0.667	1	Ancesto 0 <=> 1 node_36
		1	node_21 1 ==> 0 Paraplacodus
		1	node_34 1 --> 2 node_31
35 ( )	0.667	2	node_35 0 ==> 2 node_34
		1	node_25 2 ==> 1 node_24
		1	node_28 2 --> 1 node_27
		1	node_34 2 ==> 3 node_33
		1	node_33 3 ==> 4 node_32
36 ( )	0.750	1	node_21 0 ==> 1 node_20
		1	node_35 0 ==> 2 node_34
		1	node_23 2 ==> 1 C.rostratus
		1	node_33 2 ==> 3 node_32
37 ( )	1.000	1	node_35 0 ==> 1 node_21
38 ( )	0.250	1	node_35 0 --> 1 node_34
		1	node_25 1 --> 0 node_23
		1	node_29 1 --> 0 node_28
		1	node_33 1 --> 0 Protenodontosaurus
39 ( )	0.500	1	node_35 0 ==> 1 node_34

```
                                1    node_25 1 ==> 0 node_23
40 ( )                0.500     1    node_31 0 ==> 1 node_30
                                1    node_33 0 ==> 1 Protenodontosaurus
41 ( )                1.000     1    node_30 0 ==> 1 node_29
42 ( )                1.000     1    node_35 0 ==> 1 node_21
43 ( )                1.000     1    node_35 0 ==> 1 node_34
44 ( )                0.333     1    node_24 0 ==> 1 Sinocyamodus
                                1    node_30 0 ==> 1 node_29
                                1    node_33 0 --> 1 node_32
45 ( )                1.000     1    node_25 0 ==> 1 node_23
46 ( )                0.333     1    node_34 0 ==> 1 node_31
                                1    node_29 1 --> 0 node_28
                                1    node_32 0 ==> 1 Parahenodus
47 ( )                0.333     1    node_30 0 ==> 1 node_29
                                1    node_34 0 --> 1 node_33
                                1    node_32 1 --> 0 Henodus
48 ( )                0.500     1    node_35 0 ==> 1 node_34
                                1    node_29 1 ==> 0 node_28
49 ( )                0.500     1    node_35 0 --> 1 node_34
                                1    node_31 1 --> 0 node_30
50 ( )                0.500     1    node_29 0 --> 1 node_28
                                1    node_33 0 ==> 1 Protenodontosaurus
51 ( )                0.500     1    node_35 0 --> 1 node_34
                                1    node_31 1 --> 0 node_25
52 ( )                1.000     1    node_34 0 ==> 1 node_31
53 ( )                1.000     1    node_35 0 ==> 1 node_34
54 ( )                0.500     2    node_35 0 ==> 2 node_34
                                1    node_29 2 --> 1 node_28
                                1    node_27 1 --> 2 Placochelys
55 ( )                0.500     1    node_35 0 ==> 1 node_21
                                1    node_23 0 ==> 1 C.rostratus
56 ( )                0.200     1    node_36 0 ==> 1 Palatodonta
                                1    node_21 0 ==> 1 node_20
                                1    node_30 0 --> 1 node_26
                                1    node_27 0 ==> 1 Placochelys
                                1    node_33 0 ==> 1 node_32
57 ( )                0.667     1    Ancesto 0 <=> 1 node_36
                                1    node_21 1 ==> 2 node_20
                                1    node_34 1 ==> 2 node_31
58 ( )                1.000     1    node_36 0 ==> 1 node_35
59 ( )                1.000     1    node_36 0 ==> 1 node_35
60 ( )                0.500     1    Ancesto 0 <-> 1 node_36
                                1    node_33 1 ==> 0 node_32
61 ( )                1.000     1    Ancesto 0 <-> 1 node_36
62 ( )                0.333     1    node_36 0 ==> 1 Palatodonta
                                1    node_21 0 ==> 1 node_20
                                1    node_33 0 ==> 1 Protenodontosaurus
63 ( )                0.500     1    node_35 0 --> 1 node_21
                                1    node_20 1 --> 0 P.gigas
64 (Character 64)     1.000     1    node_35 0 ==> 1 node_34
65 (Character 65)     0.500     1    Ancesto 0 <-> 2 node_36
                                1    node_21 2 ==> 1 node_20
                                1    node_31 2 ==> 1 node_25
                                1    node_33 2 --> 0 node_32
66 (Character 66)     1.000     1    node_35 0 ==> 1 node_21
67 (Character 67)     0.500     1    node_34 0 ==> 1 node_31
                                1    node_27 1 ==> 0 Placochelys
68 (Character 68)     1.000     1    node_21 0 ==> 1 Paraplacodus
69 (Character 69)     0.333     1    Ancesto 0 <-> 1 node_36
                                1    node_21 1 --> 0 Paraplacodus
                                1    node_28 1 ==> 0 Psephochelys
70 (Character 70)     1.000     1    node_20 0 ==> 2 P.inexpectatus
                                1    node_29 0 ==> 1 Psephoderma
71 (Character 71)     0.500     1    Ancesto 0 <-> 1 node_36
                                1    node_21 1 ==> 2 node_20
                                1    node_24 1 ==> 2 Sinocyamodus
                                1    node_31 1 --> 0 node_30
72 (Character 72)     0.500     1    node_20 0 ==> 1 P.inexpectatus
                                1    node_35 0 --> 1 node_34
73 (Character 73)     0.400     1    Ancesto 0 <-> 1 node_36
```

```
                          1    node_21 1 --> 2 node_20
                          1    node_25 1 --> 2 node_23
                          1    node_29 1 --> 0 node_28
                          1    node_28 0 --> 2 Psephochelys
74 (Character 74) 1.000   1    node_35 0 ==> 1 node_34
75 (Character 75) 1.000   1    node_35 0 ==> 1 node_21
76 (Character 76) 0.500   1    node_21 0 --> 1 node_20
                          1    node_31 0 --> 1 node_30
77 (Character 77) 0.500   1    Ancesto 0 <-> 1 node_36
                          1    node_21 1 --> 0 Paraplacodus
78 (Character 78) 0.500   1    Ancesto 0 <-> 1 node_36
                          1    node_21 1 --> 0 Paraplacodus
79 (Character 79) 1.000   1    node_35 0 ==> 1 node_34
80 (Character 80) 1.000   1    node_35 0 ==> 1 node_21
81 (Character 81) 0.500   1    Ancesto 0 <-> 1 node_36
                          1    node_21 1 --> 0 Paraplacodus
82 (Character 82) 1.000   1    node_35 0 ==> 1 node_34
83 (Character 83) 0.333   1    node_35 0 --> 1 node_34
                          1    node_24 1 --> 0 Sinocyamodus
                          1    node_29 1 --> 0 node_28
84 (Character 84) 0.500   1    node_31 0 --> 1 node_30
                          1    node_27 1 ==> 0 Placochelys
85 (Character 85) 0.500   1    node_29 0 ==> 1 node_28
                          1    node_34 0 --> 1 node_33
86 (Character 86) 0.500   1    node_29 0 ==> 1 Psephoderma
                          1    node_34 0 --> 1 node_33
87 (Character 87) 0.500   1    node_24 0 ==> 1 C.hildegardis
                          1    node_29 0 ==> 1 Psephoderma
88 (Character 88) 1.000   1    node_34 0 --> 1 node_33
89 (Character 89) 1.000   1    node_30 0 ==> 1 node_26
90 (Character 90) 0.667   1    node_35 0 ==> 1 node_34
                          1    node_31 1 --> 2 node_30
                          1    node_29 2 --> 1 node_28
```

Apomorphy lists:

Branch	Character	Steps	CI	Change
node_36 <-> Ancestor	18 ( )	2	0.333	2 <-> 0
	33 ( )	1	0.667	1 <=> 0
	57 ( )	1	0.667	1 <=> 0
	60 ( )	1	0.500	1 <-> 0
	61 ( )	1	1.000	1 <-> 0
	65 (Character 65)	1	0.500	2 <-> 0
	69 (Character 69)	1	0.333	1 <-> 0
	71 (Character 71)	1	0.500	1 <-> 0
	73 (Character 73)	1	0.400	1 <-> 0
	77 (Character 77)	1	0.500	1 <-> 0
	78 (Character 78)	1	0.500	1 <-> 0
	81 (Character 81)	1	0.500	1 <-> 0
node_36 --> Palatodonta	9 ( )	1	0.500	0 ==> 1
	32 ( )	1	0.400	0 ==> 2
	56 ( )	1	0.200	0 ==> 1
	62 ( )	1	0.333	0 ==> 1
node_36 --> node_35	10 ( )	1	1.000	0 ==> 1
	58 ( )	1	1.000	0 ==> 1
	59 ( )	1	1.000	0 ==> 1
node_35 --> node_21	37 ( )	1	1.000	0 ==> 1
	42 ( )	1	1.000	0 ==> 1
	55 ( )	1	0.500	0 ==> 1
	63 ( )	1	0.500	0 --> 1
	66 (Character 66)	1	1.000	0 ==> 1
	75 (Character 75)	1	1.000	0 ==> 1
	80 (Character 80)	1	1.000	0 ==> 1
node_21 --> Paraplacodus	5 ( )	1	0.250	0 ==> 1
	17 ( )	1	0.333	0 ==> 1
	33 ( )	1	0.667	1 ==> 0
	68 (Character 68)	1	1.000	0 ==> 1
	69 (Character 69)	1	0.333	1 --> 0
	77 (Character 77)	1	0.500	1 --> 0

	78 (Character 78)	1	0.500	1 --> 0
	81 (Character 81)	1	0.500	1 --> 0
node_21 --> node_20	36 ( )	1	0.750	0 ==> 1
	56 ( )	1	0.200	0 ==> 1
	57 ( )	1	0.667	1 ==> 2
	62 ( )	1	0.333	0 ==> 1
	65 (Character 65)	1	0.500	2 ==> 1
	71 (Character 71)	1	0.500	1 ==> 2
	73 (Character 73)	1	0.400	1 --> 2
	76 (Character 76)	1	0.500	0 --> 1
node_20 --> P.gigas	18 ( )	1	0.333	2 --> 1
	63 ( )	1	0.500	1 --> 0
node_20 --> P.inexpectatus	16 ( )	1	0.400	0 ==> 1
	70 (Character 70)	1	1.000	0 ==> 2
	72 (Character 72)	1	0.500	0 ==> 1
node_35 --> node_34	16 ( )	2	0.400	0 ==> 2
	19 ( )	1	1.000	0 ==> 1
	20 ( )	1	1.000	0 ==> 1
	26 ( )	1	0.500	0 ==> 1
	27 ( )	1	1.000	0 ==> 1
	30 ( )	1	0.667	0 ==> 1
	31 ( )	1	0.500	0 --> 1
	35 ( )	2	0.667	0 ==> 2
	36 ( )	1	0.750	0 ==> 2
	38 ( )	1	0.250	0 --> 1
	39 ( )	1	0.500	0 ==> 1
	43 ( )	1	1.000	0 ==> 1
	48 ( )	1	0.500	0 ==> 1
	49 ( )	1	0.500	0 --> 1
	51 ( )	1	0.500	0 --> 1
	53 ( )	1	1.000	0 ==> 1
	54 ( )	2	0.500	0 ==> 2
	64 (Character 64)	1	1.000	0 ==> 1
	72 (Character 72)	1	0.500	0 --> 1
	74 (Character 74)	1	1.000	0 ==> 1
	79 (Character 79)	1	1.000	0 ==> 1
	82 (Character 82)	1	1.000	0 ==> 1
	83 (Character 83)	1	0.333	0 --> 1
	90 (Character 90)	1	0.667	0 ==> 1
node_34 --> node_31	7 ( )	1	0.500	0 --> 1
	18 ( )	1	0.333	2 --> 1
	24 ( )	1	0.500	0 ==> 1
	33 ( )	1	0.667	1 --> 2
	46 ( )	1	0.333	0 ==> 1
	52 ( )	1	1.000	0 ==> 1
	57 ( )	1	0.667	1 ==> 2
	67 (Character 67)	1	0.500	0 ==> 1
node_31 --> node_25	12 ( )	1	0.500	0 ==> 1
	15 ( )	1	0.333	0 ==> 1
	31 ( )	1	0.500	1 --> 0
	51 ( )	1	0.500	1 --> 0
	65 (Character 65)	1	0.500	2 ==> 1
node_25 --> node_23	8 ( )	1	0.200	0 --> 1
	9 ( )	1	0.500	0 ==> 1
	13 ( )	1	1.000	0 ==> 1
	22 ( )	1	1.000	0 ==> 1
	23 ( )	1	1.000	0 ==> 1
	38 ( )	1	0.250	1 --> 0
	39 ( )	1	0.500	1 ==> 0
	45 ( )	1	1.000	0 ==> 1
	73 (Character 73)	1	0.400	1 --> 2
node_23 --> C.rostratus	18 ( )	1	0.333	1 ==> 0
	32 ( )	1	0.400	0 ==> 2
	36 ( )	1	0.750	2 ==> 1
	55 ( )	1	0.500	0 ==> 1
node_23 --> node_22	11 ( )	1	0.500	0 ==> 1
	16 ( )	1	0.400	2 ==> 1
	28 ( )	1	0.500	0 ==> 1
node_22 --> C.kuhnschnyderi	8 ( )	1	0.200	1 --> 0
	25 ( )	1	1.000	0 ==> 1

	29 ( )	1	0.250	0 ==> 1
node_25 --> node_24	35 ( )	1	0.667	2 ==> 1
node_24 --> C.hildegardis	14 ( )	1	0.333	0 ==> 1
	87 (Character 87)	1	0.500	0 ==> 1
node_24 --> Sinocyamodus	32 ( )	1	0.400	0 ==> 2
	44 ( )	1	0.333	0 ==> 1
	71 (Character 71)	1	0.500	1 ==> 2
	83 (Character 83)	1	0.333	1 --> 0
node_31 --> node_30	2 ( )	1	0.500	0 ==> 1
	3 ( )	1	1.000	0 --> 1
	5 ( )	1	0.250	0 ==> 1
	6 ( )	1	0.333	0 ==> 1
	17 ( )	1	0.333	0 ==> 1
	21 ( )	1	1.000	0 ==> 1
	30 ( )	1	0.667	1 ==> 2
	32 ( )	1	0.400	0 --> 1
	40 ( )	1	0.500	0 ==> 1
	49 ( )	1	0.500	1 --> 0
	71 (Character 71)	1	0.500	1 --> 0
	76 (Character 76)	1	0.500	0 --> 1
	84 (Character 84)	1	0.500	0 --> 1
	90 (Character 90)	1	0.667	1 --> 2
node_30 --> node_26	7 ( )	1	0.500	1 --> 0
	8 ( )	1	0.200	0 ==> 1
	56 ( )	1	0.200	0 --> 1
	89 (Character 89)	1	1.000	0 ==> 1
node_30 --> node_29	29 ( )	1	0.250	0 --> 1
	41 ( )	1	1.000	0 ==> 1
	44 ( )	1	0.333	0 ==> 1
	47 ( )	1	0.333	0 ==> 1
node_29 --> node_28	11 ( )	1	0.500	0 ==> 1
	16 ( )	1	0.400	2 ==> 1
	38 ( )	1	0.250	1 --> 0
	46 ( )	1	0.333	1 --> 0
	48 ( )	1	0.500	1 ==> 0
	50 ( )	1	0.500	0 --> 1
	54 ( )	1	0.500	2 --> 1
	73 (Character 73)	1	0.400	1 --> 0
	83 (Character 83)	1	0.333	1 --> 0
	85 (Character 85)	1	0.500	0 ==> 1
	90 (Character 90)	1	0.667	2 --> 1
node_28 --> node_27	5 ( )	1	0.250	1 ==> 0
	6 ( )	1	0.333	1 ==> 0
	14 ( )	1	0.333	0 ==> 1
	26 ( )	1	0.500	1 --> 2
	35 ( )	1	0.667	2 --> 1
node_27 --> Placochelys	4 ( )	1	0.500	0 ==> 1
	15 ( )	1	0.333	0 ==> 1
	54 ( )	1	0.500	1 --> 2
	56 ( )	1	0.200	0 ==> 1
	67 (Character 67)	1	0.500	1 ==> 0
	84 (Character 84)	1	0.500	1 ==> 0
node_27 --> Glyphoderma	17 ( )	1	0.333	1 ==> 0
node_28 --> Psephochelys	2 ( )	1	0.500	1 ==> 0
	8 ( )	1	0.200	0 ==> 1
	18 ( )	1	0.333	1 ==> 2
	24 ( )	1	0.500	1 ==> 0
	26 ( )	1	0.500	1 ==> 0
	29 ( )	1	0.250	1 --> 0
	69 (Character 69)	1	0.333	1 ==> 0
	73 (Character 73)	1	0.400	0 --> 2
node_29 --> Psephoderma	70 (Character 70)	1	1.000	0 ==> 1
	86 (Character 86)	1	0.500	0 ==> 1
	87 (Character 87)	1	0.500	0 ==> 1
node_34 --> node_33	4 ( )	1	0.500	0 ==> 1
	14 ( )	1	0.333	0 ==> 1
	26 ( )	1	0.500	1 --> 2
	29 ( )	1	0.250	0 --> 1
	35 ( )	1	0.667	2 ==> 3
	47 ( )	1	0.333	0 --> 1

	85 (Character 85)	1	0.500	0 --> 1
	86 (Character 86)	1	0.500	0 --> 1
	88 (Character 88)	1	1.000	0 --> 1
node_33 --> node_32	3 ( )	1	1.000	0 --> 2
	6 ( )	1	0.333	0 --> 1
	8 ( )	1	0.200	0 ==> 1
	12 ( )	1	0.500	0 --> 1
	15 ( )	1	0.333	0 ==> 1
	28 ( )	1	0.500	0 --> 1
	32 ( )	1	0.400	0 --> 1
	35 ( )	1	0.667	3 ==> 4
	36 ( )	1	0.750	2 ==> 3
	44 ( )	1	0.333	0 --> 1
	56 ( )	1	0.200	0 ==> 1
	60 ( )	1	0.500	1 ==> 0
	65 (Character 65)	1	0.500	2 --> 0
node_32 --> Henodus	47 ( )	1	0.333	1 --> 0
node_32 --> Parahenodus	46 ( )	1	0.333	0 ==> 1
node_33 --> Protenodontosaurus	5 ( )	1	0.250	0 ==> 1
	30 ( )	1	0.667	1 ==> 2
	38 ( )	1	0.250	1 --> 0
	40 ( )	1	0.500	0 ==> 1
	50 ( )	1	0.500	0 ==> 1
	62 ( )	1	0.333	0 ==> 1

Reconstructed states for internal nodes:

	1 2 3 4 5 6 7 8 9
Node	234567890123456789012345678901235678901234567890123456789012345678901234567890123456789
20	00000000100000002000000000000001011000010000000000001121111110110010202011110110000000000
21	00000000100000002000000000000001001000010000000000001011111010210010101010110110000000000
22	00000111111101101110111011101002220000001011011001120021111001101010112100111011100000001
23	00000111101101201110111011001002220000001011011001120021111001101010112100111011100000001
24	00000100101001201110001011001002120110001001011001120021111001101010111100111011100000001
25	00000100101001201110001011001002220110001001011001120021111001101010111100111011100000001
26	11011010100000211111001011002112220111001001010011120121111001201010011101111011111000012
27	11000100110010111111001021012112120011101100100111110021111001201010010101111011011000001
28	11011100110000111111001011012112220011101100100111110021111001201010010101111011011000001
29	11011100100000211111001011012112220111011011100111200211110012010100111011110111111000002
30	11011100100000211111001011002112220111001001010011120021111001201010011101111011111000002
31	00000100100000201110001011001102220110001001011011120021111001201010111100111011110000001
32	02101010101011202110000021111111430110001100111010120111101001000010111100111011101101
33	00100000100010202110000021011101320110001000111010120011111001200010111100111011101101
34	00000000100000202110000011001101220110001000011010120011111001200010111100111011100000001
35	00000000100000002000000000000001000000000000000000000000011111000200010101000110010000000
36	00000000000000002000000000000001000000000000000000000000010011000200010101000110010000000