

1 **An early Miocene skeleton of *Brachydiceratherium* Lavocat, 1951 (Mammalia,**  
2 **Perissodactyla) from the Baikal area, Russia, and a revised phylogeny of Eurasian**  
3 **teleoceratines**

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13 **Abstract.** Hippo-like rhinocerotids, or teleoceratines, were a conspicuous component of  
14 Holarctic Miocene mammalian faunas, but their phylogenetic relationships ~~are widely under-~~  
15 ~~investigated.~~ Excavations in lower Miocene deposits of ~~the~~ Olkhon Island (Tagay locality,  
16 Eastern Siberia; 16–18 Ma) have opened a unique window on the poorly-known early history  
17 of the Lake Baikal ecosystems, notably ~~in~~ unearthing a skeleton of the teleoceratine  
18 *Brachydiceratherium shanwangense* (Wang, 1965). The ~~concerned~~ remains provide new  
19 insights into ~~cranio-mandibular, dental, and~~ postcranial **morpho-anatomy** of this elusive  
20 species. ~~Comparison to most teleoceratine species described in Eurasia allows for proposing~~  
21 ~~phylogenetic relationships among Teleoceratina through a formal parsimony analysis.~~  
22 *Diaceratherium* Dietrich, 1931, ~~as a~~ monotypic ~~genus~~ (earliest Miocene, Western Europe), is  
23 retrieved as the earliest teleoceratine offshoot. Other genera ~~are both~~ plurispecific and  
24 monophyletic, with *Prosantorhinus* Heissig, 1974 (early Miocene, Eurasia) ~~and~~ *Teleoceras*  
25 Hatcher, 1894 (Miocene, North America) forming the sister clade of ~~the~~ (*Brachypotherium*

26 Roger, 1904 (Miocene, Old World) ~~plus~~ *Brachydiceratherium* Lavocat, 1951) ~~clade~~. The  
27 ~~latter genus~~ includes eight species spanning the late Oligocene–late Miocene ~~interval~~ in  
28 Europe and Asia. All teleoceratine genera ~~but~~ *Diaceratherium* span considerable geographical  
29 and stratigraphical ranges, likely related to their ultra-generalist ecological preferences.  
30  
31 **Keywords:** Rhinocerotidae, *Brachydiceratherium shanwangense*, Tagay, Early Miocene,  
32 Siberia, Lake Baikal, phylogeny, biogeographical history.

### 33 INTRODUCTION

34 Although they are nearly extinct today, rhinoceroses were one of the most widespread  
35 and successful groups of mammals on ~~all~~ the northern continents for over 40 million years.  
36 They ~~have freely circulated between~~ Eurasia and North America since ~~the~~ middle Eocene, and  
37 are known from Africa since the early Miocene (e.g., Prothero et al., 1989; Antoine et al.,  
38 2003, **accepted; Geraads, 2010**). They have also occupied many different ~~modes of life around~~  
39 ~~the world during their long evolutionary history~~. They ranged from slender- and long-legged  
40 savannah roamers (**e.g., elasmotheriines**) to hippo-like forms that apparently lived along rivers  
41 and lakes (**teleoceratines**; Prothero et al., 1989; Antoine, 2002). Most hippo-like rhinocerotids  
42 are ~~gathered within~~ teleoceratines, a clade at the tribal to sub-tribal level, the phylogenetic  
43 relationships of which have never been fully elucidated (Antoine, 2002; Lu et al., 2021). Most  
44 teleoceratines had skulls, **either hornless or with a small nasal horn**, barrel-shaped bodies, and  
45 shortened limb bones ~~adapted to swamps and riversides~~. Teleoceratines span the late  
46 Oligocene–latest Miocene ~~interval~~ in Eurasia (Antoine, in press), the Miocene ~~epoch~~ in Africa  
47 (Geraads & Miller, 2013), and the early Miocene–early Pliocene in North and Central  
48 America (Prothero, 2005). Most of them are interpreted ~~as~~ browsers (based on both dental  
49 morphology and isotopic studies; MacFadden, 1998; Hullot et al., 2021).

50 In this study, we describe a skeleton of a teleoceratine from lower Miocene deposits  
51 ~~from the~~ Olkhon Island, Lake Baikal area, Siberia, ~~identify~~ its species assignment and  
52 compare it to most teleoceratine species described ~~in~~ Eurasia. This in-depth comparison  
53 ~~allows for performing~~ a parsimony analysis ~~aiming at retrieving~~ phylogenetic relationships  
54 among Eurasian Teleoceratina, and for discussing key events in the ~~historical biogeography~~ of  
55 teleoceratine rhinocerotids.

## 56 LOCALITY AND GEOLOGICAL SETTINGS

57 Lake Baikal, located in the Baikal Rift System, is morphologically characterised by  
58 three basins (Southern, Central and Northern). The Southern and Central basins are thought to  
59 have existed permanently since the Paleogene, whereas the Northern Basin did not develop  
60 before the Late Miocene (Mats et al., 2010, 2011). Olkhon Island (Russian: ОЛЬХОН) is  
61 located in the transitional zone between the Central and the Northern basins of Lake Baikal. It  
62 is separated from the mainland in the west by a shallow Maloe More strait (Russian: Малое  
63 Море; in English literally the Small Sea) of the Northern Basin that extends far to the south.  
64 In the south, Maloe More strait is connected through the narrow Olkhonskie Vorota strait  
65 (Russian: Ольхонские Ворота; in English literally the Olkhon Gate) to the central part of  
66 Lake Baikal. From the northwestern part of Olkhon Island, one locality known as Tagay or  
67 Tagai (Russian: Тагай or Тогай) has yielded numerous terrestrial fossils of the Neogene (Fig.  
68 1). The Neogene sediments in Tagay Bay belong to the Tagay Formation (Logachev **et al.**,  
69 1964; Mats et al., 2001; Mats, 2013, 2015). Sediments are exposed in the northeastern part of  
70 the bay in a steep erosional cliff up to 15 m high. Elsewhere along the shores of the bay, **this**  
71 **cliff** is levelled by landslides. The cliff borders **a large landslide cirque** and a sandy beach  
72 below.

73 The Tagay locality was discovered in the 1950s (Kitainik & Ivaniev, 1958). First  
74 paleontological studies of the large mammals were performed in 1958 under the direction of  
75 N.A. Logachev (Logachev et al., 1964). Studies of small mammals had been carried out  
76 ~~occasionally by A.G. Pokatilov~~ since the 1970s (Pokatilov, 2004; Daxner-Höck et al., 2022).  
77 Tagay preserves an abundant fossil fauna that includes molluscs and vertebrates such as fish,  
78 amphibians, reptiles, birds and mammals. However, a significant part of the paleontological  
79 material was determined only tentatively ~~for a long time~~: Mustelidae and Felidae among  
80 carnivorans, *Anchitherium* sp, *Metaschizotherium*(?) sp., and *Dicerorhinus*(?) sp. among  
81 perissodactyls, *Palaeomeryx* sp. and Bovidae among artiodactyls (Logachev et al., 1964).  
82 Artiodactyl remains ~~were reexamined, which~~ led to the following list: Cervidae  
83 (*Amphitragulus boulangeri*, *Lagomeryx parvulus*, *Stephanocemas* sp.), Palaeomerycidae  
84 (*Orygotherium tagaiense*, *Palaeomeryx* cf. *kaupi*) and Anthracotheriidae (*Brachyodus*  
85 *intermedius*) (Vislobokova, 1990, 1994, 2004). Chelonians were studied by Khosatzky and  
86 Chkhikvadze (1993) and the ichthyofauna by Sytchevskaya (Filippov & Sytchevskaya, 2000).  
87 Small mammals from the Tagay-1 section were recently revised, with a list of 21 taxa  
88 documenting erinaceids, talpids, plesiosoricids, and soricids among eulipotyphlans,  
89 palaeolagid lagomorphs, and sciurids, aplodontids, mylagaulids, glirids, castorids, eomyids,  
90 and cricetodontine muroids among rodents (Daxner-Höck et al., 2022).  
91 The ~~Neogene sediments were examined based on~~ sedimentological, stratigraphical, and  
92 palaeontological aspects by Kossler (2003). A new phase of the study of Tagay locality  
93 started in 2008. ~~Annual palaeontological studies have been carried out since that year~~ (Rage &  
94 Danilov, 2008; Klementiev, 2009; Danilov et al., 2012; Syromyatnikova, 2014, 2015;  
95 Tesakov & Lopatin, 2015; Klementiev & Sizov, 2015; Zelenkov, 2016; Sotnikova et al,  
96 2021).

97 The Tagay Formation consists of alternating beds of clays and clayey sands containing  
98 interlayers and lenses of carbonate concretions of diagenetic origin. Deposits rest upon the  
99 crystalline basement, ~~submerging~~ below the water to the south. Clay beds are mostly green  
100 and brown, sometimes black. There are also lenses and interlayers of brick red and red clay  
101 and loam. Bone beds, **coinciding with sedimentary cycles**, were **given** letters from **top to**  
102 **bottom (i.e., downsection: A–H)**; Fig. 2 A, B). Most clay beds have predominant ferruginous-  
103 magnesian montmorillonites composition. A remarkable feature of clay sediments is the high  
104 (up to 8%) content of silt-psammite-psephite admixtures. Moreover, most psammite-psephitic  
105 fragments are not rounded and have angular and indented outlines, which indicates ~~their~~  
106 ~~insignificant~~ transportation. ~~Lithological descriptions of the sections and specification of the~~  
107 ~~bone beds are available in the papers~~ (Logachev et al., 1964; Sizov & Klementiev, 2015).

108 Neogene continental deposits in the late early Miocene Tagay locality have yielded a  
109 diverse vertebrate fauna. **The vast majority of unearthed forms are strictly or predominately**  
110 **woodland inhabitants. Taxonomically, the fauna represents a mixture of European, Asian, and**  
111 **North American taxa, and thus is of great importance for intercontinental and pan-Eurasian**  
112 **faunal correlations. Based on the faunal similarity, the Tagay fauna likely correlates with the**  
113 **Shanwangian Mammal Age/Stage of China (19–16 Ma).** ~~According to the views of various~~  
114 ~~specialists, the age of the Tagay Fauna correlates to the interval of units~~ MN3 through MN5  
115 **(20–15 Ma;** Rössner & Mörs, 2001; Vislobokova, 2004; Klementiev & Sizov, 2015;  
116 Sotnikova et al., 2021), **a hypothesis that we favour.** ~~Other researchers have correlated the~~  
117 ~~Tagay fauna with the European Mammal Zone~~ MN 7+8 and ~~the~~ Chinese Mammal Unit  
118 NMU7 (13–11 Ma; Daxner-Höck et al., 2013). **More recently, Daxner-Höck et al. (2022)**  
119 **proposed an** age of ~16.5–16.3 Ma based on micromammalian bicostratigraphy and the  
120 **magnetic polarity pattern of the Tagay-1 section (Fig. 1 B), in full agreement with our**  
121 **preferred interval.**

## 122 MATERIAL AND METHODS

123 All the remains described here belong to a single adult individual (IZK79-1-08C-1/),  
124 stored in the collection of the Institute of the Earth's Crust (Irkutsk, Russia). Alexey  
125 Klementiev and Gennady Turkin discovered this skeleton in 2008 **at Tagay site** (Fig. 2 B, C)  
126 (Klementiev, 2009).

127 **C**apital letters are used for upper teeth (I, C, D, P, M), and lower-case letters for lower  
128 teeth (i, c, d, p, m). **Rhinocerotid dental terminology follows Heissig** (1969, 1972a: pl. 13) and  
129 Antoine (2002), while dental and skeletal measurements were taken according to Guérin  
130 (1980). Anatomical ~~features described~~ follow basically the same sequence as in Antoine  
131 (2002), and Antoine et al. (2010). Dimensions are given in mm.

132 The stratigraphical framework **is based on geological time scales and European Land**  
133 Mammal Ages for the Neogene (Hilgen, Lourense & Van Dam, 2012; Raffi et al, 2020).

### 134 **3D-rendering**

135 All **describable** bones of the rhinoceros were scanned with a resolution of 0.25 mm  
136 using a RangeVision Smart ~~a~~ 3D scanner, ~~working~~ on the principle of structured  
137 illumination. RangeVision Smart has **three areas of scanning and is equipped with colour**  
138 **cameras 1.3 MP** ~~and is equipped with a specially designed software~~ RangeVision 2020.2  
139 ~~which we used~~ for visualization, segmentation and 3D rendering.

### 140 **Parsimony analysis**

141 The ~~parsimony~~ analysis was ~~performed through~~ 282 cranio-mandibular, dental, and  
142 postcranial characters primarily derived from ~~those~~ of Antoine (2002, 2003) ~~and~~ scored on 31  
143 ceratomorph species (i.e., one tapirid ~~plus~~ 30 rhinocerotoids). All multistate characters were  
144 treated as additive, except for ~~the~~ characters 72, 94, 102, 140, and 187 (non-additive; **as in**  
145 **Antoine, 2002**).

146           The ~~outgroup includes the~~ living Brazilian tapir *Tapirus terrestris* (Linnaeus, 1758), the  
147 Eocene non-rhinocerotid rhinocerotoid *Hyrachyus eximius* Leidy, 1871 and the Paleogene  
148 stem rhinocerotids *Trigonias osborni* Lucas, 1900 (Eocene of North America) and  
149 *Ronzotherium filholi* (Osborn, 1900) (Oligocene of Western Europe). ~~Aside from the~~  
150 ~~outgroup, we have included a branching group~~ (Antoine, 2002, 2003; Orliac et al., 2010;  
151 Boivin et al., 2019), ~~aimed at i) further testing the monophyly of the in-group and ii)~~  
152 ~~branching it precisely among a large set of Rhinocerotinae. It~~ consists of 12 species ~~classically~~  
153 ~~assigned to all suprageneric groups but Teleoceratina among Rhinocerotinae, including~~ an  
154 early-diverging representative of Rhinocerotinae (*Plesiaceratherium mirallesi* (Crusafont,  
155 Villalta & Truyols, 1955)), three species ~~among~~ Aceratheriini (*Aceratherium incisivum* Kaup,  
156 1832, *Acerorhinus zernowi* (Borissiak, 1914), and *Alicornops simorreense* (Lartet, 1851)), and  
157 eight members of the Rhinocerotina, encompassing all five living rhinoceroses, namely the  
158 Indian rhino (*Rhinoceros unicornis* Linnaeus, 1758), the Javan rhino (*Rhinoceros sondaicus*  
159 Desmarest, 1822), the Sumatran rhino (*Dicerorhinus sumatrensis* (Fischer, 1814)), the white  
160 rhino (*Ceratotherium simum* (Burchell, 1817)), and the black rhino (*Diceros bicornis*  
161 (Linnaeus, 1758)), ~~but also~~ three fossil species: *Lartetotherium sansaniense* (Lartet in  
162 Laurillard, 1848) (Miocene of Europe; Heissig, 2012), *Gaindatherium browni* Colbert, 1934  
163 (Miocene of South Asia; Heissig, 1972a; Antoine, in press), and *Nesorhinus philippinensis*  
164 (Von Koenigswald, 1956) (early Middle Pleistocene of the Philippines; Antoine et al., 2022  
165 and references therein).

166           The ingroup sensu stricto (Teleoceratina) comprises 15 ~~terminals~~, with *Teleoceras*  
167 *fossiger* Cope, 1878 (late Miocene to earliest Pliocene, North America), *Brachypotherium*  
168 *brachypus* (Lartet in Laurillard, 1848) (late early and middle Miocene, Eurasia),  
169 *Brachypotherium perimense* (Falconer & Cautley, 1847) (Miocene, South Asia),  
170 *Prosantorhinus germanicus* (Wang, 1929) (late early and middle Miocene, Europe),

171 *Prosantorhinus douvillei* (Osborn, 1900) (late early and early middle Miocene, Europe),  
172 *Prosantorhinus laubei* Heissig & Fejfar, 2007 (early Miocene, central Europe), and a  
173 comprehensive sample of ~~terminals~~ either classically or more recently assigned to  
174 *Diaceratherium* Dietrich, 1931. They consist of the type species *D. tomerdingense* Dietrich,  
175 1931 from the earliest Miocene of Tomerdingen (Germany), *D. lemanense* (Pomel, 1853)  
176 from the latest Oligocene-early Miocene of Western Europe (also described under the  
177 *Diceratherium* (*Brachydiceratherium*) *lemanense* combination by Lavocat, 1951), *D.*  
178 *aurelianense* (Nouel, 1866) from the early Miocene of Western Europe, *D. asphaltense*  
179 (Depéret & Douxami, 1902) from the earliest Miocene of Western Europe, *D. fatehjangense*  
180 (Pilgrim, 1910), from the Miocene of Pakistan and early Miocene of Kazakhstan (previously  
181 described as “*Brachypotherium aurelianense* Nouel, var. nov. *Gailiti*” by Borissiak, 1927), *D.*  
182 *aginense* (Répelin, 1917) from the earliest Miocene of Western Europe, *D. shanwangense*  
183 (Wang, 1965) from the late early Miocene of eastern China (Shanwang; Lu et al., 2021),  
184 Japan, and eastern Siberia (Tagay; this work), and *D. lamilloquense* Michel, in Brunet et al.,  
185 1987 from the late Oligocene of France. *Aceratherium gajense intermedium* Lydekker, 1884  
186 has disputed taxonomic affinities. ~~Even if it has been subsequently~~ assigned to the  
187 aceratheriine genera *Subchilotherium* (e.g., Heissig, 1972a) or *Chilotherium* (e.g., Khan et al.,  
188 2011), Antoine et al. (2003) considered that this taxon might document a teleoceratine  
189 ~~instead, although~~ of uncertain generic assignment, ~~based on a parsimony analysis taking into~~  
190 ~~account the holotype and original hypodigm~~. The recognition of associated dental and  
191 postcranial remains from the Potwar Plateau (late early to early late Miocene, Pakistan)  
192 allowed for defining the new combination *Diaceratherium intermedium* (Lydekker, 1884), as  
193 recently proposed by Antoine (in press). This debated taxonomic issue will be tested here.

194 Three indisputable representatives of Teleoceratina, ~~such as~~ *Diaceratherium* cf.  
195 *lamilloquense* from the late Oligocene of Thailand (Marivaux et al., 2004), *Brachypotherium*



196 *gajense* (Pilgrim, 1910), from the late Oligocene–earliest Miocene of Pakistan, and  
197 *Prosantorhinus shahbazi* (Pilgrim, 1910), from the early Miocene of Pakistan (combinations  
198 proposed by Antoine et al., 2010 and Antoine, in press) were not included in the analysis, due  
199 to their ~~very elusive~~ hypodigms, restricted to a few elements ~~likely to blur the phylogenetic~~  
200 ~~signal and to generate much uncertainty in the analysis.~~

201 Moreover, *Diaceratherium askazansorense* Kordikova, 2001 from the early Miocene of  
202 Kazakhstan was not included ~~either~~, as dental and postcranial elements assigned to this taxon  
203 closely resemble those of *Pleuroceros blanfordi*, a stem member of Rhinocerotinae (early  
204 Miocene of South Asia; Antoine et al., 2010; Prieto et al., 2018) and, to a lesser extent, of  
205 *Pleuroceros pleuroceros* (earliest Miocene of western Europe; Antoine et al., 2010; Antoine  
206 & Becker, 2013). Similarly, the early late Oligocene species *Diaceratherium massiliae*  
207 Ménouret & Guérin, 2009 was recently shown to be a junior synonym of the short-limbed and  
208 early-diverging rhinocerotid *Ronzotherium romani* Kretzoi, 1940, through a ~~thorough re-~~  
209 examination of most available material and the recognition of new associated dental and  
210 postcranial specimens in Switzerland (Tissier et al., 2021). ~~Hence, it was not considered in the~~  
211 ~~present phylogenetic analysis.~~

212 ~~Details about the way all terminals were scored (specimens, collections, direct~~  
213 ~~observation and/or literature survey, with references used) are provided in the data matrix, as~~  
214 ~~notes to every taxon (supplementary file S3).~~

215 ~~The parsimony~~ analyses were performed through the heuristic search of PAUP 4  
216 3.99.169.0 (Swofford, 2002), with tree ~~bissection-reconnection~~ (reconnection limit = 8), 1000  
217 replications with random addition sequence (10 trees held at each step), gaps treated as  
218 missing, and no differential weighting or topological constraint ~~a priori~~. ~~Branch support was~~  
219 ~~estimated through Bremer indices (Bremer, 1994).~~

## 220 Systematics

221 Generic and suprageneric systematics follows the ~~arrangement as supported by the~~  
222 present parsimony analysis (see below).

223 SYSTEMATIC PALAEOLOGY

224 Order Perissodactyla OWEN, 1848

225 Family Rhinocerotidae GRAY, 1821

226 Subfamily Rhinocerotinae GRAY, 1821

227 Tribe Rhinocerotini GRAY, 1821

228 Subtribe Teleoceratina HAY, 1902

229 Genus *Brachydiceratherium* LAVOCAT, 1951

230 **Syn. *Diaceratherium* DIETRICH, 1931 (partim)**

231

232 **Type species: *Acerotherium lemanense* Pomel, 1853** by subsequent designation

233 **(Lavocat, 1951)**

234

235 **Referred species: *Rhinoceros aurelianensis* Nouel, 1866** from the early Miocene of  
236 Western Europe; ***Aceratherium intermedium* Lydekker, 1884**, from the early–late Miocene of  
237 the Indian Subcontinent and China (**Deng and Gao, 2006**; Antoine et al., 2013; Antoine, in  
238 press); ***Diceratherium asphaltense* Depéret & Douxami, 1902** from the earliest Miocene of  
239 Western Europe; ***Teleoceras fatehjangense* Pilgrim, 1910**, from the Miocene of Pakistan and  
240 early Miocene of Kazakhstan (senior synonym of “*Brachypotherium aurelianense* Nouel, var.  
241 nov. *Gailiti*” by Borissiak, 1927); ***Teleoceras aginense* Répelin, 1917** from the earliest  
242 Miocene of Western Europe; ***Plesiaceratherium shanwangense* Wang, 1965** from the late  
243 early Miocene of eastern China (Shanwang; Lu et al., 2021), Japan, and eastern Siberia

244 (Tagay; this work); *Diaceratherium lamilloquense* Michel, in Brunet et al., 1987 from the late  
245 Oligocene of France.

246

247 **Diagnosis:** Teleoceratines with a small nuchal tubercle, articular tubercle smooth on the  
248 squamosal, with cement present on cheek teeth, protocone always constricted on P3-4, labial  
249 cingulum usually absent on lower premolars and always present on lower molars, foramen  
250 vertebrale lateralis present and axis-facets transversally concave on the atlas, a postero-distal  
251 apophysis low on the tibia, and a latero-distal gutter located posteriorly on the fibula.

252 Distinct from *Diaceratherium tomerdingense* in possessing a long metaloph on M1-2,  
253 no mesostyle on M2, a distal gutter on the humeral epicondyle, an anterior side of the  
254 semilunate with a sharp distal border, no posterior expansion on the pyramidal-facet of the  
255 unciform, and a trapezium-facet present on the McII.

256 Differs from representatives of *Brachypotherium* in having close parietal crests, a  
257 median ridge on the occipital condyles, a mandibular symphysis less massive, a labial  
258 cingulum usually or always absent on upper premolars, an external groove developed on the  
259 ectolophid of lower cheek teeth, a V-shaped lingual opening of the posterior valley of lower  
260 premolars (in lingual view), a paraconid developed on p2, no second distal radius-ulna facet, a  
261 symmetric semilunate-pyramidal distal facet, a posterior McIII-facet present on the McII, and  
262 a fibula-facet subvertical on the astragalus.

263 Distinct from species referred to as *Prosantorhinus* in showing no latero-ventral  
264 apophysis on the nasals, close fronto-parietal crests, and no posterior groove on the processus  
265 zygomaticus of the squamosal.

266

267 **Geographical and stratigraphical range:** Late Oligocene and/or Miocene of Eurasia,  
268 with an early Miocene climax.

269

270 *Brachydiceratherium shanwangense* (Wang, 1965)

271 See synonymy list in Lu et al. (2021)

272

273 **Diagnosis:** Representative of *Brachydiceratherium* with a lateral apophysis present on  
274 the nasals, a median nasal horn present on the nasals, premolar series short with respect to the  
275 molar series, roots distinct on the cheek teeth, crochet always simple and lingual cingulum  
276 usually absent and always reduced on P2-4, crista always present on P3, protocone strongly  
277 constricted on M1-2, lingual cingulum usually absent on lower premolars and always absent  
278 on lower molars, d1/p1 absent in adults, glenoid fossa with a medial border straight on the  
279 scapula, distal gutter absent on the lateral epicondyle of the humerus, proximal radius-ulna  
280 facets always fused, and trochanter major low on the femur.

281 Distinguished from *Bd. lamilloquense*, *Bd. lemanense*, *Bd. asphaltense*, and/or *Bd.*  
282 *aurelianense* in having I1s oval in cross section, no labial cingulum on upper cheek teeth, a  
283 strong paracone fold on M1-2 and a constricted hypocone on M1, M3s with a triangular  
284 occlusal outline, a radius with a high posterior expansion of the scaphoid-facet, a femoral  
285 head hemispheric, an astragalus with a laterodistal expansion, very low-and-smooth  
286 intermediate reliefs on metapodials, and a long insertion of m. interossei on lateral  
287 metapodials.

288 Differs from *Bd. aginense* in having a processus postorbitalis on the frontal bone and a  
289 median ridge on the occipital condyle, but no posterior groove on the processus zygomaticus  
290 of the squamosal, molariform P2s (protocone and hypocone lingually separate), a long  
291 metaloph on M1-2, a posterior groove on M3, a shallow gutter for the m. extensor carpi on the  
292 radius, a posterior MtII- MtIII facet developed, but no cuboid-MtIII contact.

293 Distinct from *D. intermedium* in showing usually a lingual cingulum on upper molars, a  
294 strong paracone fold on M1-2, a lingual cingulum usually absent on lower premolars, and a  
295 right angle between the cuboid-facet and the base of the tuber calcanei on the calcaneus  
296 Differs from *Bd. lemanense* in possessing a low zygomatic arch with a processus postorbitalis,  
297 a small processus posttympanicus and a well-developed processus paraoccipitalis.  
298 Distinct from *Bd. asphaltense* in having closer fronto-parietal crests and a brachycephalic  
299 shape.  
300 Differs from *D. lamilloquense* in showing a protoloph joined to the ectoloph on P2 and  
301 molariform P3-4s (protocone and hypocone lingually separate).  
302 Differs from *D. aurelianense* in having no metaloph constriction on P2-4 and a protocone  
303 weakly developed on P2.

304

305 **Geographical and stratigraphical range:** Late early Miocene of the Shanwang Basin,  
306 Shandong Province, China (see Lu et al., 2021) and of Irkutsk Region, Russia (Tagay locality,  
307 Olkhon Island, Lake Baikal).

308

309 **Material available:** IZK79-1-08C-1, almost complete skeleton, including the skull  
310 (occipital, parietal, frontal, the right zygomatic and lacrimal, both nasals, and temporals with  
311 processes and also premaxillae), the jaws, most vertebrae and ribs, both humeri, radii and  
312 ulnae, both femora, tibiae, right fibula, most metacarpals, and several metatarsals and  
313 phalanges. The skeleton described herein was found disarticulated at the junction of layers of  
314 sand and clay (Fig. 2 B, C). In general, the right side of the individual is much better  
315 preserved than the left one.

316 DESCRIPTION

## 317 **Skull**

318 The skull (Fig. 3, **Table 1**) was found **disarticulated**, but there is no doubt that the  
319 separate bones belong to the same individual, because they were found in close proximity to  
320 one another with no extraneous elements, and they fit together well. The temporal, zygomatic  
321 and lacrimal, nasal, frontal, parietal and occipital fit each other perfectly. The remaining  
322 bones are matching in size, colour and texture. The skull is short and relatively wide (**Length**  
323 **from condyles to nasals** = 540 mm, **Width at the** frontals  $\approx$  190 mm), belonging to a large-  
324 sized adult rhinocerotid. The separated nasal bones are long and longer than the **preserved part**  
325 **of the** premaxilla, relatively thin and bear a lateral apophysis. Roughness for a small nasal  
326 horn is preserved at the tip of the nasals. In lateral view, the foramen infraorbitalis and the  
327 posterior border of the U-shaped nasal notch are both located above the P3, while the anterior  
328 border of the orbit is above the M1. The minimum distance between the posterior edge of the  
329 nasal notch and the anterior border of the orbit is 67.2 mm.

330 **Cranial features.** The skull was partly destroyed and some elements were reconstructed  
331 in anatomical position by one of us (AS). It is short, broad, and elevated. The dorsal profile of  
332 the skull is concave, with a small protuberance for a short nasal horn and an upraised parietal  
333 bone ( $50^\circ$ ). In lateral view, the nasals have a small ventrolateral prominence (lateral  
334 apophysis, sensu Antoine, 2002). The maxilla is badly damaged and the area of the foramen  
335 infraorbitalis is restored on both sides. Nevertheless, based on the preserved part of the  
336 maxilla, a position above P4 can be hypothesised. The posterior end of the nasal notch is  
337 located above the anterior part of P3. The nasal septum is not ossified at all. The premaxillae  
338 are broken rostrally. They form a short and elevated strip, slightly dipping forward, with a  
339 deep ventral sulcus. Relations between nasal and **lacrimal** bones are not observable, and  
340 neither are the **lacrimal** processi. The anterior border of the orbit is situated above the middle  
341 of M1. On the frontal, a pair of smooth tubercles lay on the dorsal and posterodorsal edges of

342 the orbit (processus postorbitalis). The anterior base of the processus zygomaticus **maxillari** is  
343 low, ~1 cm above the neckline of molars. The zygomatic arch forms a straight, low, and  
344 oblique strip, with parallel dorsal and ventral borders. It is parallel to the dorsal outline of the  
345 skull, with a rounded and rugose posterodorsal tip. A marked processus postorbitalis deforms  
346 the dorsal edge of the zygomatic process, at the junction between the jugal and the squamosal.  
347 Its tip, located on the latter bone, has a rugose aspect. Most of the temporal fossa elements are  
348 not preserved and it is therefore impossible to consider the shape and relations of the foramina  
349 sphenorbitale and rotundum. The area between the temporal and nuchal crests is depressed,  
350 forming a deep gutter. The external auditory pseudo-meatus is partly closed ventrally. The  
351 posterior side of the processus zygomaticus is flat in lateral view (no posterior groove). The  
352 occipital side is inclined up- and forward, with a very salient nuchal tubercle (although small,  
353 i.e., not extended on a wide area), determining a diamond-shape to the skull in dorsal view.  
354 The occipital condyles are oriented in the same axis as the skull in lateral view. The posterior  
355 tip of the tooth row reaches the posterior third of the skull. The pterygoids are not preserved,  
356 as most of the basicranium, vomer, and basal foramina. The skull is brachycephalic  
357 (interzygomatic width/total length ~0.57; **Table 1**). As observable in dorsal view, the nasals  
358 have a sharp tip. They are long and unfused, fully separate by a deep groove from tip to tip.  
359 There were no lateral nasal horns, but a small median nasal horn, as unambiguously shown by  
360 the presence of axial vascularised rugosities in the anterior quarter of the nasal bones. In  
361 contrast, the frontal bones have a smooth aspect, thus indicating the absence of a frontal horn.  
362 The orbits were not projected laterally. The zygomatic arches are 1.51 times wider than the  
363 frontals. From this frontal ambitus, run posteriorly two straight and smooth frontal crests,  
364 getting closer by the parietals (minimum distance = **30 mm**; **Table 1**), and then abruptly  
365 diverging and forming an occipital crest **that is** concave posteriorly. The transition from the  
366 maxilla to the processus zygomaticus maxillary is progressive, with no brutal inflection. The

367 articular tubercle of the squamosal is smooth (in lateral view) and straight (in sagittal view).  
368 The right processus postglenoidalis forms a rounded right dihedron in ventral view. The  
369 foramen postglenoideum is remote from the latter. The left one is not preserved. The occipital  
370 side is wide and, accordingly, the processus posttympanicus and the processus paraoccipitalis  
371 are distant. The former is poorly developed, while the latter is very long, slender, and vertical.  
372 The foramen magnum is not preserved well enough to allow any observation. The occipital  
373 condyle has a median ridge but no medial truncation.

#### 374 **Mandible**

375 In lateral view, the symphysis is upraised, with an angular ventral profile determined by  
376 two successive inflections. The foramen mentale is widely open and located below p2 (left)  
377 and p3 (right). The corpus mandibulae is low, with a straight ventral border (Table 2). It is  
378 getting gradually higher to the mandibular angle, smooth, rounded and hugely developed.  
379 There is a shallow vascular incisure. The ramus is low, with a posterior border that is oblique  
380 up- and forward and a vertical anterior border. The processus coronoideus is high, tapering  
381 dorsally, and somewhat concave posteriorly. The condyloid process is high and sharp-edged,  
382 separate from the latter by a deep mandibular notch. In dorsal view, the symphysis is massive,  
383 well developed anteroposteriorly and narrow, with i2s and lateral edges parallel and two  
384 circular alveoli for small i1s. The posterior border of the symphysis is located between the  
385 trigonids of p3. The tooth rows are more parallel than the bodies (Fig. 4), which widely  
386 diverge posteriorly. The spatium retromolare is wide on both sides. The mylohyoid sulci are  
387 present but very shallow. The foramen mandibulare opens below the teeth-neck line.

#### 388 Dental material

389 The dental formula is 1-0-4-3/2-0-3-3. No decidual dentition is known.

390 **Upper dentition** (Fig. 4, Table 3). The first upper incisors are not preserved, but  
391 straight and sagittally-elongated alveoli point to an oval cross section for them (as usual in



392 teleoceratines). There are no I2, I3, or C. The premolar series is short with respect to the  
393 molar series ( $LP3-4/LM1-3 \times 100 = 48.7$ ;  $Lp3-4/Lm1-3 \times 100 = 45.8$ ), which is further highlighted  
394 by the small size of P2 and p2. The enamel is thick, wrinkled and corrugated, and partly  
395 covered with a thin layer of cement. Teeth are low crowned, with roots partly joined. The  
396 labial cingulum is absent on the upper cheek teeth. A thick paracone fold is present on P2-M3,  
397 vanishing with wear on P2-M1 and marked until the neck on M2-3. There is no metacone fold  
398 or mesostyle on the upper cheek teeth. Short and wide crochet is present on P3-4 (always  
399 simple), but absent on P2. There is no metaloph constriction on P2-4. The lingual cingulum is  
400 absent on all upper cheek teeth, except for a small tubercle on the anterolingual base of the  
401 hypocone on both P4. The postfossette forms a small and deep isometric pit. The antecrochet  
402 is getting stronger backward, from absent on P2 and short on P3-4 to very elongate on M1-3.  
403 The first upper cheek tooth is most likely a persistent D1: it is much more worn than other  
404 teeth and the enamel is also much thinner. It is preserved on the right side and its presence is  
405 further attested by two alveoli on the left side (heart-shaped anterior root; peanut-shaped  
406 posterior root). It has a sharp anterolingual cingulum, a straight lingual edge, and rounded  
407 posterior and labial edges. P2-4 are fully molariform (bilophodont, with an open lingual  
408 valley). On P2, the metaloph is transverse labially, but curved posterolingually due to the  
409 position of the hypocone. The latter is much more developed than the protocone. The  
410 protoloph is thin but continuous and transversely oriented. There is no medifossette on P3-4,  
411 but a short crista on P4 and on P3 (mostly wiped out by wear on P3). The protocone is  
412 constricted anteriorly on P3-4. The metaloph forms a dihedron on P3-P4, with the crochet as a  
413 tip and the hypocone located posterior to the metacone. The protoloph is complete and  
414 continuous and there is no pseudometaloph on P3. The metacone is not constricted or isolated  
415 on P3-4. The crochet is long and sagittal on M1-M3, with a rounded tip on M1, and a sharp  
416 tip on M2-3. There is no crista, medifossette, or cristella on upper molars. The lingual

417 cingulum is restricted to a small pair of tubercles on M2s and a smooth ridge on the hypocone  
418 of M3. The protocone is strongly constricted on M1-3, and trefoil shaped on M3. The  
419 parastyle is short and sagittal on M1-3; the paracone fold is very salient on M2 and especially  
420 on M3. The metastyle is very long on M1-2. The metaloph is almost as long as the protoloph  
421 on M1-2. In lingual view, the protocone is increasingly developed sagittally from M1 to M3.  
422 A deep groove carves the anterolingual side of the hypocone on M2, and a shallower one is  
423 observed on M1. The ectoloph is straight on M1 and concave on M2. The antecrochet and the  
424 hypocone are close but separate on M1-2. There is no lingual groove on the lingual side of  
425 M2. The posterior cingulum is complete on M1-2 and the postfossette is still narrower and  
426 deeper than on premolars. The right M3 has a triangular outline in occlusal view, with a  
427 straight ectometaloph (the left M3 is not preserved). The protoloph is transversely developed.  
428 There is no posterior groove on the ectometaloph and the labial cingulum is restricted to a low  
429 and smooth spur covering the lingual third of the former.

430 **Lower dentition** (Fig. 4, Table 3). There are small circular alveoli for both i1s, between  
431 the i2s, in the symphyseal part of the dentary but the shape of the concerned teeth is unknown.  
432 The presence of a short p2 is attested by three closely-appressed alveoli on the right side (area  
433 unpreserved on the left side), but no d1 or p1 was present, as attested by the sharp ridge  
434 running anterior to p2's alveoli. There are no vertical rugosities on the ectolophid of p3. On  
435 the lower cheek teeth, ectolophid grooves are developed (U-shaped) and vanishing before the  
436 neck, trigonids are rounded and forming a right angle in occlusal view, metaconids and  
437 entoconids are unconstricted. The bottom of the lingual valleys is V-shaped in lingual view on  
438 lower premolars. On lower premolars, the lingual cingulum is restricted to a low ridge  
439 continuing the anterior cingulum on the trigonid of p3s, and the labial cingulum consists of a  
440 small edge obtruding the ectolophid groove on p4s. Lower molars lack a lingual cingulum but  
441 a small cingular ridge partly obtrudes the ectolophid groove. The hypolophid is oblique in

442 occlusal view on m1-3. There is no lingual groove on the entoconid of m2-3. The posterior  
443 cingulum of m3 forms a low, horizontal, and transversely-elongated ridge.

#### 444 **Poscranial skeleton** (Tables 4, 5)

445 **Atlas.** The atlas is wide and short sagittally. In dorsal view, the transverse processes  
446 (partly broken) and the alar notches are developed and the axis-facets are concave. In anterior  
447 view, the rachidian canal has a bulb-like outline. The occipital condylar facets are kidney-like.  
448 The foramen vertebrale cuts across the anterior third of the dorsal surface on both sides and it  
449 is continued by a shallow groove laterally (for the vertebral artery). In posterior view, the  
450 foramen transversarium is present, wide and partly hidden by the lateral expansion of each  
451 axis-facet (Fig. 5, A).

452 **Axis.** The axis is stocky, with thick and cylindrical dens and tear-shaped atlas-facets  
453 (convex transversely) on the prezygapophyses. The spinous process is thick and carinated.  
454 The foramen vertebrale is large and subtriangular. The postzygapophyses have wide and  
455 circular facets for the first thoracic vertebra, forming a  $\sim 45^\circ$  angle with the horizontal line.  
456 The centrum is very long anteroposteriorly, with a pentagonal outline in posterior view (Fig.  
457 5, B). Most thoracic vertebrae are preserved. They are massive, with heart-shaped centroms,  
458 and stocky transverse processes. The dorsal spines are slender and oblique ( $45^\circ$  with the  
459 vertical line), with a length reaching up to 250% of the centrum height for the T4-6.

460 The appendicular skeleton strongly recalls that of recent Sumatran rhinoceroses  
461 (*Dicerorhinus sumatrensis*), in terms of size and robustness. The stylopodium is strikingly  
462 slender (both the femora and humeri) and there is no noticeable shortening of the autopodium.  
463 Nevertheless, the carpus is very low and massive with respect to both more proximal and  
464 more distal elements of the arm.

465 **Scapula.** The scapulae are partly preserved. They are elongated dorsoventrally, notably  
466 due to their anteroposterior narrowness ( $H/APD = \sim 0.50$ ). The scapular spine is straight,

467 much developed and with an extremely salient tuberculum bent caudally. There is no pseudo-  
468 acromion. The tuberculum supraglenoidale is well distinct from the cavitas glenoidalis. The  
469 medial border of the cavitas glenoidalis is straight, determining a semi-circular outline in  
470 ventral view.

471 **Humerus.** Both humeri are almost complete (Fig. 6, A-E). The humerus is a slender  
472 bone, with a straight diaphysis. The trochiter is high, with a smooth and rounded outline. The  
473 caput humeri is wide and rounded, with a rotation axis forming a 40° angle with the vertical  
474 line. The deltoid crest is elongated, almost reaching the mid-bone. The deltoid tuberosity is  
475 not much salient. The fossa radii is wide and shallow. The fossa olecrani is higher than wide.  
476 The distal articulation is egg-cup shaped (*sensu* Antoine, 2002, 2003), without marked median  
477 constriction. The trochlea is half-conical and the capitulum humeri is half-cylindrical. There is  
478 no synovial fossa (“trochlear scar”) on the anterodorsal edge of the trochlea. The lateral  
479 epicondyle is elongated dorsoventrally and its ventral border ends dorsal to the capitulum  
480 humeri, lacking a distal gutter.

481 **Radius.** The two bones are complete and undistorted (Fig. 06, F-J). The anterior border  
482 of the proximal articulation is straight in dorsal view but convex in anterior view. The radius  
483 is slender, with a distal extremity larger than the proximal one in anterior view. The diaphysis  
484 is quite slender, especially in its proximal half. It has a straight medial border in anterior view,  
485 but it is posterolaterally concave, which determines a wide spatium interosseum brachii when  
486 the ulna is in anatomical connection. The proximal ulnar facets are fused on both sides. The  
487 insertion of the m. biceps brachii is wide but shallow, with two small pits. Ulna and radius are  
488 independent, apart from the proximal and distal articular areas. On the anterodistal part of the  
489 diaphysis, the gutter for the m. extensor carpi is not marked at all. There is only one distal  
490 facet for the ulna on the lateral side of the bone. The posterior expansion of the scaphoid-facet

491 is high, **forming** a right-angled rectangle. There is a wide pyramidal-facet on the distal  
492 articulation.

493 **Ulna.** The bone is sturdy, with a long and heavy olecranon, the tip of which is wide and  
494 diamond shaped (Fig. 6, K-O). The diaphysis is straight, triangular in cross- section and as  
495 robust as the radius shaft. It forms a **~135°** angle with the olecranon in lateral view. The  
496 humeral facet is saddle-shaped. The proximal radio-ulna facets form a continuous pad, with a  
497 wide medial strip and a high triangular lateral **facet**. A smooth but salient anterior tubercle **is**  
498 **located above** the distal end of the bone. There is neither a second distal radius-facet on the  
499 medial side of the diaphysis nor semilunate-facet on the distal side. The almond-shaped distal  
500 radius-facet is separate proximally from a salient horizontal ridge by a deep and rugose  
501 depression. The pyramidal-facet is concavo-convex, with a quarter-circle outline in distal  
502 view.

503 **CARPUS.** The carpus is very low and massive, especially with respect to slender  
504 stylopodial and zeugopodial elements (**Fig. 7**). All carpals have salient tubercles on the  
505 anterior aspect of the bones. The right hand is more complete than the left one.

506 **Scaphoid.** The scaphoid is low and massive, with equal anterior and posterior heights  
507 (**Fig. 7, A-C**). The proximal radial facet is diamond shaped in proximal view. The  
508 posteroproximal semilunate facet is strongly distinct. It is oval, wide, and separated from all  
509 other facets. A deep depression hollows the lateral side between the semilunate-facets. The  
510 anterodistal semilunate-facet is nearly flat and crescent shaped. The magnum-facet is concave  
511 in lateral view. The trapezium-facet is smaller than other distal facets, but it forms a wide  
512 triangle, separated from the trapezoid-facet by a smooth ridge.

513 **Semilunate.** The bone is compact. In proximal view, the anterior facet only **contacts** the  
514 radius, whereas the wide posteromedial facet is for the scaphoid (**Fig. 7, F-I**). The anterior  
515 side is smooth (not keeled or carinated), with a sharp distal tip. On the lateral side, both

516 pyramidal-facets are closely appressed. The proximal one is almond shaped and the distal one  
517 is comma like. The posterior tuberosity is short. Most of the distal side is articulated, medially  
518 with the magnum and laterally with the unciform.

519 **Pyramidal.** The bone is almost cubic. The proximal side is square shaped, with a  
520 saddle-shaped ulna-facet (Fig. 7, J-M). The semilunate-facets are sagittally elongated, with a  
521 half-oval outline for the proximal one and a crescent-like shape for the distal one. The  
522 pisiform-facet is comma shaped, with a concave sagittal profile and it overhangs a strong  
523 lateral tuberosity. The distal facet, for the unciform, forms a right isosceles triangle with  
524 rounded angles. There is no magnum-facet.

525 **Pisiform.** The right pisiform is short, high, and spatulate, with large and triangular  
526 radius- and pyramidal-facets (Fig. 7, N-P). Both facets are separated by a sharp ridge and  
527 form a right angle. There is no strong constriction separating the thick body and the  
528 articulated part. The medial edge of the body is straight and vertical.

529 **Trapezium.** The right trapezium is preserved. It is a small proximo-distally flattened  
530 bone with a circular outline in proximal view. The proximal side is almost entirely occupied  
531 by a wide pentagonal scaphoid-facet (compatible with the large-sized trapezium-facet on the  
532 scaphoids). The latero-distal side bears a trapezoid-facet with a right-triangled shape,  
533 overhanging a deep pit. All other sides have a rugose aspect and they are devoid of articular  
534 facets.

535 **Trapezoid.** Only the right trapezoid is documented (Fig. 7, D-E). It is wider than high,  
536 almost cubic. Only the anterior and posterior sides (oval and pentagonal in shape,  
537 respectively) are free of articular surfaces. The proximal side, saddle shaped and tapering  
538 posteriorly, responds to the scaphoid. In medial view, the trapezium-facet is restricted to the  
539 posterior half, with a deep insertion pit located close to the anterior edge. The lateral facet is

540 al low rectangle for the magnum. The distal side **is** weakly concavo-convex, **and it** consists of  
541 a pentagonal McII-facet.

542 **Magnum.** The magnum has a very low anterior aspect, with a subrectangular outline  
543 and a salient horizontally-elongated median pad (**Fig. 7, Q-T**). The proximal border is straight  
544 in anterior view. In medial view, the anteromedial facets are in contact **throughout** their **whole**  
545 length (no anterior groove). In lateral view, the dorsal pulley for the semilunate forms a low-  
546 diameter half circle, further determining a question mark proximal profile. The distal facet is  
547 wide and tapering posteriorly. The posterior tuberosity is broken on the left magnum, and it is  
548 very short on the right specimen.

549 **Unciform.** The bone is compact, with a posterior tuberosity wide and much developed  
550 sagittally (**Fig. 7, Y-W**). The anterior side is wide and low, with a pentagonal outline and a  
551 maximum height on its lateral tip. The proximal side has two anterior facets flat transversally  
552 and convex sagittally, separated by a sharp sagittal edge. The medial one, triangular, is for the  
553 semilunate while the lateral one, diamond shaped, is for the pyramidal. The latter has a wide  
554 posterolateral expansion joining the lateral edge and the McV-facet (located on the distal side)  
555 on the right unciform. This part is broken on the left one. From the medial tip, the distal and  
556 distolateral sides have three contiguous facets, responding to the McIII (small and  
557 quadrangular), McIV (bulb-shaped), and McV (oval and deeply concave sagittally),  
558 respectively. They are only separated by smooth sagittal grooves. The McV-facet is oblique,  
559 which could suggest the presence of a functional McV (see Antoine, 2002, 2003; Boada-Saña  
560 et al., 2008).

561 **METACARPUS.** The hand and pes have a mesaxonian Bauplan. Although no McV is  
562 preserved, the hand was probably tetradactyl, as hypothesised by the vertical facet on the  
563 McIV (see above). The metapodials have salient insertions for the m. extensor carpalis. Their  
564 shafts are robust (wide transversally and flattened sagittally), with neither distal widening nor

565 clear shortening (no brachypody; see Antoine, 2002). The insertions for the m. interossei are  
566 long, reaching the mid-shaft on all available metapodials. The intermediate reliefs do not  
567 reach the anterior aspect of the distal articulation on metapodials. The intermediate relief is  
568 moderately high and quite sharp on the McIII, but low and smooth on medial and lateral  
569 metapodials.

570 **McII.** In proximal view, the proximal side consists of a large tear-shaped trapezoid-  
571 facet medial to a narrow sagittally-elongated and strip-like magnum-facet. In medial view, the  
572 trapezium-facet is large and comma shaped, higher in its posterior tip. In lateral view, the  
573 magnum-facet is a straight and low strip, separated from the McIII-facets over their length.  
574 The McIII-facets are fused into a curved strip with a shallow disto-medial constriction. The  
575 distal articulation, for the phalanx 1, has a sub-square outline in distal view, with rounded  
576 anterior angles. Above it, is a wide and salient medial tuberosity (Fig. 8, A-E).

577 **McIII.** The bone has a straight shaft. The proximal side is dominated by a wide and  
578 pentagonal magnum-facet, contiguous to two narrow sagittal strip-shaped facets (medially for  
579 the McII and laterally for the McIV). In anterior view, the proximal side consists of a  
580 subvertical medial edge (McII-facet), a very wide magnum-facet, weakly-concave medially,  
581 and a much narrower, oblique and straight McIV-facet. The magnum-facet is almost invisible  
582 in anterior view. Indeed, its dorsal outline is not much convex in medial view. The McII-  
583 facets are broadly connected, forming a thick strip with a shallow constriction in its disto-  
584 median part. In lateral view, the anterior McIV-facet is low, elongated sagittally, and tear-  
585 shaped. It is disconnected from the oval posterior McIV-facet by a narrow but deep oblique  
586 groove. This articulated surface overhangs a deep circular depression. There is no postero-  
587 distal tubercle on the diaphysis. In distal view, the distal articulation is wide and  
588 subrectangular, with straight medial and lateral edges, rounded antero-medial and -lateral  
589 angles, and a m-like posterior edge, due to a low but sharp intermediate relief (Fig. 8, F-J).



590 **McIV.** The McIV is the shortest and most robust metapodial preserved. The shaft is  
591 concave laterally in anterior view. The proximal aspect is trapezoid, deeper than wide, with a  
592 narrow medial strip (the sagittally-elongated ‘anterior’ McIII-facet) and a wide unciform-  
593 facet. In proximal view, there is no postero-lateral pad, but a small anterolateral tubercle in  
594 front of the McV-facet. In medial view, the proximal McIII-facets are connected (right  
595 specimen) and **form a** right dihedron (L-shape), with a high posterior facet. The McV-facet is  
596 vertical, suggesting a functional McV, in good agreement with the orientation of the McV-  
597 facet on the unciform. In distal view, the distal articulation forms a quarter circle, with a  
598 posteromedial right angle. There is almost no intermediate relief on the McIV (Fig. 8, K-O).

599 **Phalanges.** Only three phalanges are preserved for the manus (left/right first phalanges  
600 and left second phalanx for the McII). They have strong interphalangeal insertions and  
601 tubercles. The phalanx 1 is low and massive, with a kidney-like proximal side (McII-facet,  
602 lacking a groove responding to the intermediate relief). The distal facet is oval and  
603 transversely transversally elongated. The phalanx 2 is still lower, with a proximal facet  
604 perfectly matching in shape the distal facet on the phalanx 1. The distal facet is slightly  
605 concave transversally and convex sagittally. Both facets have similar width and depth.

606 **Coxal.** The pubic bones and ischia are lacking on both sides but the ilia are well  
607 preserved. Dorsally, the iliac crest is regularly convex. The wing of the ilium is spatulated.  
608 The sacral tuberosity has a rounded triangular shape, with a rugose aspect. The coxal  
609 tuberosity, partly broken, was probably thick and high, also with a rugose aspect. The caudal  
610 gluteal line is smooth, with a concave outline (forming a semi-circular curve). The  
611 acetabulum has a subcircular outline.

612 **Femur.** The bone is quite slender, with a shaft straight in anterior view, concave  
613 anteriorly in lateral view, and compressed sagittally (Fig. 9, A-F). The anterior part of the  
614 trochanter major is high, but the caudal part is very low, i.e., much lower than the wide and

615 hemispheric head. The fovea capitis is deep, low, and wide, with a triangular outline. The  
616 trochanter **minor** is elongated dorsoventrally. Its distal end reaches the mid-height of the third  
617 trochanter. The latter is developed, wider distally and with smooth lateral borders. The  
618 anteroproximal border of the patellar condyle is curved, with a medial lip much more  
619 developed and salient than its lateral counterpart. In lateral view, the medial lip of the trochlea  
620 and the diaphysis determine a broken angle ( $130^\circ$ ). In distal view, the anterior border of the  
621 patellar trochlea is convex medially and straight and transverse laterally. The tibial condyles  
622 are separate from the patellar trochlea by a narrow groove. The intercondylar fossa is deep  
623 and narrow. The medial condyle, with a diamond-shaped outline, is much more developed  
624 than the lateral one. The medial epicondyle is also more salient than the lateral epicondyle.

625 **Patella.** The patella is massive, wider than high, and with a triangular and rugose  
626 anterior aspect. The medial border is straight and vertical. The posterior side, almost fully  
627 articulated, **contacts** the femoral cochlea, with a wide medial lip, triangular (wider distally),  
628 and a narrower trapezoid lateral lip. In vertical view, the latter lip is almost straight while the  
629 former is more concave. The most striking feature is the weak anteroposterior development of  
630 the bone **with respect to other dimensions**.

631 **Tibia.** The tibia is high and relatively slender, with heavy extremities (Fig. 9, K-O). The  
632 medial border of the diaphysis is strikingly straight in anterior view, which widely contrasts  
633 with the concave lateral border of the shaft. This impression is highlighted by the median half  
634 of the proximal articulation being much higher than the lateral one. **The patellar ridge is thick**  
635 **and bulbous, with a rough surface. The patellar groove is deep, short dorso-ventrally, and**  
636 **regularly concave.** The proximal peroneal articulation is located low on the tibia (no contact  
637 with the lateral femoral condyle). There is neither an anterodistal groove nor medio-distal  
638 gutter (for the tendon m. tibialis posterior). Tibiae and fibulae are independent, apart from  
639 articulated areas, thus determining a wide **spatium interosseum cruris**. The distal fibula-facet

640 is low, elongated, and crescent shaped, overhung by a rugose triangular area. The posterior  
641 apophysis is low and rounded. In distal view, the outline is a trapezoid, wider than deep. The  
642 astragalar cochlea has two lips, the medial one being narrower and deeper and the lateral one  
643 wider and shallower.

644 **Fibula.** The diaphysis is straight and particularly slender, in sharp contrast with two  
645 thick ends (and the robustness of the tibia) (Fig. 9, G-J). The proximal end is nevertheless  
646 flattened sagittally, with a smooth proximal tibia-facet. The distal end is robust, with a deep  
647 laterodistal gutter for the tendon m. peroneus, located posteriorly, immediately posterior to a  
648 huge tubercle. The distal fibula-facet is low, elongated sagittally, and crescent shaped. It is  
649 contiguous to a flat and rectangular astragalus-facet, oriented at  $\sim 25^\circ$  with respect to the  
650 vertical line.

651 **PES.** The pes is not completely known (Fig. 10). The naviculars, cuneiforms, MtIII, and  
652 most phalanges are not preserved. The metatarsals are shorter than the metacarpals.

653 **Astragalus.** The astragalus is thick ( $APD/H = 0.76$ ), wide and low ( $TD/H = 1.29$ ). The  
654 fibula-facet is subvertical, wide and flat dorsoventrally (Fig. 10, A-C). The medial trochlear  
655 ridge is rounded, whereas the lateral one is sharper. The collum tali is very high (up to  $\frac{1}{4}$  of  
656 the height), especially with respect to the general proportion of the bone. The caudal border of  
657 the trochlea is sinuous in dorsal view (with a falciform shape). There is no anterodistal  
658 trochlear notch, but a wide foramen for an insertion located distally to the concerned area, in  
659 the mid-collum tali. In anterior view, the distal border is deeply concave medially (navicular-  
660 facet) and straight and oblique laterally (cuboid-facet). The medial tubercle is low and  
661 rounded, but much projected medially. The distal articulation is not twisted with respect to the  
662 axis of the trochlea ( $<15^\circ$ ), in distal view. The calcaneus-facet 1 has a wide and very low,  
663 triangular laterodistal expansion. This facet is nearly flat in lateral view. The calcaneus-facets  
664 2 (low oval) and 3 (tear shaped and low) are distinct and separate by a wide groove. In distal

665 view, the distal articulation is much wider than deep, with a cuboid-facet particularly wide  
666 transversely. The posterior stop on that cuboid-facet is abrupt and prolonged medially by a  
667 similar transversely-elongated inflection on the navicular-facet.

668 **Calcaneus.** The calcaneus is robust, with a tuber calcanei massive and oval in  
669 posteroproximal view (Fig. 10, D-F). This tuber calcanei is strongly vascularised and rugged  
670 with salient muscle/tendon insertion areas, The tibia-facet is low, wide, and almond shaped,  
671 while the fibula-facet is round and oblique with respect to the vertical and sagittal lines. The  
672 astragalus-facet 1 is lozenge shaped in anterior view and almost flat. The facet 2 is oval, wider  
673 than high and flat. It is separate from the smaller and semi-oval facet 3. The sustentaculum  
674 tali is low and very wide. In lateral view, the cuboid-facet and the posterior border of the tuber  
675 form a right angle and the processus, at the level of the sustentaculum tali, is deeper (in terms  
676 of APD) than the tuber calcanei. The insertion for the m. fibularis longus forms a salient and  
677 rugose pad, but without sharp ridges. On the distal side, the cuboid-facet forms a transversely-  
678 elongated hexagon. It is mostly flat but concave in its mediodistal quarter.

679 **Cuboid.** The cuboid is compact, wide, and low (Fig. 10, G-I). In proximal view, the  
680 large articular surface is oval, slightly tapering posteriorly, and split into two equally-  
681 developed and sagittally-elongated facets. The astragalus-facet (medial) is separated from the  
682 calcaneus-facet (lateral) by a narrow and shallow groove. The anterior side is low and  
683 pentagonal in anterior view, with a sharp proximal tip. In medial view, there are four facets.  
684 The anteroproximal one is very low and crescent like (navicular-facet). Distally to it is a much  
685 larger semi-circular ectocuneiform-facet. The posteroproximal navicular-facet, broadly  
686 joining the proximal facet for the astragalus, has an 8-shaped outline. Contiguous to it, but  
687 distally, is a semi-circular posterodistal ectocuneiform-facet. The posterior tuberosity is short  
688 sagittally and narrow, but quite elevated: its acuminate distal tip is positioned much more  
689 distally than the distal articulation (MtIV-facet). The latter facet is flat and trapezoid, with

690 larger anterior, medial, and posterior sides and a shorter lateral border. There is no MtIII-  
691 facet.

692 **MtII.** The bone is short and robust (Fig. 11, A-E). The proximal side, with a triangular  
693 outline (widening posteriorly), responds to the entocuneiform (posteromedial facet,  
694 pentagonal, and oblique), the mesocuneiform (proximal-most facet, wide and trapezoid), and  
695 to the ectocuneiform (wide strip-like facet oblique and tapering anteriorly). In lateral view, the  
696 MtIII-facets are vertical, with a large triangular anterior facet and a much lower, oval  
697 posterior facet. Both are widely connected. The shaft is straight and subcircular in cross  
698 section. The distal end is stocky and square in distal view. The distal articulation has almost  
699 no intermediate relief, even in its posterior aspect.

700 **MtIV.** The bone is short and massive, with a heavy proximal end (Fig. 11, F-J). The  
701 proximal side is entirely occupied by a flat and sub-square cuboid-facet. There are two  
702 distinct proximal tubercles at the anterolateral and posterolateral angles, but no continuous  
703 pad. In medial view, there are two equally-wide MtIII-facets. The anterior one is located more  
704 dorsally, elevated and with a half-oval outline, connecting the proximal side. The posterior  
705 one is oval, isolated, and anteroventrally-posterodorsally elongated. The shaft is slightly  
706 concave laterally but straight in lateral view, with a strong laterodistal tubercle. The distal side  
707 is entirely articulated, deeper than wide (APD>TD), and lacking an intermediate relief. Only  
708 the lateral lip is slightly concave transversely in its posterior aspect.

709 **Phalanges.** Only the first phalanges for the MtII and MtIV are known. They have strong  
710 interphalangeal insertions and tubercles. There is no groove responding to the intermediate  
711 relief. The MtII phalanx 1 is almost cubic, with a circular and slightly biconcave proximal  
712 side (MtII-facet). The distal facet (phalanx 2) is kidney shaped. The MtIV phalanx 1 is as  
713 wide as but lower than the former phalanx. The proximal facet is kidney shaped and almost

714 flat. The distal facet is oval and elongated transversely. In both phalanges, the distal facet is  
715 smaller than the proximal facet, but also slightly convex sagittally and concave transversely.

## 716 COMPARISON

717 In its general shape, proportions and morphoanatomical features, the skull from Tagay closely  
718 matches that of *Diaceratherium shanwangense* (Wang, 1965) as recently described by Lu et  
719 al. (2021). It also resembles that of late Oligocene–early Miocene teleoceratines from Western  
720 Europe classically assigned to *Diaceratherium*, except for the type species (*D. tomerdingense*,  
721 for which only an isolated nasal bone is preserved). Within *Diaceratherium*, the arched dorsal  
722 profile, the short and slender premaxillae, the zygomatic arch (straight, oblique, with a  
723 marked posterodorsal angle, and an anterior tip starting progressively), and the processus  
724 paraoccipitalis long and narrow show make it have the closest affinities with *D.*  
725 *shanwangense*, *D. aginense* (earliest Miocene; Répelin, 1917), and *D. asphaltense* (Becker et  
726 al., 2018). The only differences with the former do concern the tip of the nasal bones, pointing  
727 upward, having a small median bump (suggesting the presence of a terminal nasal horn) and a  
728 distolateral apophysis, and the stockier zygomatic arch as observed in the Tagay specimen.  
729 More specifically, the Tagay skull differs from that of *D. aginense* in having a processus  
730 postorbitalis on the frontal bone and a median ridge on the occipital condyle, but no posterior  
731 groove on the processus zygomaticus of the squamosal (Répelin, 1917). It is distinct from *D.*  
732 *lemanense* in possessing a low zygomatic arch, with a processus postorbitalis, a small  
733 processus posttympanicus and a well-developed processus paraoccipitalis (Lavocat, 1951),  
734 and from *D. asphaltense* in having closer fronto-parietal crests and a brachycephalic shape  
735 (Becker et al., 2018; Jame et al., 2019). In contrast, the shape of the processus zygomaticus,  
736 but also the presence of a small median nasal horn and of a concave occipital crest make is  
737 somewhat resemble *D. asphaltense*.

738 As for mandibular features, the Tagay jaw is also particularly resembling that of *D. aginense*  
739 among representatives of *Diaceratherium*, with an upraised symphysis (distinct from that of  
740 *D. lamilloquense* and of *D. aurelianense*), low corpus, vertical ramus and a deep and laterally-  
741 salient mandibular angle.

742 With respect to all other representatives of *Diaceratherium*, the most distinctive dental  
743 features of the Tagay rhinocerotid are a short premolar series (also observed in *D.*  
744 *shanwangense*), an enamel wrinkled and corrugated at the same time, crochets simple and  
745 lingual cingula usually absent and always reduced on P2-4, a protocone strongly constricted  
746 on M1, a lingual cingulum usually absent on lower premolars and always absent on lower  
747 molars, and the absence of d1/p1 at an adult stage (also observed in *D. shanwangense*). It can  
748 be further distinguished from *D. lamilloquense*, *D. lemanense*, *D. asphaltense*, and/or *D.*  
749 *aurelianense* by its IIs oval in occlusal view, the absence of labial cingulum on upper  
750 premolars and molars, the presence of a strong paracone fold on M1-2 and of a constricted  
751 hypocone on M1, and M3s with a triangular occlusal outline. Contrary to *D. lamilloquense*,  
752 the rhino from Tagay has a protoloph joined to the ectoloph on P2, but also a protocone and a  
753 hypocone lingually separate on P3-4 (molariform). With respect to *D. aurelianense*, it has no  
754 metaloph constriction on P2-4 and a protocone weakly developed on P2. In other words,  
755 dental remains from Tagay are strictly similar to those of *D. shanwangense* (Lu et al., 2021).  
756 They further have very close affinities with those of *D. aginense* and *D. intermedium* among  
757 *Diaceratherium* representatives. Nevertheless, the Tagay rhinocerotid differs from *D.*  
758 *aginense* in bearing a protocone and a hypocone lingually separate on P2 (molariform) and  
759 from both species in having a long metaloph on M1-2 and a posterior groove on M3.

760 Even though postcranial elements are not known in all *Diaceratherium* species, the cervical  
761 vertebrae and/or limb bones from Tagay are perfectly matching those of *D. shanwangense*  
762 (Lu et al., 2021). They are also very similar to those of *D. aginense* and of *D. intermedium*,

763 notably in terms of size and proportions. They differ, however, from all representatives of the  
764 genus (including the latter species), in having a scapular glenoid fossa with a straight medial  
765 border and a tibia-facet on the calcaneus, but no distal gutter on the humeral lateral  
766 epicondyle. It can be further distinguished from *D. lamilloquense*, *D. lemanense*, *D.*  
767 *asphaltense*, and/or *D. aurelianense* by a radius with a high posterior expansion of the  
768 scaphoid-facet, a femoral head hemispheric, an astragalus with a laterodistal expansion, the  
769 presence of very low-and-smooth intermediate reliefs on metapodials but also a long insertion  
770 of m. interossei on lateral metapodials. The Tagay rhinocerotid differs from *D. aginense* in  
771 bearing a shallow gutter for the m. extensor carpi on the radius, a posterior MtII-facet  
772 developed on the Mt3, but no contact between the cuboid and the MtIII, from *D. intermedium*  
773 in showing a right angle between the cuboid-facet and the base of the tuber calcanei on the  
774 calcaneus, and from both species in having a scaphoid with equal anterior and posterior  
775 heights, a short posterior tuberosity on the magnum, a wider astragalus ( $TD/H > 1.2$ ), and a  
776 fibula-facet on the calcaneus.

777 In fact, the Tagay rhinocerotid individual is identical in all aspects to corresponding  
778 specimens of the complete skeleton from the early Miocene of eastern China recently  
779 assigned to as *Diaceratherium shanwangense* by Lu et al. (2021). The only differences lie in  
780 the occipital crest being more concave in the Tagay skull than in the Shanwang one, following  
781 the description by Lu et al. (2021). This feature is likely to document either sexual  
782 dimorphism, ontogenetic variation, or interindividual variability. Accordingly, we consider  
783 unambiguously the Tagay rhinocerotid as documenting *D. shanwangense*.

#### 784 PHYLOGENETIC ANALYSIS

785 We have first run a preliminary analysis (see supplementary materials: files S1 and S2),  
786 with 32 taxa i.e., the Tagay individual and *B. shanwangense* scored as two distinct terminals.



787 In that analysis, these terminals differ in a single and only feature (char. 36: occipital crest  
788 concave in the former). Accordingly, we have merged them into a single terminal, for running  
789 the final analysis (see supplementary materials: files S3 and S4). A single most parsimonious  
790 tree is retrieved (length = 1315 steps; consistency index = 0.2700; retention index = 0.4923;  
791 Fig. 13; see supplementary files S3 and S4). Twenty-four characters are constant, due to their  
792 original definition for solving phylogenetic relationships within Elasmotheriina (Antoine,  
793 2002), a rhinocerotid subtribe the representatives of which are not included here. Character  
794 distribution at each node and corresponding indices are detailed in the supplementary  
795 materials (file S4). Suprageneric relationships within Rhinocerotinae (i.e., the clade including  
796 Rhinocerotini + Aceratheriini) are consistent with those proposed by Antoine (2002, 2003),  
797 Antoine et al. (2010, 2022), Becker et al. (2013), Tissier et al. (2021), and Pandolfi et al.  
798 (2021): *Plesiaceratherium mirallesi* is the earliest offshoot among Rhinocerotinae (node 1; 26  
799 unambiguous synapomorphies; Bremer Support [BS] > 5). Aceratheriini (node 3; nine  
800 unambiguous synapomorphies; BS = 2) and Rhinocerotini (node 5; eight unambiguous  
801 synapomorphies; BS = 2) are sister clades (node 2; 13 unambiguous synapomorphies; BS =  
802 4). Rhinocerotina (node 6; 18 unambiguous synapomorphies; BS > 5) and Teleoceratina  
803 (node 13; five dental and postcranial unambiguous synapomorphies; BS = 1) are sister clades  
804 within Rhinocerotini (Fig. 13). Aceratheriini comprise *Alicornops simorreense* as a sister  
805 species to the (*Aceratherium incisivum*, *Acerorhinus zernowi*) clade (node 4). Rhinocerotina  
806 include the (*Lartetotherium sansaniense*, *Gaindatherium browni*) clade (node 7; seven  
807 unambiguous synapomorphies; BS = 5) as the first offshoot, then *Nesorhinus philippinensis*  
808 (node 8; seven unambiguous synapomorphies; BS = 3), and the living rhino species (node 9;  
809 nine unambiguous synapomorphies; BS = 2), with the *Rhinoceros* clade (node 10; four  
810 unambiguous synapomorphies; BS = 1) being sister group to the (*Dicerorhinus sumatrensis*  
811 plus African rhinos) clade (node 11; 13 unambiguous synapomorphies; BS = 3). The clade of

812 living African rhinos is the most supported node of the tree (node 12; 38 unambiguous  
813 synapomorphies; BS > 5).

814 In the next paragraphs, we will focus on the topology, node support (Bremer Support:  
815 BS), and apomorphy distribution regarding the Teleoceratina. The monophyly of the subtribe  
816 is weakly supported by five dental and postcranial unambiguous synapomorphies (BS = 1): I1  
817 with an almond-shaped cross section, hypocone isolated by an anterior constriction on M2,  
818 ulna with the olecranon and the diaphysis forming a closed angle, robust limbs, and lateral  
819 metapodials with insertions of the m. interossei short. The earliest-diverging teleoceratine is  
820 *Diaceratherium tomerdingense*. This species is defined by ten dental and postcranial  
821 autapomorphies (teeth with enamel wrinkled and roots separate, P2-3 with an antecrochet  
822 usually absent, M1-2 with a metaloph short, M2 with a mesostyle, humerus without a distal  
823 gutter on the lateral epicondyle, semilunate with a distal border of the anterior side rounded,  
824 trapezoid with a proximal border asymmetric in anterior view, unciform with a posterior  
825 expansion of the pyramidal-facet always present, and trapezium-facet always absent on the  
826 McII; Table 6). Next node (node 14) segregates the *Brachypotherium* clade (node 15) from all  
827 other teleoceratines scored here (node 16). Node 14 (BS = 2) is weakly supported by three  
828 postcranial unambiguous synapomorphies (proximal ulna-radius facets usually fused, gutter  
829 for the m. extensor carpi weakly developed on the radius, and McII with anterior and posterior  
830 McIII-facets fused). Eleven cranio-mandibular, dental, and postcranial synapomorphies define  
831 *Brachypotherium* (node 15; BS = 2): occipital condyle without a median ridge, mandibular  
832 symphysis very massive, labial cingulum usually present on upper premolars and always  
833 present on upper molars, lower cheek teeth with a flat ectolophid, lower molars with a lingual  
834 opening of the posterior valley U-shaped, p2 with a paraconid reduced, radius-ulna with a  
835 second distal articulation, pyramidal with a distal semilunate-facet asymmetric, posterior facet  
836 always absent on the McII-McIII, and fibula-facet oblique on the astragalus. The Bremer

837 Support is low, due to an alternative topology with *B. perimense* being sister taxon to the (*B.*  
838 *brachypus*, node 16) clade appearing at 1317 steps. *Brachypotherium brachypus* are  
839 particularly well differentiated, with 27 unambiguous cranio-mandibular, dental, and  
840 postcranial autapomorphies each (see Table 6). From node 16 diverge two clades, with  
841 (*Teleoceras* plus *Prosantorhinus*) on the one hand (node 17), and all species classically  
842 assigned to *Diaceratherium* except the type species (node 20). Node 16 (BS = 2) is supported  
843 by eight cranio-dental and postcranial unambiguous synapomorphies: vomer rounded,  
844 protocone constriction usually absent on P3-4, antecrochet always present on P4, lingual  
845 cingulum always present on lower premolars, pyramidal- and McV-facets always separate on  
846 the unciform, McIV with a trapezoid outline in proximal view, calcaneus-facets 2 and 3  
847 always independent on the astragalus, and fibula-facet always present on the calcaneus. Node  
848 17 (BS = 4) places the highly-divergent *Teleoceras fossiger* (39 cranio-mandibular, dental,  
849 and postcranial unambiguous autapomorphies; Table 6) as sister species to *Prosantorhinus*,  
850 through 14 cranio-mandibular, dental, and postcranial synapomorphies: base of the processus  
851 zygomaticus maxillary low on the maxilla, zygomatic arch high, articular tubercle of the  
852 squamosal concave, lingual groove (sulcus mylohyoideus) absent on the corpus mandibulae,  
853 metaloph transverse and protoloph sometimes interrupted on P2, mesostyle present on M2, d2  
854 with a posterior valley usually open, scapula spatulated and with a medial border straight on  
855 the glenoid fossa, a trochanter major low on the femur, MtII-facet always absent and cuboid-  
856 facet present on the MtIII, and metapodials with high and acute intermediate reliefs.  
857 *Prosantorhinus* (node 18; BS = 4) is monophyletic, with *P. germanicus* (thirteen cranio-dental  
858 unambiguous autapomorphies; Table 6) as the first offshoot (node 18) and *P. laubei* and *P.*  
859 *douvillei* being sister species (node 19). The monophyly of *Prosantorhinus* is supported by  
860 seven cranio-dental unambiguous synapomorphies, some being optimised in *P. laubei* (no  
861 cranial remains available; Heissig & Fejfar, 2007): lateral apophysis present on the nasals,

862 median nasal horn present (probably in males), presence of a sagittal fronto-parietal crest, of a  
863 posterior groove on the processus zygomaticus of the squamosal, of a metacone fold on M1-2,  
864 of an unstricted metaloph on M1, and of an ectolophid fold on d2-3. *Prosantorhinus*  
865 *douvillei* (nine unambiguous dental autapomorphies; Table 6) and *P. laubei* (six unambiguous  
866 dental autapomorphies; Table 6) share six dental and postcranial unambiguous  
867 synapomorphies (node 19; BS = 4): protocone unstricted on P3-4 and M3, metaloph  
868 unstricted on M2, labial cingulum always present on lower molars, lingual groove always  
869 present on d3, and expansion of the calcaneus-facet 1 always high and narrow on the  
870 astragalus.

871 **Node** 20 (BS = 3) gathers eight terminal taxa (Fig. 13). It is supported by ten cranio-  
872 dental and postcranial synapomorphies: nuchal tubercle small, articular tubercle smooth on  
873 the squamosal, cement present on cheek teeth, protocone always constricted on P3-4, labial  
874 cingulum usually absent on lower premolars and always present on lower molars, foramen  
875 vertebrale lateralis present and axis-facets transversally concave on the atlas, postero-distal  
876 apophysis low on the tibia, and latero-distal gutter located posteriorly on the fibula. Two  
877 clades diverge from **node** 20. The first one (node 21, BS = 3) gathers *Brachydiceratherium*  
878 *shanwangense*, *Bd. aginense*, and *Bd. intermedium*, based on eight dental and postcranial  
879 synapomorphies: I1 with an oval occlusal outline, labial cingulum always absent on upper  
880 premolars, crista usually present on P3, scapula elongated, fossa olecrani high on the  
881 humerus, fovea capitis low and wide on the femur, latero-distal gutter deep on the fibula,  
882 limbs slender, and insertions for the m. interossei long on lateral metapodials. Most of them  
883 are optimised in *Bd. intermedium*. *Brachydiceratherium shanwangense* is well diagnosed,  
884 with sixteen cranio-dental and postcranial unambiguous synapomorphies: lateral apophysis  
885 present on the nasals, median nasal horn present on the nasals, premolar series short with  
886 respect to the molar series, roots distinct on the cheek teeth, crochet always simple and lingual

887 cingulum usually absent and always reduced on P2-4, crista always present on P3, protocone  
888 strongly constricted on M1-2, lingual cingulum usually absent on lower premolars and always  
889 absent on lower molars, d1/p1 absent in adults, glenoid fossa with a medial border straight on  
890 the scapula, distal gutter absent on the lateral epicondyle of the humerus, proximal radius-ulna  
891 facets always fused, and trochanter major low on the femur. **Node 22** (BS = 3) is supported by  
892 five dental and postcranial unambiguous synapomorphies: metaloph short on M1-2, posterior  
893 height exceeding the anterior height on the scaphoid, astragalus almost as high as wide (TD/H  
894 ratio between 1 and 1.2), and tibia- and fibula-facets absent on the calcaneus.

895 *Brachydiceratherium intermedium* (five dental and postcranial unambiguous autapomorphies;  
896 Table 6) is less **derived** than *Bd. aginense* (16 dental and postcranial unambiguous  
897 autapomorphies; Table 6), which probably reflects the strong contrast in the completeness of  
898 their hypodigms (e.g., no **indisputable** cranial remains are documented for *Bd. intermedium*).

899 The second clade diverging from the node 20 (i.e., node 23) places *Bd. fatehjangense* as  
900 a sister taxon to (*Bd. aurelianense*, (*Bd. lamilloquense*, (*Bd. lemanense*, *Bd. asphaltense*))).

901 All the corresponding nodes are weakly supported ( $1 \leq \text{BS} \leq 3$ ), with low numbers of  
902 unambiguous synapomorphies (ranging from three to six). **Node 23** is the **least-supported** one  
903 (BS = 1), with five dental and postcranial synapomorphies (metacone fold present on M1-2,  
904 second distal radius-ulna articulation present, posterior expansion of the scaphoid-facet low  
905 on the radius, postero-proximal semilunate-facet usually absent on the scaphoid, and  
906 expansion of the calcaneus-facet 1 usually wide and low on the astragalus).

## 907 DISCUSSION

### 908 **Ontogenetic age and sex**

909 Both the complete dental eruption and the wear stages of upper and lower teeth concur  
910 to consider this individual as an adult, most likely ~7-15 years old (with reference to recent

911 rhinos; e.g., Hillman-Smith et al., 1986; Hullot et al., 2020). In the absence of I1s (usually  
912 highly dimorphic in teleoceratines), and due to the fragmentary state of i2s, it is not possible  
913 to determine its sex.

#### 914 **Taxonomic inferences**

915 Surprisingly, *Diaceratherium tomerdingense* Dietrich, 1931 is retrieved as the first  
916 offshoot among Teleoceratina (Fig. 13). Moreover, the assignment of this hornless and robust-  
917 limbed rhinocerotine to the subtribe is not well supported at all (BS = 1): in other words, this  
918 species could be closely related to Rhinocerotina instead among Rhinocerotini, as suggested  
919 by some of its peculiar features, retrieved as autapomorphies in the current analysis (metaloph  
920 short on M1-2; distal gutter on the lateral epicondyle absent on the humerus, distal border of  
921 the anterior side of the semilunate rounded, and trapezium-facet absent on the McII).  
922 Accordingly, and **taking into account** both the topology of the most parsimonious tree and the  
923 character distribution along its branches, we propose that *Diaceratherium* Dietrich, 1931 shall  
924 be restricted to the type species.

925 Indeed, all other species previously assigned to *Diaceratherium* in the last decades form  
926 a well-supported clade remote from the type species (Fig. 13). This clade is split into two  
927 sister clades encompassing three and five species, respectively (*D. shanwangense*, *D.*  
928 *aginense*, and *D. intermedium*; *D. fatehjangense*, *D. aurelianense*, *D. lamilloquense*, *D.*  
929 *asphaltense*, and *D. lemanense*). Except for *D. lamilloquense* Michel, 1987, these species  
930 were originally or subsequently assigned to pre-existing genera, i) either unambiguously non-  
931 related to Teleoceratina, such as *Aceratherium* (*D. lemanense*), *Diceratherium* (*D.*  
932 *asphaltense*, *D. lemanense*), *Aprotodon* (*D. fatehjangense*), *Chilotherium* or *Subchilotherium*  
933 (*D. intermedium*), and *Plesiaceratherium* (*D. shanwangense*), or ii) among Teleoceratina,  
934 with *Teleoceras* and/or *Brachypotherium* (*D. aginense*, *D. aurelianense*, *D. shanwangense*,  
935 and *D. fatehjangense*). Finally, and to our knowledge, the only species belonging to this clade

936 for which a genus-group name has been unambiguously proposed is *D. lemanense*. Indeed,  
937 Lavocat (1951) has erected the subgenus *Brachydiceratherium* for “*Acerotherium lemanense*  
938 Pomel, 1853”. Interestingly, Lavocat did assign these species and subgenus to *Diceratherium*  
939 Marsh, 1875, a genus consistently assigned to Elasmotheriinae in the last decades (e.g.,  
940 Antoine, 2002). We propose that all these eight species be assigned to *Brachydiceratherium*  
941 Lavocat, 1951, especially as the five-species clade, with *D. fatehjangense*, *D. aurelianense*,  
942 *D. lamilloquense*, *D. asphaltense*, and *D. lemanense*, is not well supported (BS = 1; 5  
943 unambiguous synapomorphies). Noteworthy, *D. asphaltense* and *D. lemanense* are sister  
944 species in the most parsimonious tree and given their low number of morpho-anatomical  
945 discrepancies, they could be considered as well as intraspecific variants within *D. lemanense*  
946 (senior synonym).

947 Other teleoceratine genera are monophyletic in the present analysis. *Brachypotherium*  
948 Roger, 1904 includes *B. brachypus* and *B. perimense* and this genus is a sister group to a  
949 clade gathering *Teleoceras* Hatcher, 1894 plus *Prosantorhinus* Heissig, 1974 on one branch  
950 and *Brachydiceratherium* on the other one (see above).

### 951 **Historical biogeography of Eurasian teleoceratines**

952 During early Miocene times, Teleoceratina were particularly species-rich in Eurasia,  
953 with 5–8 coeval species in any time slices (Fig. 14). A common thread between  
954 *Brachypotherium*, *Brachydiceratherium*, and *Prosantorhinus* is their huge geographical range  
955 at the generic level, encompassing most of the Eurasian landmasses for the latter two genera  
956 (e.g., Heissig, 1999; Antoine et al., 2010, 2013), plus Afro-Arabia for *Brachypotherium* (e.g.,  
957 Hooijer, 1963, Geraads & Miller, 2013; Pandolfi & Rook, 2019). An early representative of  
958 *Brachydiceratherium* has been recognised in Thailand (*Bd. cf. lamilloquense*; Marivaux et al.,  
959 2004). It has the closest affinities with *Bd. lamilloquense*, from the late Oligocene of Western  
960 Europe (Fig. 15). To our knowledge, no occurrence has been reported between both areas for

961 this species. *Prosantorhinus* has a similar geographical range, extending from Western  
962 Europe (*P. germanicus* and *P. douvillei*; Heissig, 1972b; Antoine et al., 2000; Heissig, 2017)  
963 and Central Europe (*P. laubei*; Heissig & Fejfar, 2007) to Southern Pakistan (*P. shahbazi*;  
964 Antoine et al., 2010, 2013). If confirmed, the recognition of *Bd. fatehjangense* in lower  
965 Miocene beds of the Turgai region in Kazakhstan, previously described as a representative of  
966 *Bd. aurelianense* by Borissiak (1927) and Lu et al. (2021), would considerably expand  
967 latitudinally the range of this species, previously restricted to the Indian Subcontinent. It  
968 would then be documented on both sides of the Himalayas (Fig. 15). The ubiquitous  
969 distributions of most teleoceratine taxa likely underline ultra-generalist ecological preferences  
970 (Hullot et al., 2021). Moreover, such ranges seemingly support the absence of efficient  
971 ecological and geographical barriers at the Eurasian scale for the concerned teleoceratines, at  
972 least by early Miocene times (Fig. 15).

973 Moreover, ghost lineages within *Brachypotherium* and *Prosantorhinus* (Fig. 14) are  
974 likely to be bridged by *B. gajense* and *P. shahbazi*, from the latest Oligocene–earliest  
975 Miocene and the early Miocene of Pakistan, respectively (for further discussion, see Antoine  
976 et al., 2013 and Antoine, in press).

977 *Brachydiceratherium shanwangense* was previously only documented at Shanwang,  
978 eastern China (N32°, E116.5°). The well-supported specific assignment of the Tagay  
979 rhinoceros (N53°, E107.5°) points to an unsuspectedly wide geographical range for this  
980 species, further pleading for both a low climatic and environmental gradient in the concerned  
981 area at that time and very broad ecological preferences for this species (Fig. 15). Moreover, it  
982 can be suspected that the smallest teleoceratine remains described over the early Miocene  
983 interval in Japan (Kani and Mizunami formations) and referred to the *Brachypotherium*  
984 *pugnator* (Matsumoto, 1921), otherwise of gigantic dimensions (Fukuchi & Kawai, 2011;  
985 Tomida et al., 2013; Handa, 2020), may have particularly close affinities with those of *Bd.*



986 *shanwangense*. More generally, the concerned Japanese assemblages are very similar to the  
987 Tagay and/or Shanwang ones (e.g., with the equid *Anchitherium* cf. *gobiense*, the  
988 proboscidean *Gomphotherium annectens*, and the beaver *Youngofiber sinensis*; Qiu & Qiu,  
989 2013), thus strengthening the existence of a single eastern Asian biogeographical province at  
990 mid latitudes at that time (Fig. 15). Indeed, closed forest environments under a subtropical  
991 climate, with precipitation averaging ca. 1500 mm per year, are reported for the Shanwang  
992 Basin based on early Miocene floras and vertebrates (Lu et al., 2021). The same proxies allow  
993 for considering the Tagay area as a lake, also surrounded by dense forests under subtropical  
994 conditions, with precipitation averaging ca. 1000-1500 mm per year (Logachev et al, 1964;  
995 Belova, 1985; Sizov & Klementiev, 2015).

## 996 CONCLUSIONS

997 The numerous associated features documented and scored in the Tagay rhinocerotid  
998 skeleton have allowed for assigning it to the same teleoceratine species (*Brachydiceratherium*  
999 *shanwangense*) as in Shanwang, eastern China. These remains further contribute to a refined  
1000 depiction of phylogenetic relationships and to a revision of generic assignments among  
1001 Eurasian Teleoceratina.

1002 The genus *Diaceratherium* Dietrich, 1931 should be restricted to the type species,  
1003 *Diaceratherium tomerdingense* Dietrich, 1931. This monotypic genus is the first offshoot  
1004 within Teleoceratina. Our results support the reappraisal of *Brachydiceratherium* Lavocat,  
1005 1951, with eight assigned species: *Brachydiceratherium lemanense* (Pomel, 1853),  
1006 *Brachydiceratherium aurelianense* (Nouel, 1866), *Brachydiceratherium intermedium*  
1007 (Lydekker, 1884), *Brachydiceratherium asphaltense* (Depéret & Douxami, 1902),  
1008 *Brachydiceratherium fatehjangense* (Pilgrim, 1910), *Brachydiceratherium aginense* (Répelin,  
1009 1917), *Brachydiceratherium shanwangense* (Wang, 1965) and *Brachydiceratherium*

1010 *lamilloquense* Michel, 1983. *Brachydiceratherium* is a sister group to a clade encompassing  
1011 *Prosantorhinus* and the North American genus *Teleoceras*. *Brachyotherium* is more closely  
1012 related to the latter three genera than to *Diaceratherium*.

1013 All Old World teleoceratines have extended geographical distributions at the genus  
1014 level, which is also true for some species, such as the late Oligocene *Brachydiceratherium*  
1015 *lamilloquense* and the early Miocene *Brachydiceratherium shanwangense*. The latter range  
1016 supports the existence of a single eastern Asian biogeographical province at mid latitudes at  
1017 that time for such megaherbivores.

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## 1324 SUPPORTING INFORMATION

1325 Additional supporting information may be found online in the supporting information

1326 tab for this article. Supplementary Files:

- 1327 • **S1.** Character matrix for the preliminary phylogenetic analysis, including 282 cranial,  
1328 dental, and postcranial characters controlled on 32 terminal taxa (one tapirid,  
1329 rhinocerotoids, and rhinocerotids), with Tagay rhinoceros and “*Diaceratherium*  
1330 *shanwangense*” as separate terminals.
- 1331 • **S2.** Output log text of the preliminary phylogenetic analysis (282 characters and 32  
1332 taxa).
- 1333 • **S3.** Character matrix for the **final** phylogenetic analysis, including 282 cranial, dental,  
1334 and postcranial characters controlled on 31 terminal taxa (one tapirid, rhinocerotoids,  
1335 and rhinocerotids).
- 1336 • **S4.** Output log text of the **final** phylogenetic analysis, with Bremer Support
- 1337 • **S5** Measurements for *Brachydiceratherium shanwangense* from Tagay site.

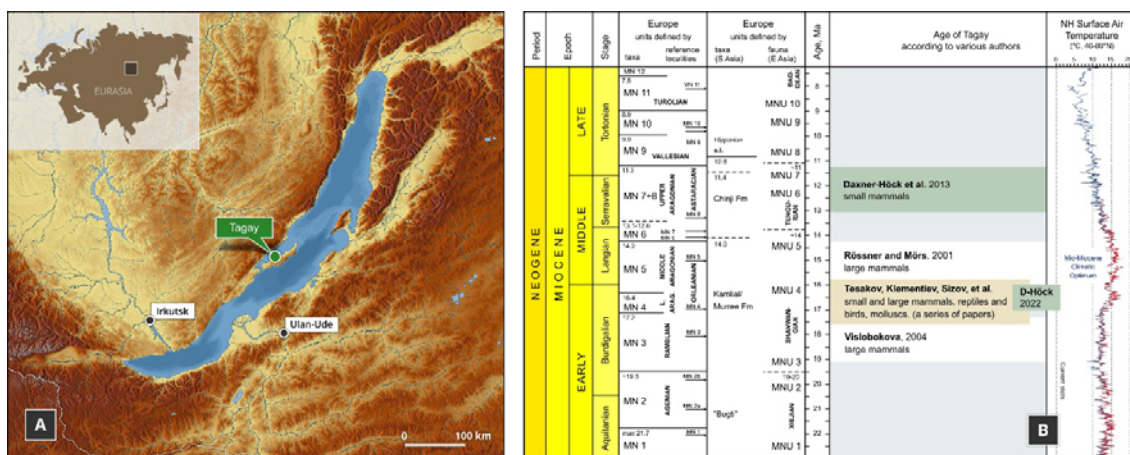
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## 1341 FIGURES

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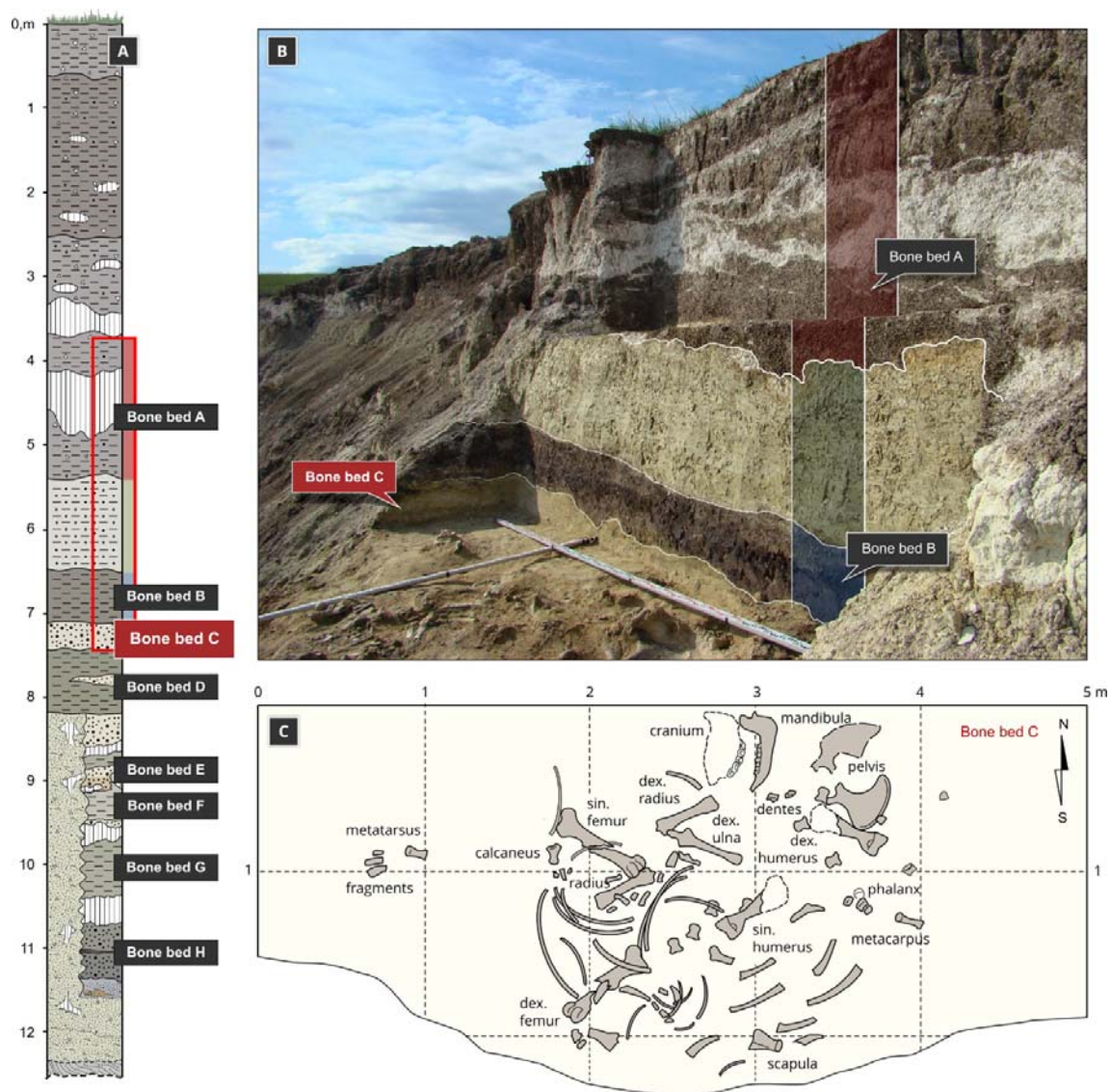


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1344 **Fig. 1.** Geographic position of Tagay locality on Olkhon Island, Baikal Region, Russia (A)

1345 and age of Tagay Formation according to various authors (B). [Full width suggested]





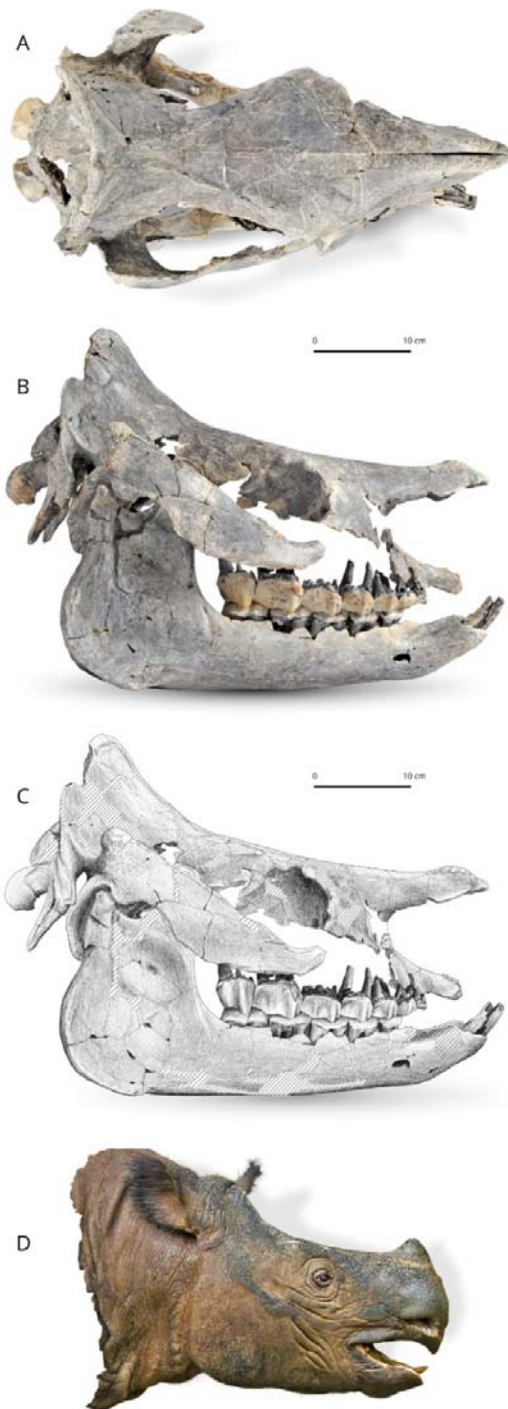
1346

1347 **Fig. 2.** Geological structure of the Tagay section (A), photo (B) and plan (C) of the

1348 excavations of the Miocene rhinocerotid at Tagay site in 2008 (Olkhon Island, Baikal Region,

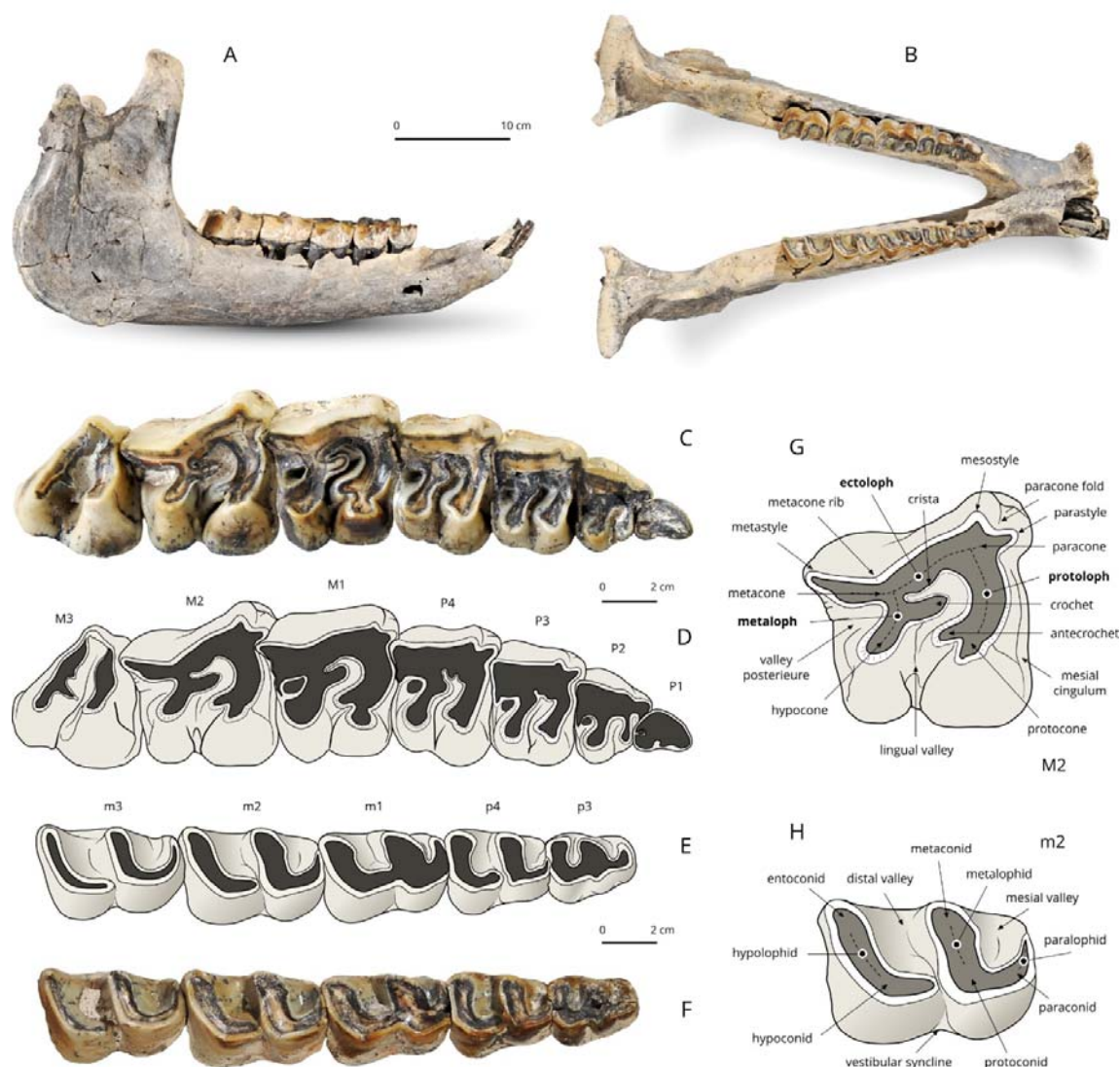
1349 Russia). [Full width suggested]

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1352 **Fig. 3.** *Brachydiceratherium shanwangense* (Wang, 1965) from Tagay, Baikal Region,  
1353 Russia, late early Miocene. Photos in dorsal (A) and lateral views (B) of the skull and  
1354 mandible IZK79-1-08C-1. C - Scientific drawing of the right lateral view of the skull (based  
1355 on B). Striped areas are reconstructed. D - Tentative reconstruction of the head in lateral  
1356 view, by one of us (AS). [One column width suggested]



1357

1358 **Fig. 4.** *Brachydiceratherium shanwangense* (Wang, 1965) from Tagay, Baikal Region,

1359 Russia, late early Miocene. Mandible and dental material. A, B – Mandible in right lateral (A)

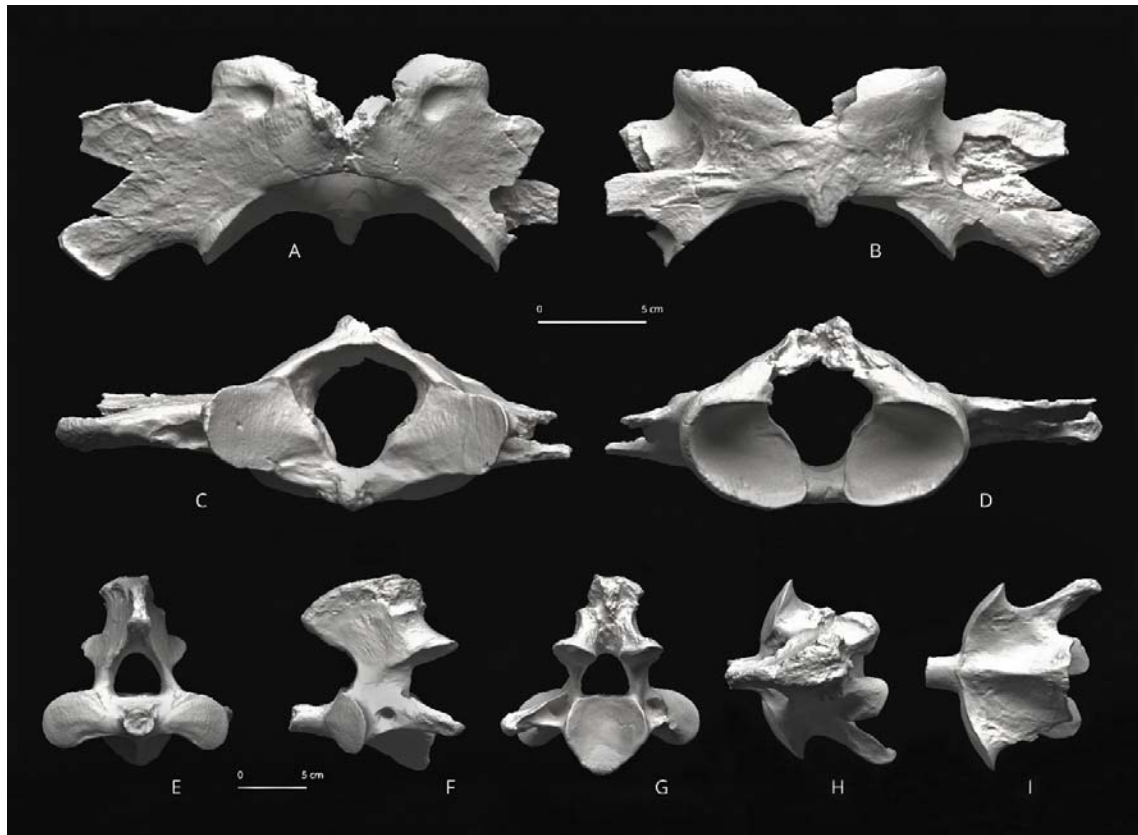
1360 and occlusal views (B); C, D – Right upper cheek teeth (P3–M3) in occlusal view: photograph

1361 (C) and interpretative sketch (D); E, F – Right lower cheek teeth (p3–m3) in occlusal view:

1362 photograph (E) and interpretative sketch (F); G, H – Dental terminology used for rhinocerotid

1363 upper tooth (G) and lower tooth (H). [Full width suggested]

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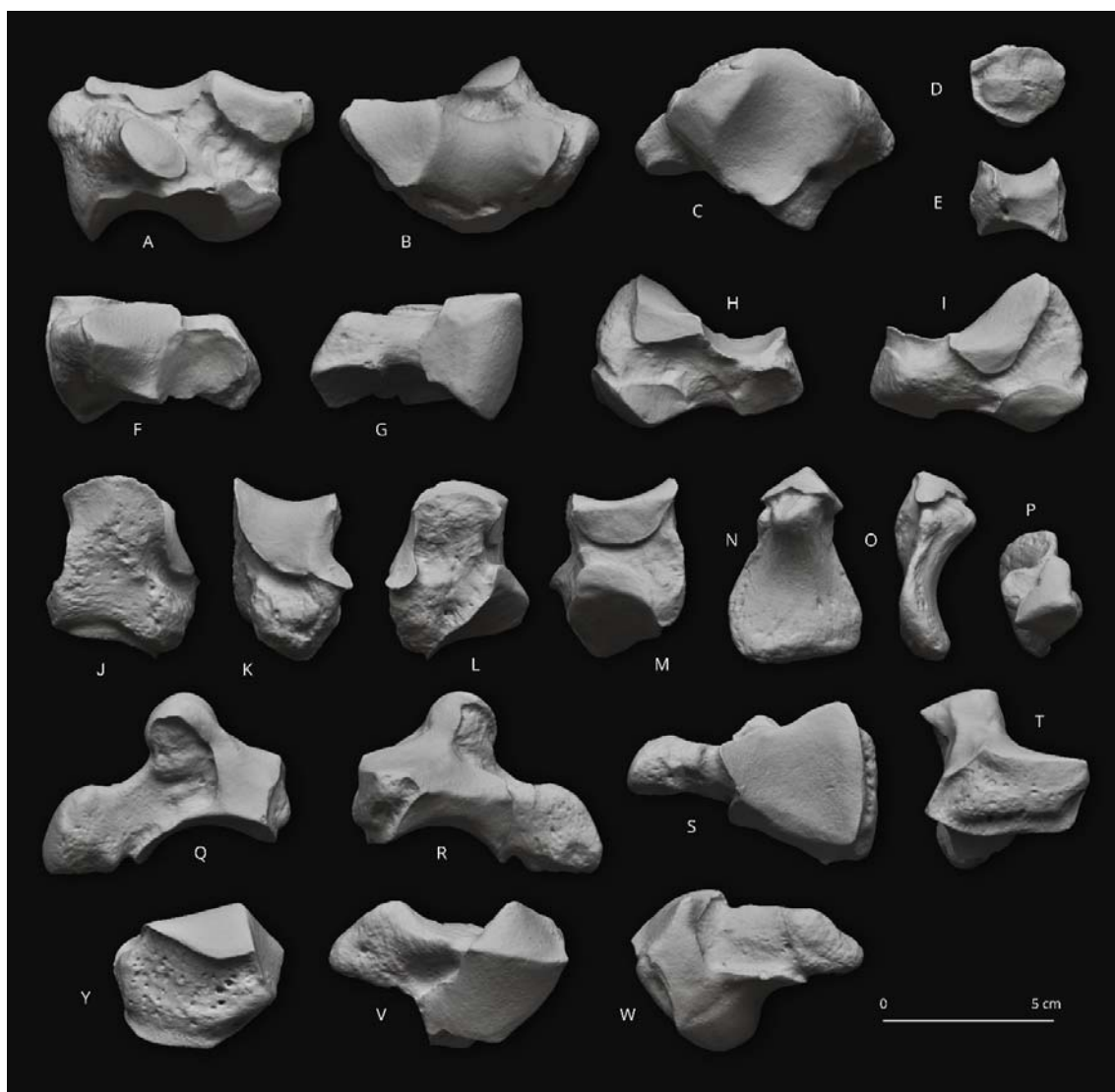
1365

1366 **Fig. 5.** *Brachydiceratherium shanwangense* (Wang, 1965) from Tagay, Baikal Region,  
1367 Russia, late early Miocene. A-D – Atlas in dorsal (A), ventral (B), cranial (C) and posterior  
1368 views (D); E-I – Axis in anterior (E), left lateral (F), posterior (G), dorsal (H), and ventral  
1369 views (I). [Full width suggested]



1370

1371 **Fig. 6.** *Brachydicraterium shanwangense* (Wang, 1965) from Tagay, Baikal Region,  
1372 Russia, late early Miocene. Long bones of the right forelimb. A-E – humerus in posterior (A),  
1373 medial (B), anterior (C), lateral (D), and proximal views (E); F-J – radius in anterior (F),  
1374 lateral (G), posterior (H), medial (I), and proximal views (J); K-O – ulna in proximal (K),  
1375 medial (L), anterior (M), lateral (N), and posterior views (O). [Full width suggested]



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**Fig. 7. *Brachydiceratherium shanwangense* (Wang, 1965) from Tagay, Baikal Region,**

1378 **Russia, late early Miocene. Carpal bones. A-C – left scaphoid in posterior (A), proximal (B),**  
1379 **and distal views (C); D-E – right trapezoid in anterior (D), and distal views (E); F-I – left**  
1380 **semilunate in distal (F), proximal (G), medial (H), and lateral views (I); J-M – left pyramidal**  
1381 **in anterior (J), lateral (K), posterior (L), and medial views (M); N-P – right pisiform in**  
1382 **anterior (N), lateral (O), and proximal views (P); Q-T – right magnum in lateral (Q), medial**  
1383 **(R), distal (S), and anterior views (T); Y-W – right unciform in anterior (Y), proximal (V),**  
1384 **and distal (W). [Full width suggested]**



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1386 **Fig. 8.** *Brachydiceratherium shanwangense* (Wang, 1965) from Tagay, Baikal Region,  
1387 Russia, late early Miocene. Left metacarpal bones. A-E – second metacarpal in lateral (A),  
1388 posterior (B), medial (C), anterior (D), and proximal views (E); F-J – third metacarpal in  
1389 proximal (F), lateral (G), posterior (H), medial (I), and anterior views (J); K-O – fourth  
1390 metacarpal in proximal (K), lateral (L), posterior (M), medial (N), and anterior views (O).  
1391 [Full width suggested]

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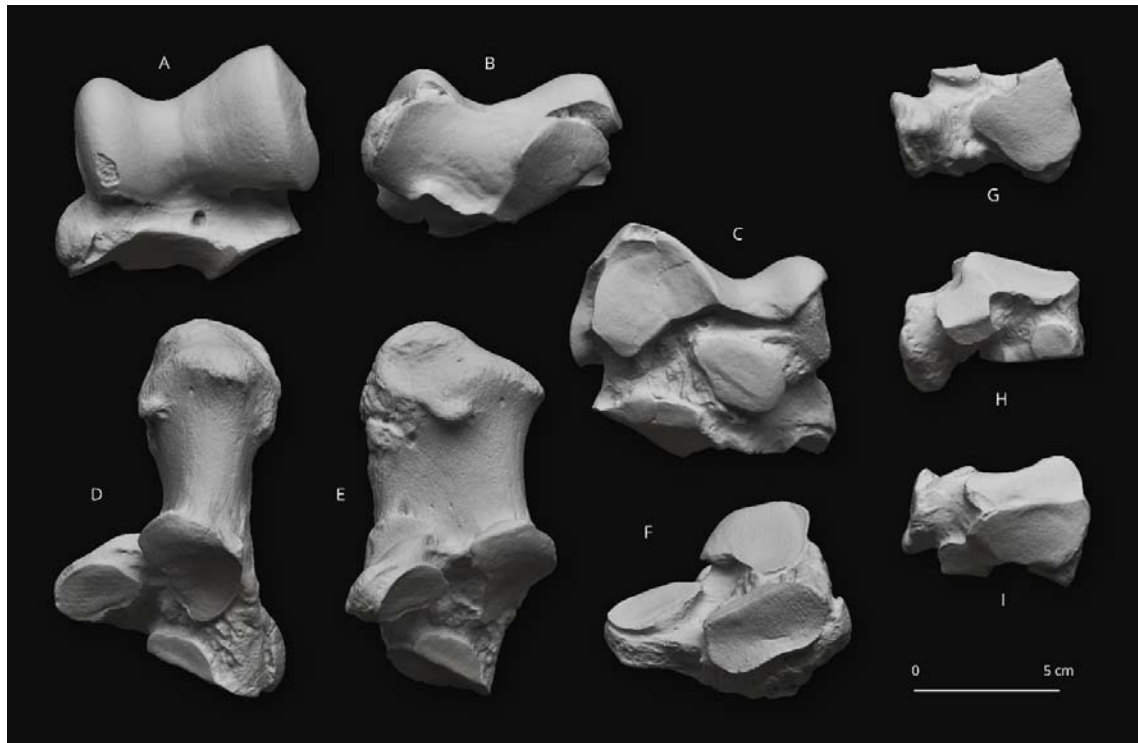
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1395 **Fig. 9. *Brachydicraterium shanwangense* (Wang, 1965) from Tagay, Baikal Region,**  
1396 **Russia, late early Miocene. Long bones of the left hind limb. A-F – femur in anterior (A),**  
1397 **medial (B), posterior (C), lateral (D), proximal (E), and distal views (F); G-J – fibula in lateral**  
1398 **(G), posterior (H), medial (I), and anterior views (J); K-O – tibia in anterior (K), medial (L),**  
1399 **posterior (M), lateral (N), and proximal views (O). [Full width suggested]**





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1401 **Fig. 10.** *Brachydiceratherium shanwangense* (Wang, 1965) from Tagay, Baikal Region,  
1402 Russia, late early Miocene. Tarsal bones. A-C – left astragalus in anterior (A), distal (B), and  
1403 posterior views (C); D-F – left calcaneus in proximal (D), medial (E), and anterior views (F);  
1404 G-I – left cuboid in distal (G), lateral (H), and proximal views (I). [Full width suggested]

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1409 **Fig. 11.** *Brachydiceratherium shanwangense* (Wang, 1965) from Tagay, Baikal Region,  
1410 Russia, late early Miocene. Metatarsal bones. A-E – left second metatarsal in lateral (A),  
1411 posterior (B), medial (C), anterior (D), and proximal views (E); F-J – right fourth metatarsal  
1412 in proximal (F), medial (G), posterior (H), lateral (I), and anterior views (J). [Full width  
1413 suggested]

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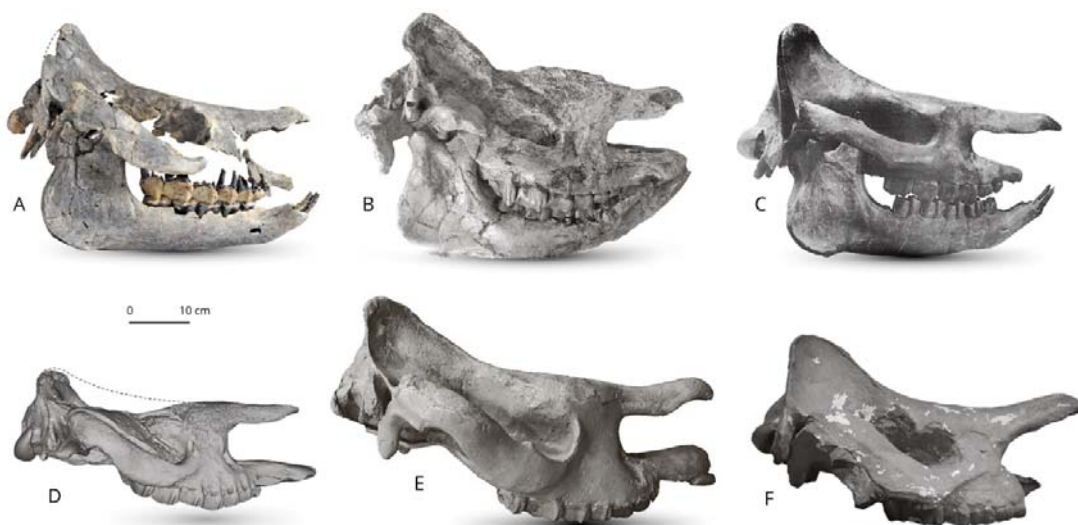
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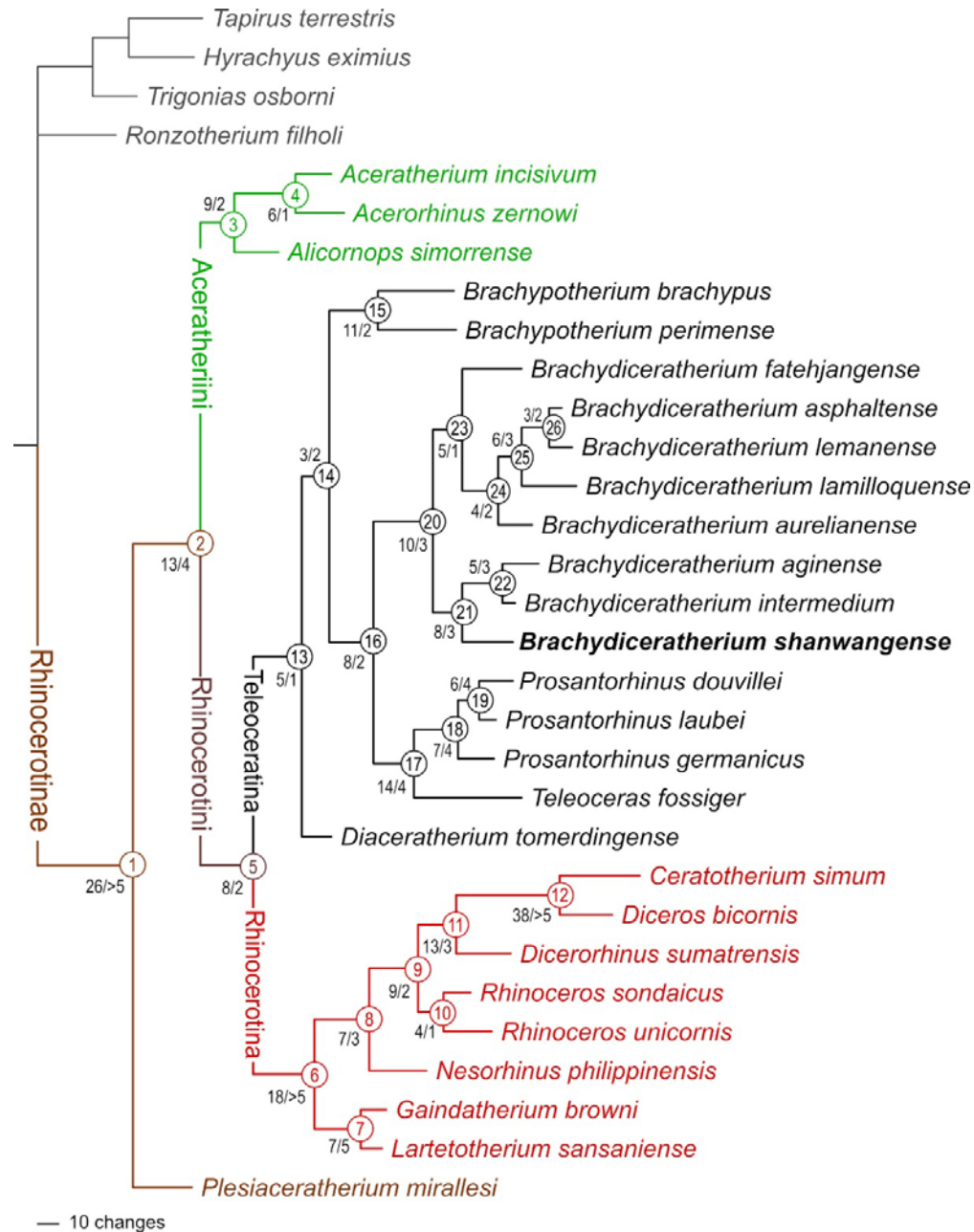
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1423 **Fig. 12.** Skulls of different species of *Brachydiceratherium* in **right** lateral view. **A** -  
1424 *Brachydiceratherium shanwangense* from Tagay (**Baikal Region, Russia, late early Miocene**)  
1425 №IZK79-1-08C-1/1; **B** - *Brachydiceratherium shanwangense* from Jijiazhuang locality STM  
1426 44-98 (deformed, mirrored) (MN4 - **early Miocene**, Shanwang Basin, Shandong Province,  
1427 China) №MHNT.PAL.2013.0.1001; **C** - *Brachydiceratherium aginense* (Répelin, 1917) from  
1428 Laugnac (MN2 - **early Miocene**, Lot-et-Garonne, France); **D** - *Brachydiceratherium*  
1429 *lemanense* from Gannat (MN1 - **early Miocene**, France) №MNHN-AC-2375, holotype; **E** -  
1430 *Brachydiceratherium asphaltense* (Depéret et Douxami, 1902) from Saulcet (MN1 - **earliest**  
1431 Miocene, Allier, France). №NMB-Sau1662; **F** - *Brachydiceratherium aurelianense* from  
1432 Neuville-aux-Bois (MN3 - **early Miocene**, France) №MHNT.PAL.2013.0.1001, cast of the  
1433 holotype; **[Full width suggested]**

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— 10 changes

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**Fig. 13.** Phylogram of Rhinocerotinae, with a focus on Teleoceratina. Most parsimonious tree

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(1315 steps; consistency index = 0.2700; retention index = 0.4923), retrieved from 282

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unweighted cranio-mandibular, dental, and postcranial characters scored in 31 tapirid and

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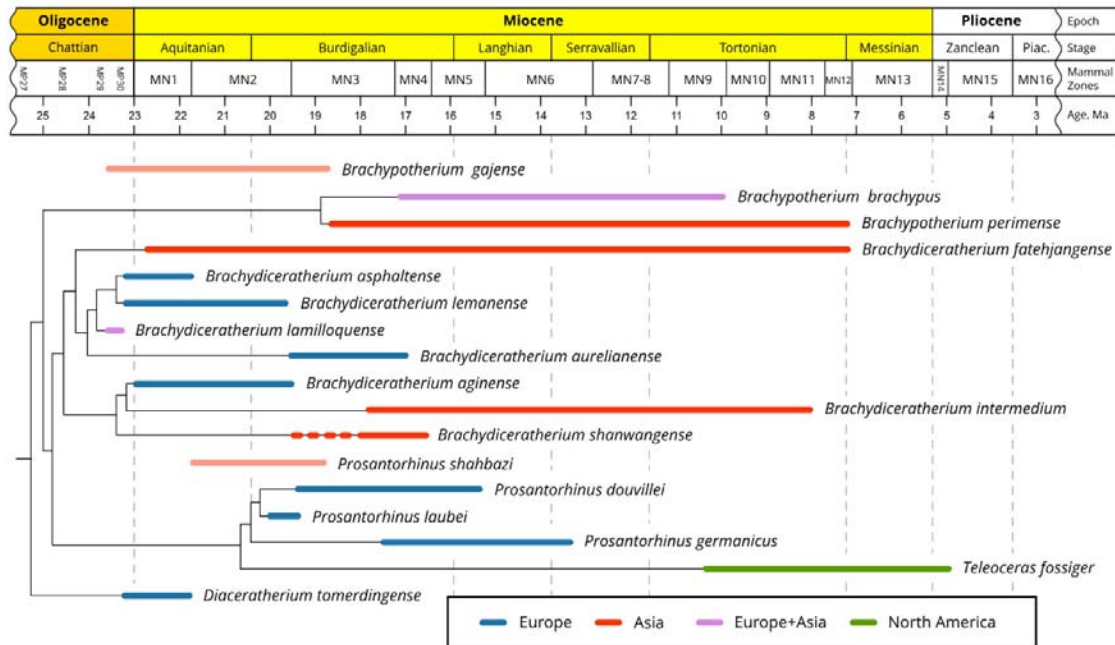
rhinocerotoid species (see S3 and S4).

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Node numbers appear in empty circles. Number of unambiguous synapomorphies/Bremer Support are indicated left to nodes. [Full width

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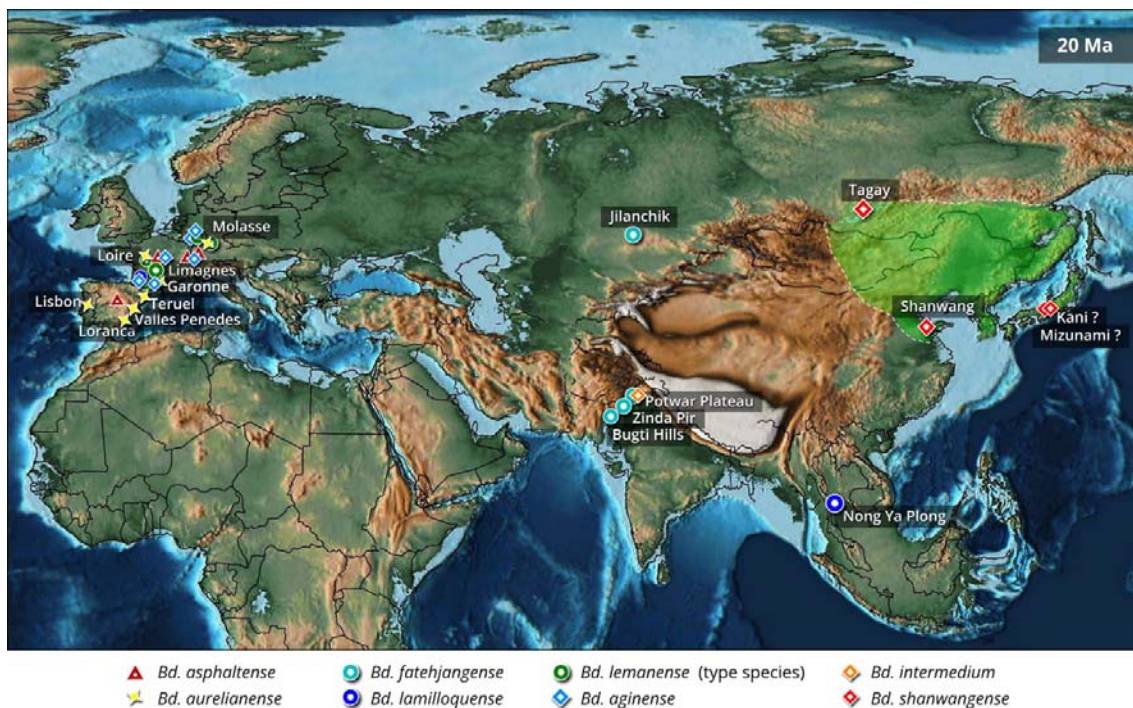
suggested]



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1443 **Fig. 14.** Phylogenetic relationships of Teleoceratina versus time (see Fig. 13), with new  
 1444 combinations. Although they were not included in the current parsimony analysis, the  
 1445 temporal distributions of *Brachypotherium gajense* and *Prosantorhinus shahbazi* are provided  
 1446 here, as these species might bridge a stratigraphic gap for the concerned genera. Red dotted  
 1447 line for *B. shanwangense* stands for the age uncertainty of Tagay locality (MN3-5) [Full width  
 1448 suggested]

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1451 **Fig. 15.** Paleomap of Eurasia by early Miocene times (~20 Ma), showing the main  
1452 occurrences of representatives of the teleoceratine rhinocerotid *Brachydiceratherium*, at the  
1453 basin scale (apart from Tagay, Shanwang, and Nong Ya Plong localities). The Green area  
1454 depicts the interpolated geographical range of *B. shanwangense* (with possible occurrences on  
1455 Honshu Island, Japan). Based on data from Borissiak (1927), Cerdeño (1993), Antoine et al.  
1456 (2000, 2013), Becker et al. (2009), Antoine & Becker (2013), Tomida et al. (2013), Jame et  
1457 al. (2019), Handa (2020), Lu et al. (2021), Antoine (in press), and the present work.  
1458 PalaeoAtlas by Scotese (2016, under cc 4.0 license) with added paleomap for the Baikal area  
1459 (Mats et al., 2011). [Full width suggested]

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1464

1465 **Table 1.** Cranial measurements of *Brachydiceratherium shanwangense*, from Tagay, early  
 1466 Miocene of Eastern Siberia, in mm. 1, Length (occipital-premaxilla distance); 2, Length  
 1467 (occipital-nasal distance); 3, Upper length (nasal-occipital crest distance); 4, Nasal incisure  
 1468 length; 5, Minimal width; 6, Occipital crest-postorbital process distance; 8, Occipital crest-  
 1469 lacrimal process distance; 9, Nasal incisure-orbit distance; 13, Post-M3-condyle distance; 14,  
 1470 Nasal-orbit distance; 15, Occipital crest width; 16, Mastoid apophyses width; 17, Inter  
 1471 frontoparietal crest minimal distance; 18, Postorbital process width; 19, Lacrimal process  
 1472 width; 21, Zygomatic width; 22, Nasal incisure width; 23, Occipital height; 25, P2-level  
 1473 height; 26, P4-M1-level height; 27, M3-level height; 31, Foramen magnum width; 32, Inter-  
 1474 occipital condyle width. Numbers coincide with measurements as defined and illustrated by  
 1475 Guérin (1980, fig. 1, table 1).

<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b>6</b>	<b>8</b>	<b>9</b>	<b>13</b>	<b>14</b>	<b>15</b>	<b>16</b>
505	540	455.8	(174)	125	249.6	293.6	(72.6)	(254)	219	(160)	224.8
<b>17</b>	<b>18</b>	<b>19</b>	<b>21</b>	<b>22</b>	<b>23</b>	<b>25</b>	<b>26</b>	<b>27</b>	<b>31</b>	<b>32</b>	
26.7	179	189	308.2	69.7	144.6	(140)	(155)	(156)	43	112.4	

1483

1484

1485 **Table 2.** Right mandibular measurements of *Brachydiceratherium shanwangense*, from  
1486 Tagay, early Miocene of Eastern Siberia, in mm. 1, Maximal length; 2, Length without the  
1487 symphysis; 3–8, Heights of the corpus mandibulae, between p2-p3, p3-p4, p4-m1, m1-m2,  
1488 m2-m3, and behind m3, respectively; 9 and 10, Transverse diameters of the corpus  
1489 mandibulae, between p4-m1 and behind m3, respectively; 11, Antero-posterior length of the  
1490 symphysis; 13, Antero-posterior diameter of the ramus (at the level of the occlusal line); 14,  
1491 Transverse diameter of the articular condyle; 15, Height of the articular condyle; 16, Height  
1492 of the coronoid process. Numbers coincide with measurements as defined and illustrated by  
1493 Guérin (1980, fig. 1, table 3).

1494

1	2	3	4	5	6	7	8	9	10	11	13	14	15	16
467.4	136.8	68	68	70.7	75	76.4	77.7	38.1	41.3	118.2	136.8	96.2	203.3	229.2

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1497 **Table 3. Dental measurements of *Brachydiceratherium shanwangense*, from Tagay, early**

1498 **Miocene of Eastern Siberia, in mm. Abbreviations: H, crown height; L, length; W, width.**

1499

		<b>P1</b>	<b>P2</b>	<b>P3</b>	<b>P4</b>	<b>M1</b>	<b>M2</b>	<b>M3</b>	<b>p2</b>	<b>p3</b>	<b>p4</b>	<b>m1</b>	<b>m2</b>	<b>m3</b>
<b>left</b>	<b>L</b>		25.1	31.5	35.3	47.0	50.5			28.0	31.8	38.6	43.8	43.9
	<b>W</b>		31.5	41.1	47.7	51.7	54.2			21.8	25.2	27.6	29.8	30.5
	<b>H</b>		17.1	21.7	28.3	30.5	37.5			18.2	23.2	28.8	30.2	29.8
<b>right</b>	<b>L</b>	19.3	27.2	29.0	35.5	47.1	50.6	42.1		29.8	32.0	37.7	44.1	45.4
	<b>W</b>	14.5	31.9	40.0	47.6	51.4	56.2	46.1		21.9	27.2	28.1	30.0	30.3
	<b>H</b>	8.8	18.0	21.1	27.0	29.7	37.6	37.8		19.8	23.0	24.8	28.7	27.0

1500



1513 **Table 5.** Postcranial measurements of *Brachydiceratherium shanwangense*, from Tagay, early  
 1514 Miocene of Eastern Siberia, in mm. Hind limb bones. Abbreviations: ant, anterior; APD,  
 1515 antero-posterior diameter; art, articulation; artic, articular; As3, astragalus-3 (sensu Heissig,  
 1516 1972); astr, astragalus; Cc1, calcaneus-1 (sensu Heissig, 1972); Cc2, calcaneus-2 (sensu  
 1517 Heissig, 1972); D, distance; dist, distal; ext, extremity; H, height; L, length; lat, lateral; maj,  
 1518 major; max, maximal; med, medial; mesocun, mesocuneiform; mid, middle; min, minimum;  
 1519 post, posterior; sust, sustentaculum; TD, transverse diameter; tr, trochanter; troch, trochlea;  
 1520 tuber, tuberosity.

1521

<b>Femur</b>	L 486.9	proximal ext TD APD	164.2 72.4	maj tr TD	97	third tr TD H	54.5 51.6	diaphysis TD APD	63.5 43	dist ext TD APD	129.4 144.8	distal condyles TD D	114.3 10.7
<b>Patella</b>	TD 80.1	APD 34	H 84	articulation TD H	68.3 82.5	med lip TD	53.5	lateral lip TD H	29.2 69.5				
<b>Tibia</b>	L 333	proximal ext TD APD	115.3 100.5	diaphysis TD APD	47 40.5	dist ext TD APD	89.5 60.6	fibula-facet APD H	33.6 9.7	astr cochlea TD APD	70.6 50.1		
<b>Fibula</b>	L 267.7	proximal ext TD APD	25 39.3	diaphysis TD APD	47 40.5	dist ext TD APD	11.8 14.4	fibia-facet APD H	37.1 9.6	astr facet APD H	37.1 18.7		
<b>Astragalus</b>	max TD 90.9	troch TD	max APD 53.4		H medial mid lateral	67.3 52.3 70.5		Cc1-facet TD H	40.5 37.6	Cc2-facet TD H	39.5 22.5	cuboid-facet L W	45 23.2
<b>Calcaneus</b>	H 128.9	artic H 67.3	tuberosity TD APD	46.8 61.8	beak APD	62.9	sust TD 73.7	tuber min TD APD	28.8 51	As3-facet TD H	30.1 11.4	cuboid-facet TD H	43.9 20.4
<b>Cuboid</b>	TD 43	post 31	max APD 61.9	H ant post	29.9 49.4	proximal art TD APD	39.6 43.8	distal art TD APD	37.3 37.1				
<b>MtII</b>	L 160	proximal art TD APD	31.3 39.9	mesocun-fac TD APD	25.4 28.4	lat facet H ant post	5.4 12.9	diaphysis TD APD	28.7 19.4	distal art TD APD	33.8 39.5		
<b>MtIV</b>	L 101.7	proximal art TD APD	31.7 33.3	medial facets ant TD ant H post TD post H	11.3 16.9 18.7 14.8			diaphysis TD APD	30.5 18.1	dist ext max TD	38.3	distal art TD APD	30.4 40.2

1522

1523

1524 **Table 6.** Distribution of unambiguous apomorphic characters (synapomorphies and  
1525 autapomorphies, including reversals) among teleoceratine rhinocerotids, as retrieved in the  
1526 current phylogenetic analysis. Node numbers match those of **Fig. 13**. Binominal combinations  
1527 are as detailed in the Discussion.

1528 Node 13 (Teleoceratina): -72<sup>0</sup>, 129<sup>1</sup>, 205<sup>1</sup>, 279<sup>1</sup>, 282<sup>1</sup>

1529 *Diaceratherium tomerdingense* (type and only species): -70<sup>0</sup>, 90<sup>1</sup>, 121<sup>1</sup>, 130<sup>1</sup>, -196<sup>0</sup>, 212<sup>1</sup>,

1530 216<sup>1</sup>, 223<sup>3</sup>, 228<sup>2</sup>, -251<sup>0</sup>

1531 Node 14: 199<sup>2</sup>, 202<sup>1</sup>, 227<sup>1</sup>

1532 *Brachypotherium*: -50<sup>0</sup>, 54<sup>2</sup>, -83<sup>1</sup>, -114<sup>0</sup>, 140<sup>1</sup>, -146<sup>0</sup>, 155<sup>1</sup>, 203<sup>1</sup>, 214<sup>1</sup>, -226<sup>0</sup>, 254<sup>1</sup>

1533 *Brachypotherium brachypus*: 3<sup>2</sup>, -34<sup>0</sup>, -39<sup>0</sup>, 57<sup>1</sup>, 62<sup>1</sup>, 99<sup>2</sup>, -109<sup>1</sup>, -115<sup>2</sup>, 118<sup>1</sup>, -119<sup>0</sup>, -135<sup>0</sup>,

1534 144<sup>1</sup>, -149<sup>0</sup>, 157<sup>3</sup>, -159<sup>0</sup>, -160<sup>0</sup>, 170<sup>1</sup>, 179<sup>1</sup>, 180<sup>1</sup>, 191<sup>1</sup>, -193<sup>0</sup>, -204<sup>0</sup>, 209<sup>1</sup>, 210<sup>1</sup>, 239<sup>1</sup>, 275<sup>2</sup>,

1535 -280<sup>0</sup>

1536 *Brachypotherium perimense*: 25<sup>1</sup>, 41<sup>1</sup>, 68<sup>1</sup>, 76<sup>1</sup>, -85<sup>0</sup>, 121<sup>1</sup>, -125<sup>0</sup>, 128<sup>1</sup>, -129<sup>0</sup>, 151<sup>3</sup>, 172<sup>1</sup>,

1537 173<sup>1</sup>, 175<sup>1</sup>, 181<sup>1</sup>, 199<sup>3</sup>, 200<sup>1</sup>, -205<sup>0</sup>, 228<sup>2</sup>, 246<sup>1</sup>, 248<sup>1</sup>, 255<sup>1</sup>, 263<sup>3</sup>, -271<sup>0</sup>, 272<sup>1</sup>, 274<sup>1</sup>, 277<sup>1</sup>, -

1538 282<sup>0</sup>

1539 Node 16: 38<sup>1</sup>, 101<sup>1</sup>, 107<sup>3</sup>, -147<sup>0</sup>, -222<sup>0</sup>, -230<sup>0</sup>, -263<sup>0</sup>, 264<sup>3</sup>

1540 Node 17 (*Teleoceras* + *Prosantorhinus*): 10<sup>1</sup>, 11<sup>1</sup>, 40<sup>1</sup>, 57<sup>1</sup>, 95<sup>1</sup>, 99<sup>1</sup>, 130<sup>1</sup>, 180<sup>1</sup>, 190<sup>2</sup>, 191<sup>1</sup>,

1541 234<sup>1</sup>, 272<sup>2</sup>, 275<sup>2</sup>, -280<sup>0</sup>

1542 *Teleoceras fossiger* (type species): 2<sup>1</sup>, 19<sup>1</sup>, 25<sup>1</sup>, 48<sup>1</sup>, -56<sup>0</sup>, 59<sup>1</sup>, 60<sup>0</sup>, 63<sup>1</sup>, 68<sup>1</sup>, 80<sup>1</sup>, 87<sup>2</sup>, 88<sup>2</sup>, 91<sup>2</sup>,

1543 99<sup>2</sup>, 102<sup>1</sup>, 114<sup>3</sup>, 116<sup>1</sup>, 117<sup>1</sup>, 121<sup>1</sup>, 126<sup>1</sup>, 128<sup>1</sup>, 144<sup>1</sup>, 151<sup>3</sup>, 153<sup>1</sup>, 157<sup>3</sup>, 159<sup>3</sup>, 165<sup>1</sup>, 173<sup>1</sup>, 175<sup>1</sup>,

1544 180<sup>3</sup>, -196<sup>0</sup>, 212<sup>1</sup>, 220<sup>1</sup>, 248<sup>1</sup>, -249<sup>0</sup>, 254<sup>1</sup>, 268<sup>1</sup>, 269<sup>1</sup>, 276<sup>1</sup>

1545 *Prosantorhinus*: 1<sup>1</sup>, 27<sup>1</sup>, -35<sup>0</sup>, 45<sup>1</sup>, -119<sup>0</sup>, -125<sup>0</sup>, -177<sup>0</sup>

1546 *Prosantorhinus germanicus* (type species): 37<sup>1</sup>, 85<sup>3</sup>, 105<sup>1</sup>, -109<sup>1</sup>, -110<sup>0</sup>, -111<sup>2</sup>, 115<sup>2</sup>, 147<sup>2</sup>,

1547 148<sup>1</sup>, -149<sup>1</sup>, -151<sup>1</sup>, 166<sup>1</sup>, -182<sup>0</sup>

1548 Node 19: -101<sup>0</sup>, -129<sup>0</sup>, -135<sup>0</sup>, -159<sup>1</sup>, 182<sup>2</sup>, 261<sup>3</sup>

- 1549 *Prosantorhinus laubei*: -85<sup>1</sup>, 90<sup>1</sup>, -99<sup>0</sup>, -114<sup>0</sup>, -134<sup>0</sup>, -180<sup>0</sup>
- 1550 *Prosantorhinus douvillei*: -88<sup>0</sup>, 99<sup>2</sup>, 114<sup>2</sup>, 144<sup>1</sup>, 156<sup>2</sup>, -157<sup>0</sup>, -159<sup>0</sup>, 162<sup>1</sup>, 180<sup>3</sup>
- 1551 *Brachydiceratherium*: -20<sup>0</sup>, -39<sup>0</sup>, 65<sup>1</sup>, 101<sup>3</sup>, -149<sup>1</sup>, -159<sup>0</sup>, 185<sup>1</sup>, 187<sup>2</sup>, 246<sup>1</sup>, -251<sup>0</sup>
- 1552 Node 21: 72<sup>1</sup>, 105<sup>2</sup>, -190<sup>0</sup>, -193<sup>0</sup>, 238<sup>1</sup>, 250<sup>1</sup>, -279<sup>0</sup>, -282<sup>0</sup>
- 1553 *Brachydiceratherium shanwangense*: 1<sup>1</sup>, 27<sup>1</sup>, 63<sup>1</sup>, -70<sup>0</sup>, -85<sup>0</sup>, 87<sup>2</sup>, 88<sup>2</sup>, 105<sup>3</sup>, 116<sup>1</sup>, 147<sup>2</sup>, 151<sup>3</sup>,
- 1554 157<sup>3</sup>, 191<sup>1</sup>, -196<sup>0</sup>, 199<sup>3</sup>, 234<sup>1</sup>
- 1555 Node 22: 121<sup>1</sup>, 210<sup>1</sup>, -252<sup>1</sup>, -264<sup>0</sup>, -265<sup>0</sup>
- 1556 *Brachydiceratherium aginense*: 112<sup>1</sup>, -114<sup>0</sup>, 128<sup>2</sup>, 130<sup>1</sup>, -149<sup>0</sup>, 162<sup>1</sup>, 214<sup>1</sup>, 216<sup>1</sup>, 219<sup>1</sup>, -221<sup>0</sup>, -
- 1557 226<sup>0</sup>, 256<sup>1</sup>, -262<sup>0</sup>, 263<sup>1</sup>, 272<sup>1</sup>, -280<sup>0</sup>
- 1558 *Brachydiceratherium intermedium*: -65<sup>0</sup>, 114<sup>3</sup>, 118<sup>1</sup>, -129<sup>0</sup>, 220<sup>1</sup>
- 1559 Node 23: -119<sup>0</sup>, 203<sup>1</sup>, -204<sup>0</sup>, 207<sup>1</sup>, 261<sup>1</sup>
- 1560 *Brachydiceratherium fatehjangense*: 10<sup>1</sup>, 18<sup>2</sup>, 48<sup>1</sup>, -49<sup>0</sup>, 53<sup>1</sup>, 54<sup>2</sup>, 57<sup>1</sup>, -70<sup>0</sup>, -94<sup>1</sup>, -107<sup>0</sup>, 140<sup>1</sup>, -
- 1561 149<sup>0</sup>, 151<sup>3</sup>, 155<sup>1</sup>, 174<sup>1</sup>, -202<sup>0</sup>, -205<sup>0</sup>, 209<sup>1</sup>, -224<sup>0</sup>, -227<sup>0</sup>, -247<sup>0</sup>, 261<sup>2</sup>
- 1562 Node 24: 118<sup>1</sup>, -125<sup>0</sup>, -134<sup>0</sup>, 230<sup>1</sup>
- 1563 *Brachydiceratherium aurelianense*: -53<sup>0</sup>, 86<sup>1</sup>, 90<sup>3</sup>, 114<sup>3</sup>, 124<sup>1</sup>, 130<sup>1</sup>, 147<sup>1</sup>, -193<sup>0</sup>, 198<sup>1</sup>, -199<sup>0</sup>,
- 1564 214<sup>1</sup>, 220<sup>1</sup>
- 1565 Node 25: 105<sup>1</sup>, 210<sup>1</sup>, -253<sup>0</sup>, -264<sup>0</sup>, -279<sup>0</sup>, -280<sup>0</sup>
- 1566 *Brachydiceratherium lamilloquense*: 53<sup>2</sup>, -84<sup>1</sup>, 88<sup>1</sup>, 99<sup>1</sup>, -102<sup>1</sup>, 105<sup>3</sup>, -111<sup>2</sup>, 112<sup>3</sup>, -135<sup>0</sup>, -146<sup>0</sup>,
- 1567 207<sup>2</sup>, 228<sup>2</sup>, -243<sup>0</sup>, -246<sup>0</sup>, -247<sup>0</sup>, 248<sup>1</sup>, -259<sup>0</sup>
- 1568 Node 26: -109<sup>0</sup>, -138<sup>0</sup>, -221<sup>0</sup>
- 1569 *Brachydiceratherium asphaltense*: -23<sup>0</sup>, 27<sup>1</sup>, 83<sup>3</sup>, -227<sup>0</sup>
- 1570 *Brachydiceratherium lemanense* (type species): 11<sup>1</sup>, 40<sup>1</sup>, 45<sup>1</sup>, -47<sup>0</sup>, 48<sup>1</sup>, -50<sup>0</sup>, -70<sup>0</sup>, 147<sup>1</sup>, -226<sup>1</sup>
- 1571
- 1572
- 1573