Nasutoceratops titusi (Ornithischia: Ceratopsidae), a basal centrosaurine ceratopsid from the
Kaiparowits Formation, southern Utah

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TABLE S1. Length measurements for Long bone elements of the holotype left forelimb.

ELEMENT	LENGTH (mm)
Radius	335
Ulna	400
Humerus	475
Scapula (partial)	280

TABLE S2. Character-taxon matrix. **A**, (0,1); **B**, (1,3); **C**, (2,3).*Leptoceratops gracilis*

10	20	30	40	50	60	70
1??0???001	0001?00?0?	?0?00?????	000?0000?0	000000?00?	??????????	?????????00
80	90	97				
0000000000	0000000000	00000000				

Protoceratops andrewsi

10	20	30	40	50	60	70
0??0???000	0000100000	00?0??????	000?0000?0	010000?000	0?0????????	?????????00
80	90	97				
0000000000	0000000000	00000000				

Magnirostris dodsoni

10	20	30	40	50	60	70
1??0???000	1100000001	00??1000??	000?0000??	????0?????	??????????	?????????00
80	90	97				
100?0?????	??????????	???????				

Bagaceratops rozhdestvenskyi

10	20	30	40	50	60	70
1??0???000	1000000000	00??0?????	000?0000?0	01??00?00?	??????????	?????????00
80	90	97				
10000?????	??????????	???????				

Turanoceratops tardabilis

10	20	30	40	50	60	70
??????????	?????0000?	????00001?1	?1?????0??	??????????	??????????	?????????00
80	90	97				
0????0????	??????????	???????				

Zuniceratops christopheri

10	20	30	40	50	60	70
1000000???1	010000000?	?100000102	?1101100??	0?0????001	0?0????????	?????????00
80	90	97				
000000????1	10?????????	?01?0??				

Chasmosaurus belli

10	20	30	40	50	60	70
100111000?	0100111111	101?000A02	0111111111	1011111110	0011100103	00?0?0?011
80	90	97				
0111111111	1111111111	11111111				

Pentaceratops sternbergii

10	20	30	40	50	60	70
100111000?	0110111111	1010001112	0111111111	1011111110	0011100103	00?0?0?011
80	90	97				
0111111111	1111111111	111?111				

Diabloceratops eatoni

10	20	30	40	50	60	70
0110000101	0010000?00	01??000102	?110110100	0110010111	1110011100	000101011?

TABLE S2. (Continued)

80	90	97				
????1???	????????	??????				
<i>Albertaceratops nesmoi</i>						
10	20	30	40	50	60	70
?1?000???	??01?101?0	0???000112	?111111??0	0110010111	1110011110	00010101?1
80	90	97				
101111????	??????????	??????				
<i>Rubeosaurus ovatus</i>						
10	20	30	40	50	60	70
01??0001?1	??0??????1	??0?000022	?1????????	?????101??	1?100?1000	101111?1??
80	90	97				
??????????	??????????	??????				
<i>Styracosaurus albertensis</i>						
10	20	30	40	50	60	70
0110000111	1001?11111	0100000022	1111111100	0110010111	1110011100	0111111111
80	90	97				
1011111?11	1101111111	101111?				
<i>Spinops sternbergorum</i>						
10	20	30	40	50	60	70
??1?00????	???1?????1	??0?000022	?111????10?	?????10111	1?100??112	000?0?0???
80	90	97				
??????????	??????????	??????				
<i>Centrosaurus apertus</i>						
10	20	30	40	50	60	70
0110000111	1001?11111	0100000020	1111111100	0110010111	1110011112	0001010111
80	90	97				
1011111111	1101111111	1011111				
<i>Coronosaurus brinkmani</i>						
10	20	30	40	50	60	70
011?000111	??01?11111	0100001020	1111111100	0110010111	111001111?	?001010111
80	90	97				
1011111?11	?1????1111	10?111?				
<i>Xenoceratops foremostensis</i>						
10	20	30	40	50	60	70
??????????	??????????	0?????????	??????????	01?0010?11	1?1??11101	00010101??
80	90	97				
??????????	??????????	??????				
<i>Sinoceratops zhuchengensis</i>						
10	20	30	40	50	60	70
??1???????	???001????	?????00022	010????100	011000?111	111001111B	00010101??
80	90	97				
??????????	?1????11??	???11??				
<i>Einiosaurus procurvicornis</i>						
10	20	30	40	50	60	70
?11?000???	???1?11111	0111100022	010?111100	0110010111	1110011000	1A01010111

TABLE S2. (Continued)

80	90	97				
1011111?11	?1??1?111?	?1111??				
<i>Achelousaurus horneri</i>						
10	20	30	40	50	60	70
011?000111	10?1?11112	0111100022	?10?1?1100	0110010111	11100?1000	1101010111
80	90	97				
101111????	?????????	???????				
<i>Pachyrhinosaurus Canadensis</i>						
10	20	30	40	50	60	70
0110000111	10?1?11112	011?110022	?10?111100	?1100??11?	??1???1012	1101010111
80	90	97				
101???????	?????????	???????				
<i>Pachyrhinosaurus lakustai</i>						
10	20	30	40	50	60	70
0110000111	1001?11112	0111110022	?10?1?1100	0110010111	1110011112	1101010111
80	90	97				
1011111?11	?1??111111	10111??				
<i>Pachyrhinosaurus perotorum</i>						
10	20	30	40	50	60	70
01?0000111	???1?11?12	01??110022	?10????1??	??1?010?11	1?1???111C	11010101??
80	90	97				
???1?1???1	?????????	?0111??				
<i>Avaceratops lammersi</i>						
10	20	30	40	50	60	70
01?0000111	10?1?10100	011?001111	?11011?100	011000?11?	?0100?1100	000101011?
80	90	97				
?011111111	?10?11????	???1?1?				
<i>Nasutoceratops titusi</i>						
10	20	30	40	50	60	70
0110000111	1001?10100	011?001112	?110??1100	011000?111	1010011100	00010101??
80	90	97				
?????111?1	?10???????	???????				

TABLE S3. List of currently recognized ceratopsid taxa.

	Taxon	Specimen Number	Formation	Location	Age
1	<i>Diabloceratops eatoni</i>	UMNH VP 16699	Wahweap	Southern Utah	late Camp.
2	<i>Albertaceratops nesmoi</i>	TMP 2001.26.01	Oldman	Alberta	late Camp.
3	<i>Nasutoceratops titusi</i>	UMNH VP 16800	Kaiparowits	Southern Utah	late Camp.
4	<i>Avaceratops lammersi</i>	ANSP 15800 MOR 692	Judith River Judith River	Montana Montana	late Camp. late Camp.
5	<i>Centrosaurus apertus</i>	NMC 971	Dinosaur Park	Alberta	late Camp.
6	<i>Coronosaurus brinkmani</i>	TMP 2002.68.1	Oldman	Alberta	late Camp.
7	<i>Rubeosaurus ovatus</i>	USNM 11869/ MOR 492	Two Medicin	Montana	late Camp.
8	<i>Styracosaurus albertensis</i>	CMN 344	Dinosaur Park	Alberta	late Camp.
9	<i>Einiosaurus procurvicornis</i>	MOR 456-8-9-6-1	Two Medicin	Montana	late Camp.
10	<i>Achelousaurus horneri</i>	MOR 485	Upper Two Medicine Horseshoe Canyon	Montana Alberta	late Camp. Maast.
11	<i>Pachyrhinosaurus canadensis</i>	NMC 8867	St. Mary River Prince Creek	Alberta Alaska	Maast. Maast.
12	<i>Pachyrhinosaurus lakustai</i>	TMP 1986.55.258	Wapiti	Alberta	Camp.- Maast.
13	<i>Chasmosaurus belli</i>	NMC 0491	Dinosaur Park	Alberta	late Camp.
14	<i>Chasmosaurus russelli</i>	CMN 8800	Dinosaur Park	Alberta	late Camp.
15	<i>Chasmosaurus kaiseni</i>	AMNH 5401	Dinosaur Park	Alberta	late Camp.
16	<i>Chasmosaurus irvinensis</i>	CMN 41357	Dinosaur Park	Alberta	late Camp.
17	<i>Kosmoceratops richardsoni</i>	UMNH VP 17000	Kaiparowits	Southern Utah	late Camp.

TABLE S3. (Continued)

18	<i>Agujaceratops mariscalensis</i>	UTEP P.37.7.086	Aguja	Texas	Camp.
19	<i>Utahceratops gettyi</i>	UMHH VP 16784	Kaiparowits Fruitland,	Southern Utah	late Camp.
20	<i>Pentaceratops sternbergii</i>	AMNH 6325	Lower Kirtland	New Mexico	Camp.-Maast.
21	<i>Coahuilaceratops magnaquerna</i>	CPC 276	Cerro del Pueblo	Mexico	Camp.
22	<i>Anchiceratops ornatus</i>	AMNH 5251	Horseshoe Canyon,	Alberta	Maast.
23	<i>Arrhinoceratops brachyops</i>	ROM 5135	Horseshoe Canyon, Lance	Alberta Wyoming	Maast. Maast.
24	<i>Torosaurus latus</i>	ANSP 15192	Kirtland McRae	New Mexico New Mexico	Maast. Maast.
			Javelina	Texas	Maast.
			Hell Creek	Montana	Maast.
			Hell Creek	South Dakota	Maast.
			Frenchman	Saskatchewan	Maast.
25	<i>Torosaurus utahensis</i>	USNM 15583	North Horn	Utah	Maast.
26	<i>Eotriceratops xerinsularis</i>	RTMP 2002.57.7	upper Horseshoe Canyon	Alberta	Maast.
27	<i>Nedoceratops hatcheri</i>	USNM 2412	Lance	Wyoming	Maast.
			Lance	Wyoming	Maast.
			Hell Creek	Montana	Maast.
28	<i>Triceratops horridus</i>	YPM 1820	Hell Creek	North Dakota	Maast.
			Hell Creek	South Dakotas	Maast.
			Laramie	Colorado	Maast.
29	<i>Triceratops prorsus</i>	YPM 1822	Lance	Wyoming	Maast.
		UND 3000	Hell Creek	Montana	Maast.
	(<i>Tatankaceratops</i>)	AMNH 6325	Hell Creek	North Dakota	Maast.
			Frenchman	Saskatchewan	Maast.
			Hell Creek	South Dakota	Maast.

APPENDIX S1. SPECIFIC SPECIMEN SOURCES USED FOR CHARACTER SCORING

<i>Leptoceratops gracilis</i>	AMNH 2571; CMN 8887, 8889
<i>Protoceratops andrewsi</i>	AMNH 6251, 6408, 6414, 6418, 6425, 6429, 6430, 6438, 6441, 6443, 6444, 6447, 6449, 6451, 6466, 6473, 6477, 6480, 6483, 6485, 6486, 6487 6637, 6638; BMNH R6640; R10060; IGM 100-500, 100-502, 100-522, 100-581, IVPP V12513
<i>Magnirostris dodsoni</i>	IGM 100-1008, 100-1013
<i>Bagaceratops rozhdestvenskyi</i>	ZIN PH 1868/16
<i>Turanoceratops tardabilis</i>	MSM P2101, 2102, 2110, 2224, 2225, 3196, 3197, 3201 and other MSM specimens
<i>Zuniceratops christopherei</i>	AMNH 5402; CMN 2245; ROM 843; YPM 2016
<i>Chasmosaurus belli</i>	AMNH 1624; MNA 1747; NMMNM P25084, 27468, 50000, OMNH 10165; PMU R200; SMP V1500
<i>Pentaceratops sternbergii</i>	UMNH VP 16699
<i>Diabloceratops eatoni</i>	TMP 2002.26.1
<i>Albertaceratops nesmoi</i>	MOR 492; USNM 11869
<i>Rubeosaurus ovatus</i>	AMNH 5361; CMN 344; ROM 1436; TMP 66.10.28, 89.97.01 2005.42.58
<i>Styracosaurus albertensis</i>	NHMUK R16307, 16308, 16309
<i>Spinops sternbergorum</i>	AMNH 5239, 5432; NHMUK R4244, 4245, 4859; CMN 348, 971, 8790, 8795, 8798, 11839; ROM 767, 793, 3521, 12782, 12787, 43214; SDNHM 32700, 32702; TMP 67.20.241, 79.11.38, 80.18.115, 82.16.11, 93.36.117, 95.175.64, 95.400.43, UALVP 11735, 16248; USNM 8897; YPM 2015
<i>Centrosaurus apertus</i>	TMP 2002.68.1-3, 5-7, 10-13, 18, 21, 30-32, 38, 41, 43, 46, 56, 75-84, 87, 89-91, 94, 97-101, 105, 111, 114, 120, 125, 127, 129, 130, 134, 142, 168, 173-174, 176, 182, 191, 192, 195, 1995.12.145, 1995.12.69, 1999.82.1
<i>Coronosaurus brinkmani</i>	CMN 53282, 54950, 54952-54965
<i>Xenoceratops foremostensis</i>	ZCDM V0010, 0012, various other ZCDM specimens
<i>Sinoceratops zhuchengensis</i>	MOR 373, 456, 891, 681, USNM 12745
<i>Einiosaurus procurvicornis</i>	MOR 485
<i>Achelousaurus horneri</i>	CMN 8867, 9485, 8863, 9602, 10644
<i>Pachyrhinosaurus canadensis</i>	TMP 83.55.15, 85.55.211, 86.55.47, 86.55.113, 86.55.157, 86.55.193, 239, 86.55.258, 86.55.261, 87.55.137, 87.55.141, 87.55.164, 87.55.210, 87.55.232, 87.55.252, 87.55.258, 88.55.46, 88.55.146, 89.55.125, 89.55.156, 89.55.170, 89.55.256, 89.55.427, 89.55.499, 89.55.547, 89.55.757, 89.55.781, 89.55.1085, 89.55.1144; 89.55.1234, 89.55.1503
<i>Pachyrhinosaurus lakustai</i>	DMNH 21200, 21201, 22558
<i>Pachyrhinosaurus perotorum</i>	ANSP 15800; MOR 692
<i>Avaceratops lammersi</i>	UMNH VP 16800, 19466, 19469
<i>Nasutoceratops titusi</i>	

APPENDIX S2. PHYLOGENETIC ANALYSIS CHARACTERS

The 97 characters (76 cranial and 21 postcranial) used in the phylogenetic analysis are listed below. This character list is identical to that of Farke et al. (2011). Previous uses of characters prior to Farke et al., (2011) are indicated by citations in parentheses. The characters are listed by general anatomical category, with citations indicating first use within a cladistic context. Original uses within a non-cladistic context (e.g., within a taxonomic diagnosis) are not considered. Taxa are scored for the adult condition wherever possible. There is one ordered character, number 20 (Forster, 1990).

Dermal skull roof

- (1) Anterior, extent of dorsal and ventral processes: triangular in lateral view, with short dorsal and ventral processes (0); elongate, with deeply concave caudal margin and hypertrophied dorsal and ventral processes (1); (Dodson et al., 2004, character 1).
- (2) Premaxillary septum, shape: anteriorly elongate (0); semicircular (1); (Dodson et al., 2004, character 4).
- (3) Premaxillary septum, nasal contribution: septum formed by premaxilla only (0); septum formed by premaxilla and nasal (1); (Sampson et al., 2010, character 5).
- (4) Premaxilla, narial strut: absent (0); present (1); (Holmes et al., 2001, character 1).
- (5) Premaxilla, septal fossa: absent (0); present (1); (Holmes et al., 2001, character 4).
- (6) Premaxilla, triangular process: absent (0); present (1); (Forster, 1990, character 21).
- (7) Premaxilla, recess along ventral portion of septum: absent (0); present (1); (Dodson et al., 2004, character 9).
- (8) Premaxilla, posteroventral expansion of oral margin: absent (0); present (1); (Forster, 1990, character 6).
- (9) Premaxilla, ventral extent of posteroventral oral margin: at or above level of alveolar margin of maxilla (0); well below alveolar margin of maxilla (1); (Makovicky and Norell, 2006, character 12, modified).
- (10) Posteroventral oral margin, composition of ventral angle: premaxilla and maxilla (0); premaxilla only (1); (Makovicky and Norell, 2006, character 12, modified).
- (11) Premaxilla, position of caudal tip of posteroventral process: inserts into an embayment in the nasal (0); intervenes between nasal and maxilla (1); (Forster et al., 1993, character 7).
- (12) Premaxilla, distal end of posteroventral process forked: absent (0); present (1); (Forster, 1990, character 14).
- (13) Premaxilla-nasal contact in dorsal view: premaxillae insert between nasal (0); nasals insert between premaxillae (1); (Sampson et al., 2010, character 20).
- (14) Accessory antorbital fenestra: present (0); absent (1); (Forster, 1990, character 15).
- (15) Accessory antorbital fenestra size: pronounced, penetration of nasal cavity visible in lateral view (0); slight penetration, nasal cavity not visible in lateral view (1); (Sampson et al., 2010, character 22).
- (16) External antorbital fossa, size: large, 20% or more length of body of maxilla (0); greatly reduced or absent, less than 10% length of body of maxilla (1); (Forster, 1990, character 44).
- (17) Maxillary tooth row, position: ventrally displaced from anterior edentulous portion of maxilla (0); at same level as anterior edentulous portion of maxilla (1); (Sampson et al., 2010, character 24).
- (18) Maxilla, maxillary cavity: absent (0); present (1); (Sampson et al., 2010, character 26).

APPENDIX S2. (Continued)

- (19) Ectopterygoid/pterygoid complex: covers entire dorsal surface and laps onto lateral surface of caudal ramus of maxilla (0); ectopterygoid vestigial (1); (Sampson et al., 2013).
- (20) Nasal, ornamentation type in adult (ORDERED): non-pronounced (0); distinct horncore; (2) pachyostotic boss (1); (Forster, 1990, character 26, 27, 28, 126, modified).
- (21) Epinasal ossification on nasal: absent (0); present (1); (Sampson et al., 2013).
- (22) Nasal, narial spine: absent (0); present (1); (Forster, 1990, character 22).
- (23) Postorbital, extent of cornual sinuses in base of supraorbital ornamentation: sinus invades frontal and parietal (0); sinus enters postorbital (1); (Forster, 1990, character 123, modified).
- (24) Postorbital, type of supraorbital ornamentation in subadult: pointed apex, horncore at least as tall as anteroposteriorly long (0); rounded apex, horncore anteroposteriorly longer than tall (1); (Sampson, 1995, character 10, modified).
- (25) Postorbital, type of supraorbital ornamentation in adult: horncore (0); rugose boss (1); (Sampson, 1995, character 9, modified).
- (26) Postorbital, position of supraorbital horncore: centered anterodorsal or dorsal to orbit, narrow base with caudal margin of supraorbital horncore extending to or only slightly behind caudal margin of orbit (0); centered posterodorsal to orbit, broad base with caudal margin of supraorbital horncore extending well behind caudal orbit (1); (Lehman 1996, character 9).
- (27) Postorbital, orientation of supraorbital horncore base: dorsally directed (0); dorsolaterally directed (1); (Sampson et al., 2010, character 38).
- (28) Postorbital, length of supraorbital horncore: short, less than 15% basal skull length (0); present, elongate, greater than 35% basal skull length (1); (Forster, 1990, character 58, modified).
- (29) Postorbital, curvature of supraorbital horncore in lateral view: posteriorly recurved (0); anteriorly curved (1); straight (2); (Forster et al., 1993, character 2, modified).
- (30) Postorbital, curvature of supraorbital horncore in anterior view: medially recurved (0); laterally curved (1); straight (2); (Sampson et al., 2010, character 41).
- (31) Prefrontal-prefrontal contact: absent (0); present (1); (Forster, 1990, character 30, modified).
- (32) Palpebral, shape: rod-like, articulates with prefrontal only at its base and projects across dorsal orbit, ligamentous attachment (0); blocky, fully fused into dorsal orbital margin, sutural articulation with prefrontal and frontal (1); (Forster, 1990, character 31, modified).
- (33) Palpebral, antorbital buttress: absent (0); present (1); (Sampson, 1995, character 7, modified).
- (34) Palpebral, extent of antorbital buttress: present along only anterodorsal portion of orbit (0); present along entire anterior portion of orbit (1); (Currie et al., 2008, modified).
- (35) Jugal, size and orientation of jugal body: projects strongly posteroventrally, does not extend below the level of the maxillary tooth row (0); projects nearly ventrally, elongated to extend below the level of the maxillary tooth row (1); (Makovicky, 2001, character 22).
- (36) Jugal infratemporal process: absent (0); present, contacts or nearly contacts infratemporal process of squamosal (1); (Forster, 1990, character 62, modified).
- (37) Epijugal attachment scar: large blade like triangle with obtuse angle oriented towards quadratojugal (0); scar roughly equilateral in shape (1); (Serenio, 1999, character 113, modified).
- (38) Frontal fontanelle leading into supracranial cavity complex: absent (0); present (1); (Forster et al., 1993, character 3, modified).

APPENDIX S2. (Continued)

- (39) Frontal fontanelle, shape: transversely narrow, slit-like (0); key-hole shaped, circular or elongate oval (1); (Forster, 1990, characters 49 and 50, modified).
- (40) Parietal, anterior extent on dorsum of skull relative to occipital condyle: anterior end of parietal located well in front of occipital condyle (0); anterior end of parietal lies directly over occipital condyle (1); (Sampson et al., 2010, character 57).
- (41) Squamosal, shape of expanded blade: sub-rectangular in outline (0); triangular in outline, posteriorly narrowed (1); (Sampson et al., 2010, character 59).
- (42) Squamosal, anteromedial lamina forming the posterolateral floor of dorsotemporal fenestra: absent (0); present (1); (Penkalski and Dodson, 1999, character 9).
- (43) Squamosal-quadrate contact: socket-like cotylus on ventrolateral squamosal for ball-like quadrate head (0); elongate groove on medial surface of squamosal to receive lamina of quadrate (1); (Forster, 1990, character 64, modified).
- (44) Squamosal, thickened, rounded swelling along medial margin: absent, lateral surface of squamosal flat to slightly convex (0); present, lateral surface of squamosal slightly concave (1); (Forster, 1990, character 90).
- (45) Parietosquamosal contact, shape in lateral view: straight (0); curved, medially concave (1); (Forster, 1990, character 119).
- (46) Parietal, concave median embayment on caudal margin: absent (0); present (1); (Sampson et al., 2010, character 66).
- (47) Parietal, shape of concave median embayment: shallow, restricted to center of margin (0); shallow, entire transverse bar is a V-shaped embayment (1); (Forster, 1990, character 83, modified).
- (48) Parietal, rim on medial margin of dorsotemporal fenestra: absent (0); present, well-defined, laterally projecting rim defines medial margin of fenestra (1); (Forster, 1990, character 86).
- (49) Parietal, sharp median crest: absent (0); present (1); (Sampson et al., 2010, character 75).
- (50) Parietal, antero-caudal thickness of transverse bar at narrowest point: narrow and straplike, less than 10% total parietal length (0); broad, 20% or more of total parietal length (1); (Holmes et al., 2001, character 22).
- (51) Parietal, median bar, transverse width: narrow and straplike, transverse width less than 10% total parietal length (0); relatively wide, transverse width 15% or more of total parietal length (1); (Holmes et al., 2001, character 23).
- (52) Parietosquamosal frill, imbrication of marginal undulations: absent (0); present (1); (Dodson et al., 2004, character 34).

Epiossifications

- (53) Marginal dermal ossifications on parietal and squamosal: absent (0); present (1); (Forster, 1990, characters 91 and 92, modified).
- (54) Episquamosal, midlateral, shape: crescentic or ellipsoidal (0); triangular or elongate (1); (Dodson et al., 2004, character 45, modified).
- (55) Episquamosals, number per side: three to five (0); six or more (1); (Sampson et al., 2013).
- (56) Marginal ossification crossing squamosal-parietal contact: absent (0); present (1); (Dodson et al., 2004, character 43).
- (57) Epiparietals, number per side: three (0); five or more (1); (Holmes et al., 2001, character 28).
- (58) Epiparietal locus P1: absent (0); present (1); (Sampson, 1995, character 14, modified).

APPENDIX S2. (Continued)

- (59) Epiparietal, shape of locus P2: low D-shaped process, wider than long (0); elongate flattened process or spike, longer than wide (1); (Sampson, 1995, character 15, modified).
- (60) Epiparietal, curvature of locus P2: straight (0); laterally curved (1); medially curved (2); dorsally curved (3); (Sampson, 1995, character 15, modified).
- (61) Epiparietal, shape of locus P3: low D-shaped or triangular process (0); elongate flattened process or spike (1); (Sampson, 1995, character 16, modified).
- (62) Epiparietal, curvature of locus P3: uncurved or slightly medially curved (0); laterally curved (1); dorsally curved (2); (Sampson et al., 2013).
- (63) Epiparietal, locus P4 shape: low raised D-shaped process (0); elongate spike (1); (Sampson et al., 2010, character 102, modified).
- (64) Epiparietal, locus P5: absent (0); present (1); (Sampson et al., 2013).
- (65) Epiparietal, locus P5 shape: low D-shaped or triangular process (0); elongate spike (1); (Sampson et al., 2013).
- (66) Epiparietal, locus P6: absent (0); present (1); (Sampson et al., 2013).
- (67) Epiparietal, locus P6 shape: low D-shaped or triangular process (0); elongate spike (1); (Sampson et al., 2013).
- (68) Epiparietal, locus P7: absent (0); present (1); (Sampson et al., 2013).

Braincase

- (69) Supraoccipital, contribution to foramen magnum: forms dorsal margin of foramen magnum (0); eliminated from margin by exoccipital-exoccipital contact on midline (1); (Forster, 1990, character 63).

Lower jaw

- (70) Predentary, dentary processes: ventral processes much longer than abbreviated dorsal processes (0); dorsal and ventral processes elongate and subequal in length (1); (Sampson et al., 2010, character 114).
- (71) Predentary, orientation of triturating surface: nearly horizontal (0); inclined steeply laterally (1); (Dodson et al., 2004, character 57).
- (72) Dentary lateral ridge confluent with cutting surface of predentary: present (0); absent (1); (Sampson et al., 2010, character 116).
- (73) Dentary, caudal extent of tooth row: terminates at the center of the coronoid process (0); terminates caudal to the coronoid process (1); (Chinnery and Weishampel 1998, character 18).

Dentition

- (74) Teeth, number of roots: one (0); two (1); (Forster, 1990, character 34).
- (75) Teeth, number of alveoli in dentary: fewer than 20 (0); more than 20 (1); (Makovicky and Norell, 2006, character 104).
- (76) Teeth, number of replacements per alveolus: one or two replacement teeth (0); three or more replacement teeth (1); (Serenó, 1999, character 137).

Axial skeleton

APPENDIX S2. (Continued)

- (77) Cervical vertebrae, formation of syncervical: C1-3 fused or tightly articulated, atlantal hypocentrum present as a ventrally placed, wedge-like bone (0); C1-3 firmly fused, atlantal hypocentrum forms a complete ring (1); (Forster, 1990, character 122).
- (78) Axis, neural spine shape and orientation: blade-like and nearly vertical, overhangs only anteriormost portion of C3 (0); blade-like morphology lost, spine steeply angled to reach caudal margin of C3 (1); (Serenio, 1999, character 141).
- (79) Atlantal rib: present (0); absent (1); (Sampson et al., 2010, character 129).
- (80) Dorsal vertebrae, shape of centra: relatively axially elongate (0); axially shortened (1); (Sampson et al., 2010, character 130).
- (81) Sacrum, longitudinal sulcus on ventral surface: absent (0); present (1); (Serenio, 1999, character 144).

Pectoral girdle and forelimb

- (82) Scapula, relative contribution to glenoid fossa: scapula and coracoid contribute equally (0); scapula contributes well over half of the glenoid (1); (Serenio, 1999, character 145).
- (83) Olecranon process: relatively small (0); enlarged (>one-third of ulnar length) (1); (Forster, 1990, character 104, modified).
- (84) Clavicle: present (0); absent (1); (Serenio, 1999, character 147).
- (85) Manual and pedal unguals, shape: taper to distal tip (0); dorsoventrally flattened with blunt and rounded distal tips (1); (Chinnery and Weishampel 1998, character 64).
- (86) Manal and pedal penultimate phalanges shape: length exceeds width (0); width exceeds length (1); (Sampson et al., 2010, character 137).

Pelvic girdle and hind limb

- (87) Ilium, lateral eversion of dorsal margin: absent (0); present (1); (Forster, 1990, characters 108-109, modified).
- (88) Ilium, relative lengths of pubic and ischial peduncles: pubic and ischial peduncles long, extend well below body of ilium approximately the same distance (0); ischial peduncle reduced along ventral aspect, pubic peduncle projects further ventrally than ischial peduncle (1); (Sampson et al., 2010, character 139).
- (89) Pubis, prepubic process: short and unexpanded distally (0); elongate, distal end greatly expanded dorsoventrally (1); (Forster, 1990, character 111).
- (90) Pubis, position and length of postpubic rod: relatively short but extends past ischial peduncle of ilium, arises ventral to acetabulum and lies along ventral and ventromedial margin of ischium (0); very abbreviated, terminates at level of ischial peduncle, arises medial to acetabulum and passes entirely medial to ischium (1); (Forster, 1990, character 110).
- (91) Pubis and ischium, morphology of contributions to acetabulum: pubic acetabular surface faces posterolaterally, pubis and pubic process of ischium contribute equally to ventral margin of acetabulum (0); pubic acetabular surface faces laterally and forms a partial medial wall to the acetabulum, pubic process of ischium elongate and meets pubis close to anterior margin of acetabulum, ventral portion of pubic acetabular surface lies medial to pubic ramus of ischium (1); (Sampson et al., 2010, character 142).
- (92) Ischium, cross-sectional shape of shaft: thick and ovoid (0); laterally compressed and bladelike, tapered dorsally (1); (Forster, 1990, character 112).

APPENDIX S2. (Continued)

- (93) Ischium, orientation of shaft: nearly straight or slightly decurved (0); broadly and continuously curved (1); (Forster, 1990, character 113).
- (94) Femur, morphology of greater and lesser trochanters: trochanters distinct and located below the level of the femoral head (0); trochanters coalesced and level with the femoral head (1); (Dodson et al., 2004, character 72).
- (95) Femur, size of fourth trochanter: large and pendant (0); small, reduced to low prominence (1); (Serenio, 1999, character 154).
- (96) Femur-tibia proportion: tibia longer than femur (0); femur longer than tibia (1); (Forster, 1990, character 103).
- (97) Pes, metatarsal proportions: length of MT I two-thirds the length of MT II (0); MT I reduced to one half or less the length of MT II (1); (Sampson et al., 2010, character 148).

APPENDIX S3. PARAMETER SETTINGS IN MRBAYES

#NEXUS

BEGIN DATA;

DIMENSIONS NTAX=24 NCHAR=97;

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matrix

Leptoceratops gracilis

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80	90	97				
0000000000	0000000000	00000000				

Protoceratops andrewsi

10	20	30	40	50	60	70
0??0??000	0000100000	00?0???????	000?0000?0	010000?000	0?0????????	?????????00
80	90	97				
0000000000	0000000000	00000000				

Magnirostris dodsoni

10	20	30	40	50	60	70
1??0??000	1100000001	00??1000??	000?0000??	????0?????	???????????	?????????00
80	90	97				
100?0?????	???????????	????????				

Bagaceratops rozhdestvenskyi

10	20	30	40	50	60	70
1??0??000	1000000000	00??0?????	000?0000?0	01??00?00?	???????????	?????????00
80	90	97				
10000?????	???????????	????????				

Turanoceratops tardabilis

10	20	30	40	50	60	70
???????????	?????0000?	????0001?1	?1?????0??	???????????	???????????	?????????00
80	90	97				
0????0????	???????????	????????				

Zuniceratops christopheri

10	20	30	40	50	60	70
1000000???	010000000?	?100000102	?1101100??	0?0????001	0?0????????	?????????00
80	90	97				
000000????1	10?????????	?01?0??				

APPENDIX S3. (Continued)

Chasmosaurus belli

10	20	30	40	50	60	70
??????????	??????????	0?????????	??????????	01?0010?11	1?1???11101	00010101??
80	90	97				
??????????	??????????	????????				
<i>Sinoceratops zhuchengensis</i>						
10	20	30	40	50	60	70
??1??????	???001???1	?????00022	010????100	011000?111	111001111B	00010101??
80	90	97				
??????????	?1????11??	???11??				
<i>Einiosaurus procurvicornis</i>						
10	20	30	40	50	60	70
?11?000???	???1?11111	0111100022	010?111100	0110010111	1110011000	1A01010111
80	90	97				
1011111?11	?1??1?111?	?1111??				
<i>Achelousaurus horneri</i>						
10	20	30	40	50	60	70
011?000111	10?1?11112	0111100022	?10?1?1100	0110010111	11100?1000	1101010111
80	90	97				
101111????	??????????	??????				
<i>Pachyrhinosaurus Canadensis</i>						
10	20	30	40	50	60	70
0110000111	10?1?11112	011?110022	?10?111100	?1100?111?	??1???1012	1101010111
80	90	97				
101???????	??????????	??????				
<i>Pachyrhinosaurus lakustai</i>						
10	20	30	40	50	60	70
0110000111	1001?11112	0111110022	?10?1?1100	0110010111	1110011112	1101010111
80	90	97				
1011111?11	?1?1111111	10111??				
<i>Pachyrhinosaurus perotorum</i>						
10	20	30	40	50	60	70
01?0000111	???1?11?12	01??110022	?10????1??	??1?010?11	1?1???111C	11010101??
80	90	97				
???1?1???1	??????????	?0111??				
<i>Avaceratops lammersi</i>						
10	20	30	40	50	60	70
01?0000111	10?1?10100	011?001111	?11011?100	011000?11?	?0100?1100	000101011?
80	90	97				
?011111111	?10?11????	???1?1?				
<i>Nasutoceratops titusi</i>						
10	20	30	40	50	60	70
0110000111	1001?10100	011?001112	?110?11100	011000?111	1010011100	00010101??
80	90	97				
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APPENDIX S3. (Continued)

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CTYPE ordered: 20;

LSET coding=variable rates=gamma;

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constraint root = 1-. ;

constraint Neoceratopsia = 2-. ; [ingroup]

constraint Ceratopsidae = 7-. ;

constraint Centrosaurinae = 9-. ;

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CALIBRATE *Protoceratops_andrewsi* =fixed(73.2); [Carpenter et al., 2011; Shuvalov, 2000; Hicks et al., 2001; Dashzeveg et al., 2005]

CALIBRATE *Magnirostris_dodsoni* =fixed(71.8); [Carpenter et al., 2011; Shuvalov, 2000; Hicks et al., 2001; Dashzeveg et al., 2005]

CALIBRATE *Bagaceratops_rozhdestvenskyi* =fixed(73.2); [Carpenter et al., 2011; Shuvalov, 2000; Hicks et al., 2001; Dashzeveg et al., 2005]

CALIBRATE *Turanoceratops_tardabilis* =fixed(90.5); [Sues and Averianov, 2009]

CALIBRATE *Zuniceratops_christopherei* =fixed(90.5); [Wolf et al., 2010]

APPENDIX S3. (Continued)

CALIBRATE *Chasmosaurus_belli* =fixed(75.8); [Ryan and Evans, 2005; Roberts et al., 2005; Roberts et al., 2013]

CALIBRATE *Pentaceratops_sternbergii* =fixed(73.9); [Sullivan and Lucas, 2006; Roberts et al., 2005; Roberts et al., 2013]

CALIBRATE *Diabloceratops_eatoni* =fixed(79.8); [Jinnah et al., 2009; Roberts et al., 2013]

CALIBRATE *Albertaceratops_nesmoi* =fixed(77.7); [Ryan, 2007; Roberts et al., 2005; Roberts et al., 2013]

CALIBRATE *Rubeosaurus_ovatus* =fixed(74.5); [McDonald and Horner, 2010; Roberts et al., 2005; Roberts et al., 2013]

CALIBRATE *Styracosaurus_albertensis* =fixed(75.6); [Ryan and Evans, 2005; Roberts et al., 2005; Roberts et al., 2013]

CALIBRATE *Spinops_sternbergorum* =fixed(77.3); [Farke et al., 2011; Roberts et al., 2005; Roberts et al., 2013]

CALIBRATE *Centrosaurus_apertus* =fixed(76.3); [Ryan and Evans, 2005; Roberts et al., 2005; Roberts et al., 2013]

CALIBRATE *Coronosaurus_brinkmani* =fixed(77.3); [Ryan and Russell, 2005; Roberts et al., 2005; Roberts et al., 2013]

CALIBRATE *Xenoceratops_foremostensis* =fixed(79.2); [Ryan et al., 2012; Roberts et al., 2005; Roberts et al., 2013]

CALIBRATE *Sinoceratops_zhuchengensis* =fixed(72.4); [Hone et al., 2011]

CALIBRATE *Einiosaurus_procurvicornis* =fixed(74.4); [Sampson, 1995; Roberts et al., 2005; Roberts et al., 2013]

APPENDIX S3. (Continued)

CALIBRATE *Achelousaurus_horneri* =fixed(74.2); [Sampson, 1995; Roberts et al., 2005;

Roberts et al., 2013]

CALIBRATE *Pachyrhinosaurus_canadensis* =fixed(71.7); [Campbell et al., 2012; Eberth and

Braman, 2012]

CALIBRATE *Pachyrhinosaurus_lakustai* =fixed(73.2); [Currie et al., 2008]

CALIBRATE *Pachyrhinosaurus_perotorum* =fixed(69.5); [Fiorillo and Tykoski, 2012]

CALIBRATE *Avaceratops_lammersi* =fixed(78.3); [Dodson, 1986; Penkalski and Dodson,

1999; Roberts et al., 2005; Roberts et al., 2013]

CALIBRATE *Nasutoceratops_titusi* =fixed(76.6); [Sampson et al., 2013; Roberts et al., 2005;

Roberts et al., 2013]

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PRSET clockvarpr=igr;

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PRSET clockratepr=normal(0.01,0.1);

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PRSET nodeagepr = calibrated;

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sumt filename=Nasuto_run3_fixed relburnin=yes burninfrac=0.25 contype=allcompat; sump

filename=Nasuto_run3_fixed relburnin=yes burninfrac=0.25;

end;

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