http://app.pan.pl/SOM/app68-Czepinski_SOM.pdf

SUPPLEMENTARY ONLINE MATERIAL FOR

Skull of a dromaeosaurid *Shri devi* from the Upper Cretaceous of the Gobi Desert suggests convergence to the North American forms

Łukasz Czepiński

Published in *Acta Palaeontologica Polonica* 2023 68 (2): 227-243.
https://doi.org/10.4202/app.01065.2023

Supplementary Online Material

Emended diagnosis of *Shri devi*

Shri devi is assigned to Velociraptorinae based on the presence of a distinct ambiens tubercle located proximally on the anterior face of the pubis, a well-developed anterior tuberosity proximally located on the ischium, and a rounded longitudinal ischial ridge (after Turner et al. 2021). Additionally, the maxillary fenestra is positioned in a secondary depression within the antorbital fossa.

S. devi shares with *Velociraptor mongoliensis* a low maxillary body below the antorbital fossa, maxillary fenestra located posteriorly to the anterior margin of the antorbital fossa, pila promaxillaris being relatively anteroposteriorly longer than the pila interfenestralis, and metatarsal I lacking the medial ligament pit.

S. devi differs from *V. mongoliensis* in a very weakly developed mesial serration of teeth, thin ventral margin of the jugal bone, absence of the dorsal recess of the ectopterygoid, deep anterior pedicular fossae in the cervical vertebrae, epipophyses in the last four are not raised but instead represented by rugose circular scars (after Turner et al. 2021), very weakly developed four trochanter of femur, unfused astragalus and calcaneum, metatarsal II proximally wider than metatarsal III (although it may vary intraspecifically within *V. mongoliensis* as seen on MPC-D 100/25) and the lateral position of the tubercles on the anterior surface of metatarsals II and III, absence of the longitudinal ridge between the proximal keel and the medial trochlea of phalanx II-1, medial asymmetry of the phalanx III-1 trochlea, and medially curved phalanx IV-2.

S. devi differs from *Kuru kulla* in absence of the dorsal lacrimal hornlet, presence of the two rows of neurovascular foramina on dentary, very weakly developed mesial serration of teeth, weakly developed surangular shelf, very weakly developed four trochanter of femur, metatarsal I lacking the medial ligament pit, presence of the non-articular shaft of the metatarsal I, metatarsal II proximally wider than metatarsal III, relatively short phalanx II-1.

S. devi shares with *Tsaagan mangas* and *Linheraptor exquisitus* a very weakly developed mesial serration of teeth. *S. devi* further shares with *T. mangas* absence of the dorsoventral constriction of the jugal anteriorly, absence of the dorsal recess of the ectopterygoid, presence of two rows of neurovascular foramina on dentary. *S. devi* shares with *Linheraptor* metatarsal II proximally wider than metatarsal III and lateral position of the tubercles on the anterior surface of metatarsals II and III.

S. devi differs from *Tsaagan mangas* and *Linheraptor exquisitus* in short antorbital fenestra, maxillary fenestra positioned posteriorly to the anterior margin of the antorbital fossa, promaxillary fenestra located anteriorly to the maxillary fenestra, maxillary body dorsoventrally low below the antorbital fossa. It differs from *Linheraptor* in the absence of the dorsal ectopterygoid recess and the absence of the anterior constriction of the jugal bone.

S. devi differs from *Adasaurus mongoliensis* in a thin ventral margin of the jugal bone, metatarsal II proximally wider than metatarsal III and the lateral position of the tubercles on the anterior surface of metatarsals II and III.

The labial ridge of maxilla is more distinct and better developed in ZPAL MgD-I/97 than in any specimen of *V. mongoliensis*. This structure was considered as a diagnostic feature for *V. mongoliensis* by Barsbold and Osmólska (1999); however, it was based mostly on the reference of ZPAL MgD-I/97 to *V. mongoliensis*, and the later authors removed that feature from the revised diagnosis of the species (see Turner et al. 2012). In several specimens of *V. mongoliensis* (e.g., AMNH 6515, MPC-D 100/24, 25, 54, PIN 3143/8), there is a swollen surface bordering the antorbital fossa ventrally. There is no such ridge in *T. mangas, L. exquisitus,* nor in *"V." osmolskae* where the margin smoothly flush into the lateral wall of maxilla posteriorly. Although the ridge in ZPAL MgD-I/97 is parallel to the alveolar margin for the majority of its length, it differs from the alveolar ridge described by Tykoski (2005) in coelophysoid dinosaurs as the ventral part of the maxilla is not inset ventral to the ridge, but gradually slopes ventromedially. It is, however, similar to the condition seen in dromaeosaurids *Shanag ashile*, *Sinornithosaurus millenii* and *Daurlong wangi* (Xu et al. 2001, Turner et al. 2007a, Wang et al. 2022).

Remarks on the specimens of *Shri devi*.

ZPAL MgD-I/97 was collected in 1970 by the Polish-Mongolian Palaeontological Expedition. The metatarsus of the specimen was mentioned as *Velociraptor* sp. by Osmólska (1981, 1982), and the skull and mandibles were described and illustrated, with a particular emphasis on the palate region, as *Velociraptor mongoliensis* by Barsbold and Osmólska (1999: figs. 7, 8). This taxonomic identification of the specimen was adopted by subsequent authors (Alifanov 2012; Turner et al. 2012), with Napoli et al. (2021) mentioning the ambiguity of such assignment. The postcranial of ZPAL MgD-I/97 was captioned as the right

(sic) pes of *V. mongoliensis* by Feduccia et al. (2007: fig. 2). Recently, it was mentioned as an eudromeaosaurian distinct from *Kuru kulla* by Napoli et al. (2021). Although Barsbold and Osmólska (1999) illustrated the isolated tooth ZPAL MgD-I/97a as an example of a velociraptorine tooth with a distinct mesial serration, it cannot be confirmed, as no isolated tooth kept together with this specimen is similar to the one shown in their work. Moreover, in the main text of Barsbold and Osmólska (1999:page 213) it is referred to as a tooth from Bayan Zag.

MPC-D 100/980, the holotype of *S. devi*, was collected in 1991 by the joint expedition of the Mongolian Academy of Sciences and the American Museum of Natural History, and briefly mentioned by Norell et al. (1992) and Norell and Makovicky (1999). It was described as a specimen of the new dromaeosaurid taxon by Turner (2008), and in the subsequent official description (Turner et al. 2021), with the catalog number IGM 100/980.

The IGM is an outdated acronym for the Mongolian Institute of Geology, similarly as GIN in Barsbold and Osmólska (1999) and GI SPS, while the collection is currently housed in the Institute of Paleontology (Mongolian Paleontological Centre) of Mongolian Academy of Sciences (Ulaanbaatar, Mongolia), with the preferred official abbreviation being MPC (Ulziitseren Sanjaadash and Philip Currie, pers. comm.). Hence, to avoid the impression that the specimens belong to the multiple collections, in this paper all of them are mentioned as MPC.

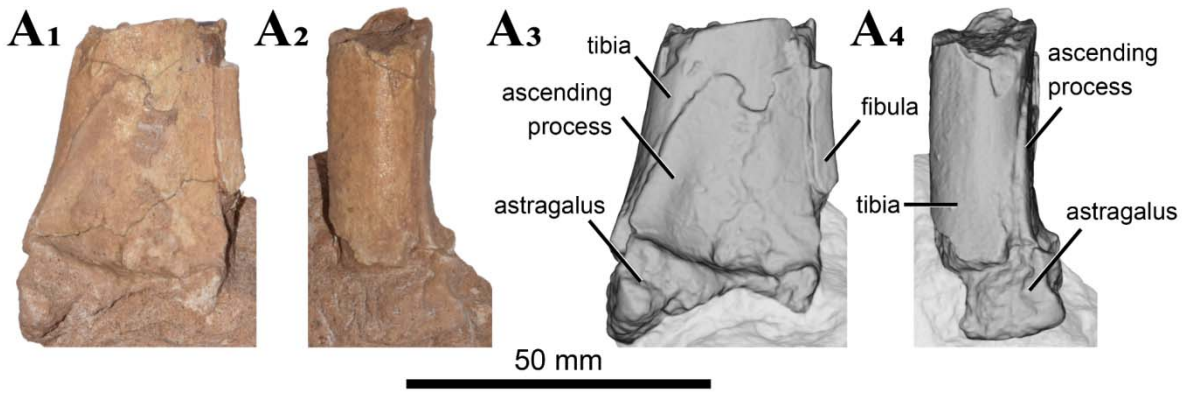

Figure S1. Dromaeosaurid *Shri devi* Turner et al., 2021, ZPAL MgD-I/97 from the Late Cretaceous, Khulsan, Ömnögovi, Mongolia. Left tibiotarsus in anterior and medial views.

Table S1. Known dromaeosaurid material from the Late Cretaceous of the Gobi Desert

Formation/Strata	Locality	Taxon	Specimens	References
Bayanshiree	Burkhant	*Achillobator giganticus*	MNUFR 15	Perle et al. 1999; Turner et al. 2012
Bayanshiree	Tel Ulan Chaltsai	Bayanshiree dromaeosaurid	MPC-D 100/22	Kubota and Barsbold 2007
Bayanshiree	Shine Us Khudag	Bayanshiree dromaeosaurid	MPC-D 100/23	Kubota and Barsbold 2007
Djadokhta	Bayan Zag	*Velociraptor mongoliensis*	AMNH 6515, AMNH 6518	Osborn 1924; Ostrom 1969
Djadokhta	Bayan Zag	*Velociraptor* sp.	MPC-D 100/982	Norell and Makovicky 1999; Powers et al. 2022
Djadokhta	Chimney Buttes	*Velociraptor mongoliensis*	MPC-D 100/986	Norell and Makovicky 1999
Djadokhta	Tögrögiin Shiree	*Velociraptor mongoliensis*	MPC-D 100/24, MPC-D 100/25, MPC-D 100/54, MPC-D 100/976, MPC-D 100/985, MPC-D 100/1252, MPC-D 100/2000; PIN 3143/8	Norell and Makovicky 1997; Barsbold and Osmólska 1999; Hone et al. 2012; Turner et al. 2007a
Djadokhta	Tögrögiin Shiree	*Mahakala omnogovae*	MPC-D 100/1033	Turner et al. 2007c
?Djadokhta	Üüden Sair	Dromaeosauridae indet.	MPC coll.	Watabe and Tsogtbaatar 2004
Bayan Mandahu	Urad Houqi	*"Velociraptor" osmolskae*	IMM 99NM–BYM–3/3	Godefroit et al. 2008
Bayan Mandahu	Bayan Mandahu	*Linheraptor exquisitus*	IVPP V16923	Xu et al. 2010, 2015
Bayan Mandahu	Bayan Mandahu	*Velociraptor* sp.	IVPP V16138	Hone et al. 2010
Bayan Mandahu	Bayan Tal	Dromaeosauridae indet.	GMC coll.	Ji et al. 2017
'Ukhaa Tolgod'	Ukhaa Tolgod	*Tsaagan mangas*	MPC-D 100/1015	Norell et al. 2006
?'Ukhaa Tolgod'	?Ukhaa Tolgod	*Halszkaraptor escuillei*	MPC-D 102/109	Cau et al. 2017
?'Ukhaa Tolgod'	Zos Wash	Zos Wash dromaeosaurid	MPC-D 100/3503	Turner et al. 2007b; Napoli et al. 2021
Baruungoyot	Khulsan	*Shri devi*	MPC-D 100/980, **ZPAL MgD-I/97**	Turner et al. 2021; **this paper**
Baruungoyot	Khulsan	*Kuru kulla*	MPC-D 100/981	Napoli et al. 2021
Baruungoyot	Khulsan	*Hulsanpes perlei*	ZPAL MgD-I/173	Osmólska 1982; Cau and Madzia 2018
Baruungoyot	Hermiin Tsav	*Natovenator polydontus*	MPC-D 102/114	Lee et al. 2022
Baruungoyot	Hermiin Tsav	Dromeosauridae indet.	ZPAL coll, MPC coll.	pers. obs.
Nemegt	Bügiin Tsav	*Adasaurus mongoliensis*	MPC-D 100/20, MPC-D 100/21	Barsbold 1983

Table S2. Postcranial measurements of *Shri devi* ZPAL MgD-I/97 and MPC-D 100/980 in millimeters. Measurements of MPC-D 100/980 are taken from Turner et al. (2021) with later additional measurements by the author of this study (indicated by [ŁC]).

	ZPAL MgD-I/97	**MPC-D 100/980**
Tibiotarsus distal transverse width	31.0	31.0
Ascending process of astragalus length	33.9	44
Metatarsal I		
Length	24.2	30.9
Distal transverse width	7.1	12.3
Distal length	9.4	14.0
Metatarsal II		
Length	76.9	90.0
Proximal transverse width	10.2	12.72
Proximal depth	14.0	13.00
Distal transverse width	13.2	15.5
Distal depth	12.3	16.5
Metatarsal III		
Length	91.0	~117
Proximal transverse width	9.5	10.3
Proximal depth	12.4	?
Distal transverse width	13.5	16.7
Distal depth	17.8	13.4
Metatarsal IV		
Length	80.2	? [ŁC]
Proximal transverse width	13.0	17.7
Proximal depth	10.1	12.1
Distal transverse width	13.8	?
Distal depth	17.5	?
I-1		
Length	19.4	22.5
Proximal transverse width	9.6	12.0
Proximal height	9.1	11.8

Distal transverse width	6.3	8.5
Distal height	7.8	9.3

I-2

Length along outer curvature	24.1	31.6 [ŁC]
Proximal transverse width	6.1	8.0
Proximal height	11.2	15.1
Facet height	8.3	10.0

II-1

Length	22.8	25.8
Proximal transverse width	13.1	16.0
Proximal height	12.2	14.3
Distal transverse width	14.3	15.2
Distal height	11.9	14.6

II-2

Length	23.1	26.5 [ŁC]
Proximal transverse width	12.6	?
Proximal height	15.2	16.1 [ŁC]
Distal transverse width	9.0	13.2 [ŁC]
Distal height	12.3	15.5 [ŁC]

II-3

Length along outer curvature	80.1	91.3
Proximal transverse width	9.1	11.3
Proximal height	22.0	28.5
Facet height	14.9	18.6

III-1

Length	37.2	47
Proximal transverse width	13.1	?
Proximal height	14.8	?
Distal transverse width	13.2	14.4
Distal height	12.1	15.9

III-2

Length	24.1	30.0

Proximal transverse width	12.0	15.2
Proximal height	12.9	15.8
Distal transverse width	11.2	13.5
Distal height	11.1	15.7
III-3		
Length	23.1	28.4
Proximal transverse width	10.2	13.2
Proximal height	12.4	14.0
Distal transverse width	8.1	11.25
Distal height	9.6	12.6
III-4		
Length along outer curvature	40.8	49.4
Proximal transverse width	8.8	11.0
Proximal height	13.9	18.3
Facet height	9.3	14.8
IV-1		
Length	31.7	41.5
Proximal transverse width	11.1	?
Proximal height	13.7	?
Distal transverse width	12.2	?
Distal height	11.9	15.4
IV-2		
Length	23.2	27.1
Proximal transverse width	10.5	14.1
Proximal height	13.9	14.7
Distal transverse width	11.0	11.8
Distal height	10.1	12.4
IV-3		
Length	18.2	23.4
Proximal transverse width	11.0	12.6
Proximal height	11.2	12.5
Distal transverse width	10.2	12.5
Distal height	8.9	11.7

IV-4		
Length	18.1	22.4
Proximal transverse width	9.1	12.0
Proximal height	11.1	12.9
Distal transverse width	8.2	10.1
Distal height	8.9	10.3
IV-5		
Length along outer curvature	?	36.5
Proximal transverse width	7.2	9.6
Proximal height	13.3	15.6
Facet height	9.1	13.1

Table S3. Measurements of the ungual II-3 in dromaeosaurids. Data from Ostrom 1969; Norell and Makovicky 1997; Xu et al. 2010; Jasinski et al. 2020; and from personal observations shared courtesy of Dr Philip Currie.

	Length (straight / outer curvature)	**Curvature ratio**	**Ratio to mt-II**
Shri devi ZPAL MgD-I/97	67.2 / 80.1	1.192	0.874 / 1.042
Shri devi MPC-D 100/980	82.1 / 91.30	1.112	0.912 / 1.014
Velociraptor mongoliensis MPC-D 100/25	71.2 / 84.0	1.179	0.791 / 0.934
Velociraptor mongoliensis MPC-D 100/54	63.6 / 74.0	1.164	0.752 / 0.875
Velociraptor mongoliensis MPC-D 100/985	53.2 / 63.0	1.184	0.747 / 0.885
Velociraptor sp. MPC-D 100/982	62.6 / 66.3	1.059	0.849 / 0.899
Linheraptor exquisitus IVPP V16923	75.0 / ?	?	0.714 / ?
Dineobellator notohesperus SMP VP-2430	32.0 / ?	?	0.685 / ?
Bambiraptor feinbergi AMNH 30556	36.0 / 43.0	1.194	0.533 / 0.637
Dakotaraptor steini PBMNH.P.10.113.T	160.0 / 240.0	1.500	0.648 / 0.972
Deinonychus antirrhopus AMNH 3015	85.0 / ?	?	0.659 / ?
Deinonychus antirrhopus MOR 747	74.1 / 92.0	1.242	0.574 / 0.713
Deinonychus antirrhopus YPM 5205	? / 122.0	?	? / 0.910
Saurornitholestes langstoni MOR 660	74.2 / 95.5	1.287	0.751 / 0.967
Saurornitholestes langstoni TMP 1988.121.0039	76.0 / 90.0	1.184	0.765 / 0.905
Saurornitholestes langstoni UALVP 55700	72.4 / 88.0	1.215	0.717 / 0.871
ROM 53680	56.2 / 67.0	1.192	0.618 / 0736

Table S4. Normalized values for PCA of maxilla measurements.

	Shri devi	*Velociraptor mongoliensis*			*Velociraptor* sp.	*Tsaagan*	*Linheraptor*	*"Velociraptor" osmolskae*
	ZPAL MgD-I/97	**AMNH 6515**	**MPC-D 100/25**	**MPC-D 100/54**	**MPC-D 100/982**	**MPC-D 100/1015**	**IVPP V16923**	**IMM 99NM-BYM-3/3**
Antorbital fossa length	-0.085864178906031	-0.368472263809344	-0.060848630720809 2	0.705168020464488	1.31635871126017	-2.011385293271119	0.726803089165212	-0.221759454182505
Antorbital fenestra height (posterior)	1.991840058603774	-0.216258979114139	0.462056941494285	-0.597864218217268	-0.219621139811084	-1.133288309205558	-0.286864353749961	
Anterior margin of antorbital fossa to maxillary fenestra length	-0.012973372835028	0.342233412808521	0.288952394961989	0.546477314553562	1.658718562099933	-1.367754253703633	-1.367754253703633	-0.087899804181714 3
Maxillary fenestra length	0.041665733752601 9	-0.878284299586786	-0.347459180588879	0.185568532263791	-0.934817541859039	-0.323964846138073	2.256740953692690	0.000550648463690714
Pila interfenestralis width	-0.631194063283622	-0.995741565146244	-0.067284646339878 2	0.016732160730022 8	1.201511541783535	-0.762203321765502	1.805293341743511	-0.567113447721833
Ventral margin height (anterior)	-0.202122211281696	-0.916786424998707	-0.345853561526458	-0.277980423910876	-1.062514043996887	0.523521480579011	2.119538348921809	0.162196836213707
Ventral margin height (posterior)	-0.174741542595061	-1.154941576141777	-0.687787418497058	-0.726618872407072	-0.706614790089792	1.366749506560002	1.260845541350889	0.823109151819833
Last mxl tooth to the posterior end of the maxilla	-1.388445448126669	1.214774430691377	0.073097659640724 6	0.006253796967860 24	-0.854514716837921	-0.411622865999311	-0.259481313535306	1.619938457199228

Table S5. Details of PCA for the maxillary measurements.

PCA Summary

PC	Eigenvalue	% variance
1	3.5662	45.388
2	2.22322	28.296
3	1.13356	14.427
4	0.671567	8.5472
5	0.203118	2.5851
6	0.0573593	0.73003
7	0.00211378	0.026903

Scores

	PC 1	**PC 2**	**PC 3**	**PC 4**	**PC 5**	**PC 6**	**PC 7**
ZPAL MgD-I/97	-0.47297	0.33143	-2.3861	0.57333	0.061395	0.11898	-0.022302
AMNH 6515	-1.7524	-1.2709	0.7353	0.49367	-0.45482	-0.17552	-0.067288
MPC-D 100/982	-1.9758	1.939	0.34287	-1.0903	0.48225	-0.072757	-0.021953
MPC-D 100/25	-0.86727	0.021274	-0.21947	0.2628	-0.17269	-0.34162	0.087076
MPC-D 100/54	-0.67729	0.62974	0.65785	-0.11435	-0.53946	0.44737	0.032339
Tsaagan	1.6845	-2.3076	-0.40725	-1.3674	0.0026771	0.010336	0.0018652
Linheraptor	3.6844	1.7673	0.39226	0.29255	-0.17195	-0.12419	-0.02234
"V". osmolskae	0.3769	-1.1103	0.88456	0.94979	0.7926	0.13741	0.012602

Loadings	**PC 1**	**PC 2**	**PC 3**	**PC 4**	**PC 5**	**PC 6**	**PC 7**
Antorbital fossa length	-0.12551	0.61732	0.22314	0.21047	0.085169	0.38211	-0.50452
Ant. fen. height (posterior)	-0.12382	0.14462	-0.64686	0.62333	0.28397	-0.27517	0.0098074
Ant. margin of ant.fo. to mxl. fen. length	-0.47542	0.25471	0.13739	-0.052523	0.32396	0.26676	0.71489
Maxillary fenestra length	0.45311	0.26744	0.018935	0.34052	-0.33575	0.36192	0.23142
Pila interfenestralis width	0.1951	0.57664	0.21784	-0.24491	0.16471	-0.66565	0.032881
Ventral margin height (anterior)	0.52244	0.077952	0.012425	0.12533	-0.093295	-0.068626	0.41138
Ventral margin height (posterior)	0.47466	-0.14599	-0.042287	-0.15228	0.79039	0.28365	-0.10207
last mxl tooth	-0.035659	-0.31889	0.68055	0.59124	0.18403	-0.2188	-0.00038991

Table S6. Postcranial measurements on base of data from Norell and Makovicky 1997, Xu et al. 2010, Turner et al. 2021, and pers. obs.

	Shri devi		*Velociraptor mongoliensis*		*Velociraptor* sp.	*Linheraptor*
	ZPAL MgD-I97	**MPC-D 100/980**	**MPC-D 100/985**	**MPC-D 100/986**	**MPC-D 100/982**	**IVPP V16923**
MT-I	24.20	30.90	21.40	27.90		22.50
MT- II	76.90	90.00	71.20	84.80	105.00	73.70
MT- III	91.00	117.00	86.20	99.10	124.00	
MT-IV	80.20	124.00	78.20	91.60	110.00	83.40
I-1	19.40	22.50	16.90			19.80
II-1	24.10					
II-2	22.80	25.80	23.60	26.60		23.90
II-3	23.10		24.00	28.00	25.00	26.10
III-1	80.10	91.30	64.80			66.30
III-2	37.20	47.00	37.60	44.00	49.00	39.60
III-3	24.10	30.00	24.90	27.40	25.00	
III-4	23.10	28.40			20.00	
IV-1	40.80	49.40	32.30			
IV-2	31.70	41.50	26.80	30.10		27.10
IV-3	23.20	27.10	21.30	23.00	23.80	
IV-4	18.20	23.40	16.80	18.60	18.60	
IV-5	18.10	22.40	16.10	18,60		

Table S7. Normalized values for PCA of postcranial measurements.

	Shri devi		*Velociraptor mongoliensis*		*Velociraptor* sp.	*Linheraptor*
	ZPAL MgD-I97	**MPC-D 100/980**	**MPC-D 100/985**	**MPC-D 100/986**	**MPC-D 100/982**	**IVPP V16923**
MT-I	0.788894800031063	0.946170518711464	-1.0637816729794	0.414512837739775	-1.08579648350291	
MT- II	0.893500632409761	-0.475909720238136	-0.667205498487721	-0.364610361943826	-0.9594629324852	1.57368788074512
MT- III	0.357929951349824	0.708509892000865	-0.891417929826865	-1.21887244234909		1.04385052882526
MT-IV	-0.287647854332633	1.95463109432946	-0.641509991158845	-0.632069477072718	-0.519382719335031	0.125978947569771
I-1	1.108455385105555	-0.282985152619543	-1.234484929223356		0.409014696737554	
II-1	0.448047600870289	-1.69281349682648	0.941915747268578	0.168328196598217	0.13452195208941	
II-2	0.135222227031773		0.428777275120991	0.396013254193514	0.780990500091369	-1.74100325643764
II-3	0.957580316207147	0.080029986047893 1			-1.037610302255 04	
III-2	0.517768582622548	0.361200170602866	0.753558749991 38	0.105968951546642		-1.73849645476344
III-3	0.646524641690164	0.505293299355249				-1.15181794104541
III-4	0.748974546621446	0.386615772527945	-1.13559031914939			
IV-1	0.920709586462907	1.240042713055 79	-0.523102757649088	-0.820132658470069	-0.817516883399533	
IV-2	1.299453172075 89	0.408269517484845	0.216883818537677	-0.611843728266472		-1.31276277983195
IV-3	0.861524799210148	1.038454670777 4	-0.009045314927 25555	-0.503036794899321		-1.38789736016097
IV-4	1.009487153580 75	0.705077420767111	-0.773808705498409	-0.940755868849459		
IV-5		-0.707106781186548	0.707106781186548			

Table S8. Details of PCA for the measurements of pes.

PCA Summary

PC	Eigenvalue	% variance
1	4.49759	40.887
2	3.58584	32.599
3	1.55057	14.096
4	0.743088	6.7553
5	0.622915	5.6629

Scores

	PC 1	PC 2	PC 3	PC 4	PC 5
ZPAL MgD-I/97	2.1998	0.88268	2.1717	-0.0040989	0.07707
MPC-D 100/980	2.9928	0.88998	-1.7031	0.24785	-0.024839
MPC-D 100/982	-1.2891	0.70774	-0.35216	-1.5615	0.42948
MPC-D 100/985	-2.3564	1.1415	-0.10782	1.0906	0.77353
MPC-D 100/986	-1.5021	0.18846	-0.015469	0.12723	-1.5044
Linheraptor	0.14497	-3.8103	0.0068217	0.099913	0.24914

Loadings	**PC 1**	**PC 2**	**PC 3**	**PC 4**	**PC 5**
Metatarsal I	0.34245	-0.020425	0.076424	0.22052	-0.60216
Metatarsal II	0.17593	-0.39826	0.4098	0.20449	0.029892
Metatarsal III	0.30783	-0.23861	-0.03963	-0.22846	0.45405
Metatarsal IV	0.37445	-0.011898	-0.47607	0.14243	0.061726
I-1	0.16731	-0.021924	0.37125	-0.55437	-0.22051
II-1	-0.3029	0.0050761	0.47783	0.11229	0.19576
II-2	-0.11529	0.43895	-0.0058819	-0.23578	-0.11302
II-3	0.15571	0.010157	0.29779	0.44037	-0.12002
III-2	-0.0029016	0.46198	0.05347	0.2016	0.006831
III-3	0.1176	0.3017	0.069091	0.0020208	-0.080169
III-4	0.23738	-0.016233	0.14067	-0.30837	-0.26658
IV-1	0.40378	0.032687	0.03155	0.24366	0.16638
IV-2	0.18015	0.37061	0.27137	0.033212	0.27328
IV-3	0.2408	0.38306	0.013117	0.011121	0.14274
IV-4	0.32798	0.025544	0.14053	-0.21344	0.28157
IV-5	-0.1682	0.0099184	0.1455	0.16039	0.18125

Phylogenetic analysis

Data matrix from Turner et al. 2021

The first dataset used in the analysis was the Theropod Working Group matrix of Turner et al. 2021 with coded holotype of *Shri devi*, modified from Brusatte et al. (2014) with added observations from Pei et al. (2020), and with further modifications from Napoli et al. (2021) including addition of *Kuru kulla*, and modifications to *Adasaurus*, *V. mongoliensis* and *Tsaagan*.

Additional modifications were added to the dataset:

- *Adasaurus:* 184:1>0 (fourth trochanter is present, after Kubota and Barsbold 2007)
- *Atrociraptor:* 236:?>1, 488:?>1
- *Kuru:* 196:?>0, 632:0>1, 782:?>0
- *Linheraptor:* 27:2>1, 58:0>1 (ectopterygoid dorsal recess was mentioned to be present by Xu et al. 2015), 246:0>0&1 (teeth are mostly of similar size)
- *Saurornitholestes:* 734:?>0 (Currie and Evans 2020)
- *Tsaagan:* 246:0>0&1 (teeth are mostly of similar size); 488:0>1.
- *Velociraptor mongoliensis*: 234:1>1&2 (there is a variation in the dorsoventral placement of the maxillary fenestra within the species; e.g., MPC-D 100/54 the fenestra is located at the midpoint of the antorbital fenestra); 236:1>0&1 (the additional fossa for maxillary fenestra is not visible on all specimens); 487:1>0&1 (the condition varies even within specimens; in MPC-D 100/25 the promaxillary fenestra is placed more dorsally on the left side); 488:0>0&1 (e.g., it varies within the left and right side of MPC-D 100/54); 591:?>0; 642:?>0; 734:?>0 (as visible on MPC-D 100/54); 829:?>1.
- "*Velociraptor*" *osmolskae*: 488:0>1

First the specimen ZPAL MgD-I/97 was coded as a separate OTU.

ZPAL MgD-I/97
?0??????????????????????10111???01?0001?????????????????10?100??0?0100??11?????010010100?????????
???010?01
1010010??0???0????0???????11?????2?111??????1?001?0????0???3????????????0?00?????????????????????
?00????0??
????????????????????????0000?0000?01???????00????????0???????????????????00??????????????00??010???
0??00?10????????0????00???10?00?0?10?0?????0??00???0?0??0010
00?000?00??????????????????0????0?00????????0??0????????0??
???????????????????????????000000000000????????0???0?????0?0?????????????????????0?0?????00???????
?????????????????????????0?000?10???11?????01??????????00???0

After recovering the ZPAL MgD-I/97 and the holotype of *Shri devi* as sister OTUs, confirming the observations from this study, the scoring for both specimens were merged together:

Shri devi (MPC-D 100/980 + ZPAL MgD-
I/97)?0??????????????????????10111???01?0001?????????????????10?100??0?0100??11?????010010100?011
0001100011121011[01]?100??1????1?1?????????????????????????????00?211?0111?20220201111 2?100???111
0000??00010?0110100100?0???0?1??0?????0011?00102?111??????1?001?0????0???3?12?????????0?00?????
???????????????????00????0???00000000??
??????????????????0000000000000000000000000000000000?01???????00????????00???????1?1????????00???
???????????00??010???0??00?10????????0????00???10?00?0?10?0?????0??00????????????????????????????
????????????0?0??001000?000?00??????????????????0????0?00????????0??0????????0????????0001000100?
???0000????????????????001000011??01???0000000?000000000000000????????02??0????10?0?0000??????
?????00?0?010??0??00000000??????????000000???0001?0000000010???11?0??001??100???0100?1?0

The analyses performed with *Allosaurus* as an outgroup, recovered 668 trees of 3535 steps (CI= 0.306, RI= 0.780). Four taxa were excluded from the consensus (*Dakotaraptor*, *Graciliraptor*, *Pyroraptor*, *Yurgovuchia*). Results for Deinonychosauria are presented on figures S3 to S5.

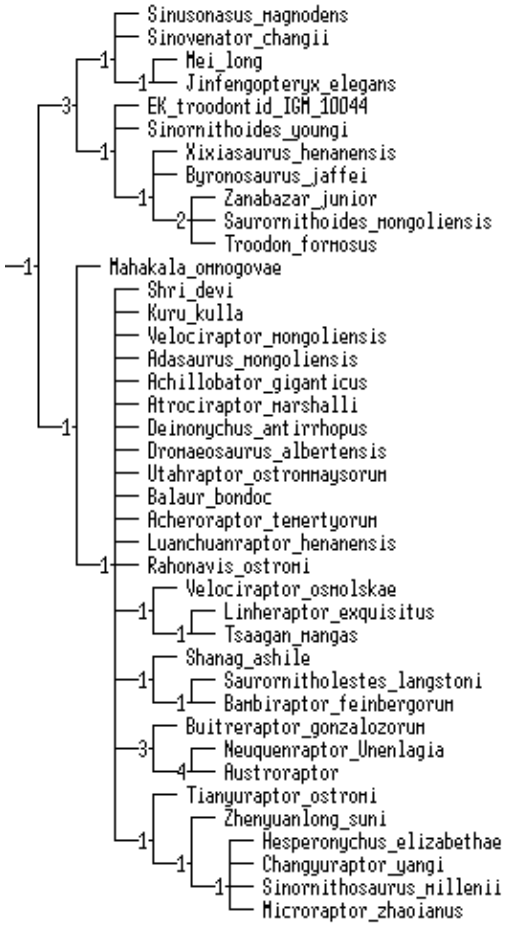

Fig. S3. Strict consensus tree with Bremer support values.

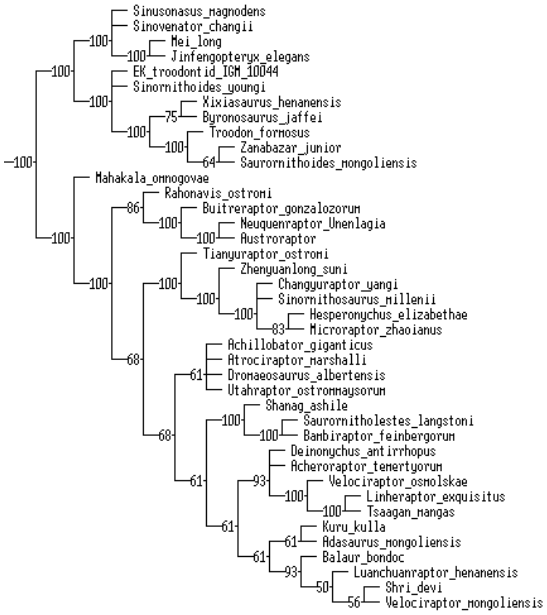

Fig. S4. 50% majority rule consensus tree.

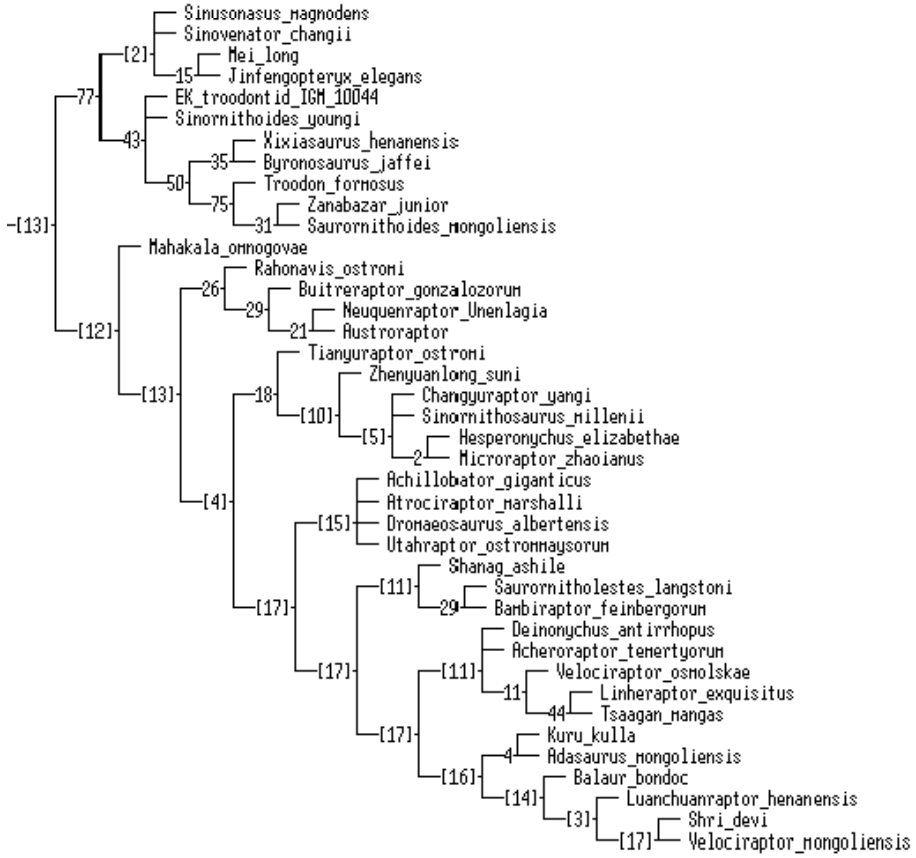

Fig. S5. 50% majority rule consensus tree with bootstrap values.

Potential synapomorphies:

- *Shri devi* + *Velociraptor mongoliensis:* 151:0 (shallowly concave ventral margin of the preacetabular process of ilium), 226:1 (presence of the longitudinal flange on the posterior surface of the metatarsal IV).

- *Balaur* + *Luanchuanraptor* + (*Shri* + *Velociraptor*): 111:0 (absence of the pneumatic foramina on the lateral surfaces of the sacral vertebra), 160:1 (ridge bounding cuppedicus fossa of ilium expanding far posteriorly).

- *Kuru* + *Adasaurus*: 72:2 (large surangular foramen), 312:1 (centra of the thoracic vertebrae significantly longer than wider).

- (*Kuru*+*Adasaurus)*+(*Balaur* + (*Luanchuaraptor* + (*Velociraptor*+*Shri*))): 133:1 (fusion of scapula and coracoid into scapulocoracoid)

- *Linheraptor* + *Tsaagan*: 28:0 (maxillary fenestra situated at anterior border of the antorbital fossa).

- "*V". osmolskae* + (*Linheraptor*+*Tsaagan*): 488:1 (maxillary fenestra length greater than distance between anterior margin of the antorbital fossa and maxillary fenestra).

- *Deinonychus* + *Acheroraptor* + (*"V". osmolskae* + (*Linheraptor* + *Tsaagan*))*:* 487:1 (promaxillary fenestra located in the anteroventral corner of the antorbital fossa).

- Velociraptorinae: 19:1 (Exits for cranial nerves X-XII located in the shallow, bowl-like depression), 20:2 (maxillary process of the premaxilla extends posteriorly to separate maxilla from nasal posterior to nares), 173:1 (presence of the tubercle on the anterior edge of ischium), 496:1 (convex ventral margin of the anterior region of the maxilla).

Data matrix from Powers et al., 2022

The second dataset was that of Powers et al. (2022), being is a modified dataset from Currie and Evans (2020), with a further addition of *Dineobellator notohesperus* from Jasinski et al. (2022).

Additional modifications:

- *Linheraptor:* 21:0>1.

- *Tsaagan*: 21:0>1; 53:0>1 (Norell et al. 2006); 65:1>0 (Norell et al. 2006).

Shri devi

????0?0110001?020???1??????2??11?????????11?????????????????????0??101011?1??10001000?200?1011
0111111??????0?????????????????10000100?00112??1011?10??11010001111010011010?

Kuru kulla

??????????????????????????11???100?101??1??1??01?00???100??011?1
1????????02?????????????????0?????????????????????????????????11?0011?10010110???

The analyses performed with *Archaeopteryx* as an outgroup, recovered 111 trees of 408 steps (CI= 0.471, RI= 0.573). *Dineobellator* was excluded from the consensus.

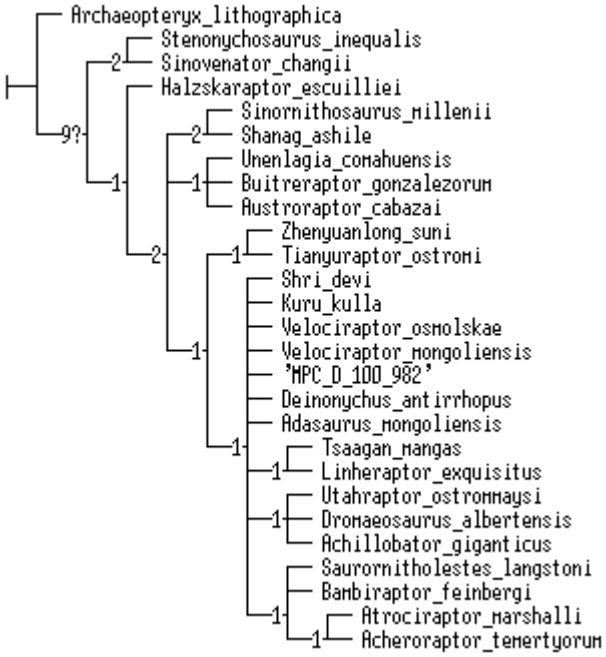

Fig. S6. Strict consensus tree with Bremer support values.

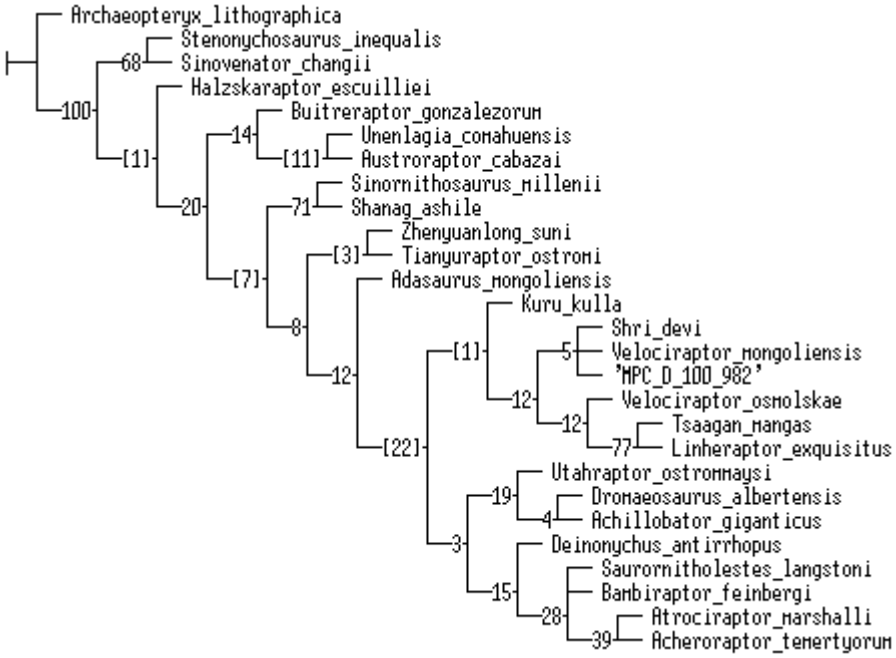

Fig. S7. 50% majority rule consensus tree with bootstrap values.

Potential synapomorphies:

- *Velociraptor mongoliensis* +*Velociraptor* sp. (MPC-D 100/982) + *Shri devi:* 12:0 (maxillary fenestra positioned posteriorly relative to the promaxillary fenestra), 49:1 (the ascending ramus of the quadratojugal bowed anteriorly; not confirmed in *Shri devi*).

- *Tsaagan* + *Linheraptor*: 6:2 (relatively short antorbital fossa, less than 24% of the maxillary length), 12:2 (maxillary fenestra positioned dorsal relative to the promaxillary fenestra), 29:2 (anterior ramus of the maxilla extremely long, greater than 37% of the maxillary length), 89:2 (absence of the mesial serration of teeth).

- *"V". osmolskae* + (*Tsaagan* + *Linheraptor*): 5:1 (ventral margin of the antorbital fossa does not extend below the maxillary alveoli), 8:0 (promaxillary fenestra positioned in the anteroventral border of the antorbital fossa)

- (*Velociraptor mongoliensis* + MPC-D 100/982 + *Shri devi)* + (*"V". osmolskae* + (*Tsaagan* + *Linheraptor*)): 67:1 (presence of the symphyseal "chin" on the ventral margin of the dentary), 68:1 (dentary strongly bowed in lateral view)

- Velociraptorinae: 25:1 (nasal process of the premaxilla projects posteriorly), 26:1 (prominent narial fossa of the premaxilla), 66:1 (dorsal margin of the symphyseal region of dentary concave).

References

1. Alifanov, V.R. 2012. Order Dinosauria. In: E.N. Kurochkin and A.V. Lopatin (eds.) *Iskopaemye pozwonočnye Rossii i sopredel'nyh stran. Iskopaemye reptilii i pticy. Čast' 2,* 153–355. GEOS, Moscow.
2. Barsbold, R. 1983. Carnivorous dinosaurs from the Cretaceous of Mongolia [in Russian]. *Sovmestnaâ Sovetsko-Mongol'skaâ Paleontologičeskaâ Ekspeditciâ, Trudy*, 19: 1–117.
3. Barsbold, R. and Osmólska, H. 1999. The skull of *Velociraptor* (Theropoda) from the Late Cretaceous of Mongolia. *Acta Palaeontologica Polonica*, 44: 189–219.
4. Brusatte, S.L., Lloyd, G.T., Wang, S.C., and Norell, M.A. 2014. Gradual assembly of avian body plan culminated in rapid rates of evolution across the dinosaur-bird transition. *Current Biology*, 24: 2386–2392.
5. Cau, A. and Madzia, D. 2018. Redescription and affinities of *Hulsanpes perlei* (Dinosauria, Theropoda) from the Upper Cretaceous of Mongolia. *PeerJ*, 6: e4868.
6. Currie, P.J. and Evans, D.C. 2020. Cranial anatomy of new specimens of *Saurornitholestes langstoni* (Dinosauria, Theropoda, Dromaeosauridae) from the Dinosaur Park Formation (Campanian) of Alberta. *The Anatomical Record*, 303: 691–715.
7. Feduccia, A., Martin, L.D., and Tarsitano, S. 2007. Perspectives in Ornithology *Archaeopteryx* 2007: Quo Vadis?. *The Auk*, 124: 373–380.
8. Godefroit, P., Currie, P.J., Hong, L., Yong, S.C., and Dong, Z. 2008. A new species of *Velociraptor* (Dinosauria: Dromaeosauridae) from the Upper Cretaceous of northern China. *Journal of Vertebrate Paleontology*, 28: 432–438.
9. Hone, D.W, Choiniere, J., Sullivan, C., Xu, X., Pittman, M. and Tan, Q. 2010. New evidence for a trophic relationship between the dinosaurs *Velociraptor* and *Protoceratops*. *Palaeogeography, Palaeoclimatology, Palaeoecology*, 291: 488–492.
10. Hone, D., Tsuihiji, T., Watabe, M., and Tsogtbaatar, K. 2012. Pterosaurs as a food source for small dromaeosaurs. *Palaeogeography, Palaeoclimatology, Palaeoecology*, 331: 27–30.
11. Jasinski, S.E., Sullivan, R.M., and Dodson, P. 2020. New dromaeosaurid dinosaur (Theropoda, Dromaeosauridae) from New Mexico and biodiversity of dromaeosaurids at the end of the Cretaceous. *Scientific Reports*, 10: 1–10.

12. Jasinski, S.E., Sullivan, R.M., Carter, A.M., Johnson, E.H., Dalman, S.G., Zariwala, J., and Currie, P.J. 2022. Osteology and reassessment of *Dineobellator notohesperus*, a southern eudromaeosaur (Theropoda: Dromaeosauridae: Eudromaeosauria) from the latest Cretaceous of New Mexico. *The Anatomical Record*.
13. Ji, S.A., Zhang, L., Lu, L., and Hao, J. 2017. The first discovery of the Late Cretaceous protoceratopsid fauna from Alxa, Inner Mongolia, China. *Acta Geologica Sinica,* 91: 1908–1909.
14. Kubota, K. and R. Barsbold. 2007. New dromaeosaurid (Dinosauria Theropoda) from the Upper Cretaceous Bayanshiree Formation of Mongolia. *Journal of Vertebrate Paleontology*, 27: 102A.
15. Lee, S., Lee, Y.N., Currie, P.J., Sissons, R., Park, J.Y., Kim, S.H., Barsbold, R., and Tsogtbaatar, K. 2022. A non-avian dinosaur with a streamlined body exhibits potential adaptations for swimming. *Communications Biology*, 5: 19.
16. Limaye, A. 2012. Drishti: a volume exploration and presentation tool. *Developments in X-ray Tomography VIII,* 8506: 191–199.
17. Napoli, J.G., Ruebenstahl, A.A., Bhullar, B.A.S., Turner, A.H., and Norell, M.A. 2021. A new dromaeosaurid (Dinosauria: Coelurosauria) from Khulsan, central Mongolia. *American Museum Novitates*, 2021: 147.
18. Norell, M.A. and Makovicky, P.J. 1997. Important features of the dromaeosaur skeleton: information from a new specimen. *American Museum Novitates*, 3215: 1–28.
19. Norell, M.A. and Makovicky, P.J. 1999. Important features of the dromaeosaurid skeleton II: Information from newly collected specimens of *Velociraptor mongoliensis*. *American Museum Novitates*, 3282: 1–45.
20. Norell, M.A., Clark, J.M., and Perle, A. 1992. New dromaeosaur material from the Late Cretaceous of Mongolia. *Journal of Vertebrate Paleontology*, 12: 45A.
21. Norell, M.A., Clark, J.M., Turner, A.H., Makovicky, P.J., Barsbold, R., and Rowe, T. 2006. A new dromaeosaurid theropod from Ukhaa Tolgod (Ömnögov, Mongolia). *American Museum Novitates*, 3545: 1–51.
22. Osmólska, H. 1981. Coossified tarsometatarsi in theropod dinosaurs and their bearing on the problem of bird origins. *Palaeontologia Polonica*, 42: 79–95.
23. Osmólska, H. 1982. *Hulsanpes perlei* n.g. n.sp. (Deinonychosauria, Saurischia, Dinosauria) from the Upper Cretaceous Barun Goyot Formation of Mongolia. *Neues Jahrbuch für Geologie und PaläontologieMonatshefte*, 1982: 440–448.

24. Osborn, H.F. 1924. Three new Theropoda, *Protoceratops* zone, Central Mongolia. *American Museum Novitates*, 144: 1–12.
25. Ostrom, J.H. 1969. Osteology of *Deinonychus antirrhopus*, an unusual theropod from the Lower Cretaceous of Montana. *Peabody Museum of Natural History Bulletin*, 30: 1–165.
26. Pei, R., Pittman, M., Goloboff, P.A., Dececchi, T.A., Habib, M.B., Kaye, T.G., Larsson, H.C.E., Norell, M.A., Brusatte, S.L., and Xu, X. 2020. Potential for powered flight neared by most close avialan relatives, but few crossed its thresholds. *Current Biology*, 30: 4033–4046.
27. Perle, A., Norell, M., and Clark, J.M. 1999. A new maniraptoran theropod, *Achillobator giganticus* (Dromaeosauridae), from the Upper Cretaceous of Burkhant, Mongolia. *Contributions from the Geology and Mineralogy Chair, National Museum of Mongolia*, 101: 1–105.
28. Powers, M.J., Fabbri, M., Doschak, M.R., Bhullar, B.A.S., Evans, D.C., Norell, M.A., and Currie, P.J. 2022. A new hypothesis of eudromaeosaurian evolution: CT scans assist in testing and constructing morphological characters. *Journal of Vertebrate Paleontology*, 41: e2010087.
29. Powers, M.J., Sullivan, C., and Currie, P.J. 2020. Re-examining ratio based premaxillary and maxillary characters in Eudromaeosauria (Dinosauria: Theropoda): Divergent trends in snout morphology between Asian and North American taxa. *Palaeogeography, Palaeoclimatology, Palaeoecology*, 547: 109704.
30. Turner, A.H. 2008. *Phylogenetic relationships of paravian theropods.* 666 pp. PhD Thesis, Columbia University, New York, USA.
31. Turner, A.H., Hwang, S.H., and Norell, M.A. 2007a. A small derived theropod from Öösh, early Cretaceous, Baykhangor Mongolia. *American Museum Novitates*, 3557: 1–27.
32. Turner, A.H., Makovicky, P.J., and Norell, M.A. 2007b. Feather quill knobs in the dinosaur *Velociraptor*. *Science*, 317: 1721.
33. Turner, A.H., Pol, D., Clarke, J.A., Erickson, G.M., and Norell, M.A. 2007c. A basal dromaeosaurid and size evolution preceding avian flight. *Science*, 317: 1378–1381.
34. Turner, A.H., Makovicky, P.J., and Norell, M.A. 2012. A review of dromaeosaurid systematics and paravian phylogeny. *Bulletin of the American Museum of Natural History*, 371: 1–206.

35. Turner, A.H., Montanari, S., and Norell, M.A. 2021. A new dromaeosaurid from the Late Cretaceous Khulsan Locality of Mongolia. *American Museum Novitates*, 3965: 1–48.
36. Tykoski, R.S. 2005. *Anatomy, ontogeny, and phylogeny of coelophysoid theropods*. 553 pp. PhD Thesis, University of Texas at Austin, Austin, USA.
37. Wang, X., Cau, A., Guo, B., Ma, F., Qing, G., and Liu, Y. 2022. Intestinal preservation in a birdlike dinosaur supports conservatism in digestive canal evolution among theropods. *Scientific Reports*, 12: 1–10.
38. Watabe, M. and Tsogtbaatar, K. 2004. Report on the Japan-Mongolia Joint Paleontological expedition to the Gobi Desert, 2000. *Hayashibara Museum of Natural Sciences Research Bulletin*, 2: 45–67.
39. Xu, X., and Wu, X.C. 2001. Cranial morphology of *Sinornithosaurus millenii* Xu et al. 1999 (Dinosauria: Theropoda: Dromaeosauridae) from the Yixian formation of Liaoning, China. *Canadian Journal of Earth Sciences*, 38: 1739–1752.
40. Xu, X., Choiniere, J.N., Pittman, M., Tan, Q., Xiao, D., Li, Z., Tan, L., Clark, J.M., Norell, M.A., Hone, D., and Sullivan C. 2010. A new dromaeosaurid (Dinosauria: Theropoda) from the Upper Cretaceous Wulansuhai Formation of Inner Mongolia, China. *Zootaxa*, 2403: 1–9.
41. Xu, X., Pittman, M., Sullivan, C., Choiniere, J.N., Tan, Q.W., Clark, J.M., Norell, M.A., and Shuo, W. 2015. The taxonomic status of the Late Cretaceous dromaeosaurid *Linheraptor exquisitus* and its implications for dromaeosaurid systematics. *Vertebrata PalAsiatica*, 53: 29–62.

Data matrix modified from Napoli et al. 2021:

```
Allosaurus
?10000?0000000100011001000101200111011001O??0000000000000100000000001000100000000000010101001000
```

???10?00??00100?00?101?????????????????????????????
???000?0??????????????
????????0??0??????????????????
????0???????????????????????????0??11?????????????????00????
Anchiornis_huxleyi
000100?0010000???011010??11?0001?00001210001101?1001100?????000?011??102000000200??001000101??10010?2110?
011??0210?221100??????011(0 1)11112000??1000001(0
1)0221110111020030201?10121210?11110000?00001000110010?00000000011?0000?000??00111001100001101?010000001000
030?0(2 3)0000?0010????????00???????00??000?00000??0000000010000(0
1)0?0????????0000020000?0000??0100000?0?0010000?00001010?000010?000??00000?00000000?00000?000000000000?010
00000000?00(0
1)0000000000??????0010111011?1?1100010000000110110000?01?0110000?1001010001000000??00??01??00?0????000?01
000000??0???00??000000000000000???0000??0011?0?0?0???????????????000000001??0?0???0200000?0?112000000???0???
000000???????0001??000010?0?00000111?201?100?0000100000000?01?0(0
1)?0??0?0?0?000?0???00000?0??100000?000?1?1100?0000100100?00???0?0?010020?1000?0000000?000000000000???00?1?
?0?0000(0 1)1000011??01?0111????00?10001??
Xiaotingia_zhengi
?00??????????????????101???111000????0?12?????????10?????????????00?001??202?00??020???00??0??0???1?0?????10?
01?????????????0??????01?011112100??100000101?211101110212302?1?102?12(0
1)?????10????0?0???????1?010?00000000?1??0?10??00??00?10?011000??1?1?01??00????000???22000??00??????????????
????????0000????????00?0000?10000???0?????????010002?????????????10?000?0?001??0???0?0?0?0?00??????????00100?
00000000?0?0?0000?????0?0????????00??0?00?0?????10000????????00??11?????1?1100?100?000?110??0??0?01??1????0?
????000001?00000???0????0???0??0??????????1???00?????????????????????????????0??????0?????0?????????????????????
?????????????????02?000??0?1??0????0??????????????00?????????0???00??1???????00111?2?1?0???0000100000???????0??
?????0????????0???00000?0??100?00??00?1?11?0?0??????0?????0???????0???0??????000???0?0???00?00000000????0???????
???0?100???0?????0111????0???000???
Eosinopteryx_brevipenna
?001??????????????????10????????00?1???0012100?110??10????????????000?011???0??0?00020???00???????1????0????????
?????02?0?23???0????????1?01?112?00????0000100?21?101110200302?1?1012?2???????1?0?0???0???00??00???0000??00?1
??0??0??0???0011100?1?0?0?101?01?0?0?0??0000???2000??001???????????0????????0????0??00?????0000000?1000??0?0?
??????????00?200?0?0?????010?000?????1??0????00?0????????????????0000??00000?0000?0?0?????????0????????1?0?????
00??00???00000????????00??11?01??1?1?????00?000?110110000??????????0??0?????0010000000???0??????????00?0??????
???10??0?0??????0?????????????????????00?0??001???020000??0????0???00???
????0?000????????0?0???0????????????00111?2?1?1???000?100000??0??1??1??????0????????0???0??0??0??100000??00??
?1??0????????0?0??00???0??????0????100???00?0??????000000?0??????0?????????00100?0??????????1?????0???00????
Aurornis_xui
?001??????????????????101???1110001?000012100?11?1??0??????????????0??01????0???000020???00??0???????????????????
01???02?0?221?00??????01?011112?00???1000010?221110101020?302?1?1012?2????????????????0???0???00???0?00??00?1
??0??0??0???00111?011?000?101?01?00000??0000???2000??00????????????????????00????????0??????0?00000?1??0??0???
???????0100020?0?0???????100000????????0???00?0?0????0?????????0000??00000?0000?0?0?????????0?0??????1?0?????
00???????00000??????????0??11101??1?110??100?000?1101??00?01?0110000?10010?0001000000???00??01??00?0?????0?
0??10??000??0??10????????????00?0??0???00?0??001??020000??0????0???00???
??????????0?????????????????0??1??????0?00111?2????1???000?100000??0??1??1??????0????????0???0??0??0??100000??00??
?11?0????????0?0??00???0?0???0????100???00?0???000000000?0??????0?????????0110??0??????1???1??????0????00???
Jinfengopteryx_elegans
?0????????????????????1?01???2110???????2?1??00?0?????1???100??????00?00?10??1??0?000?1???00??1??????????????????
?????02?????2?200????????1101111???????100000?????1???????????????1???2??0???????????0????????????1??????0?0??00??
??00????????1???????0??000001???0??000???????0????200?0?000??????????????????????????????0???????0?000???0?0??0?0?
???????????????00?0???0?0?01???0??
?????10?0000?????????????0??11?01????????????????000?110??????0?01??1????0??????????0?????00??????????????????????
????????0???????????????????????????????????0?????0?????0??0??00??????????????????
????????0?0???????????????0?????????0?????1??0????00????0?????????????????????????0?????????????????0?0??00???????00??
??1?0???0?????????0???????????????????000?????????????????0?0????????00?????????001?0??????????????????????(0
2)00???
Mei_long
?0?????????0?????????11010?????0011?002012100001?1010??100??????00010010??1?0000?021???01?0011011100011?2110?
01???0110222111?1?????111?11110?0?1?1000001?012111?1??1200302?1110221?(0
1)?0111100?0101001000??110011?0?0000???00000??000100?1??001?0000?0?001?0?0000?000001020000?000??????????00?0
??0??00??0?01?????????0?0000010000(0
1)0?0?????????0100020?00?00000?0111000?0?0000000?0000000?000?01?1?0???00000????00000?00000010000??0000000000
0?000021?01101000??0???20???1010??101101?1100?10?0000?110??0??0????????????0?1?0??????01????00???0?????????????0
??????????1???00????????????????????1???0???????0?????0?????0??0?000???0????????
??0????????0?0000?????????0?????????????????01???1?1?0?????????????????????????????????0???????00???00?00?0???????02
???0????1?0?000?1001??00?0001?0?010???01??0?0000000000?000????00???0???00?000000100??????????01???????????0?0
???
Sinovenator_changii
?0???0002?000011110110101?1110?011?02???2??0011???1?10100????0?000?001??????0000011110?1??????11?10100012110?
001000110222?1?????????110111???????100?0???0?211?010112(0
2)0302?1110221201?11110000??10011000111??110?000000???000011000100?110001000??1??011??0000?0000(0
3)??0??000000000000?000000?00?0??00000?0100(1
2)00??00000?0010000?????????????????20000??00?0101?10??00?10000
0010000000000000000?0?00?020?0110?00000000020?010?10??1011010???????0000001????0000?01?011??00?1?0100010?????
0????0??????????????0????0????1???0?????????????????????????0?????????0?00????1?????????????????????0?????????0???00
000??00???0???????????????????0??00????????????????00????0???????00111??????????????0000?0??0?01????????1??0?0??0?0
?0???0?0?0????????2?0?0?1?1??0?????100?????????0????0?001?01?0?0000?00???????0?00??0???0000?0000000001?1??10??
???0??1??1?????000?0?
Sinusonasus_magnodens
?0????????????????????1??10101110??11?02?12???????????????????????0?000?001????????????11?100??????????????????????
0?10?011022?02????????????????????????????????????21??0?011200302?0110???????02??1???0???001?000??1???1??????????
??0?????????00011??010000?1?1001?0000????00????????0000000?0?????????????????????????????????????0?????????????????
??0???????????00000?????????0??????0
20?011??0????????????????????????????????????00??????????0?1?01?0110000?1?0000010???????0???0?00?0???00????????
??0??000000??????????????
????1?????????????????????????0?????0????????????????????????????????0?0???????????00?0??0?00??00000????????0?2??00??
??0?0????0???????????????0??0???0??01?0???????????????????????????????0?0????00???00101?0?1?????01??????????10?????
Sinornithoides_youngi
?0??0?????????????????1?0?0??1?10????00???2????????1???????????????00??0010????????0001111101???????11??001???????

```
????0011?102121011???1?00?1?101?0???100000????21??01??02??30???11?0??001??1110?????0???1?00??10001?0??0?0?1
??00?0???0???0010?00?00000????0??00?0???00???0?2000000?0??????????????????????10?????1?00??000??????????(0
1)0?0?????????0??0?20??0?00000?0??1000???0?1000???00?0??????????0??010?0000???000000??00??0??000????000000000
00000020?02100000000????????101??????1???0100??1??000???????????02?011?????1??????1???????0????????????????
???????????????????????????????????????????????000??0??????????????????????????????????????????????????????
??????????0?0?00?????????0?????????????????00?110101?000?000????????????????1??????0?????000???00?0???0???0?02
??0??1??0?0?????100????0?0?????????0???000?000???00??10?000?????0??00???00000000010????0?1?0?0101????0?????0?
??0
EK_troodontid_IGM_10044
?????0012????????????????????????????????????????0?????????????????1??11???????(0
1)??1??????0??????????????????????????????????????????????????????1?00000??????????????????????????????????????
???????????01?1?001???00??????0?0??1?????????0??????????????????????????????????????????????????????????????????
1?1????????????????????????????????????????????????????????????????????????????????????????????????????????
???????????????????????????????????????????????????????????????0?????????000??????????????????????????????
???????????????????????????????????????????????????????????0???????????????????????????????????????????????
???????????????????????????????????????????????????????????????????????????????????????????????????????????
??????????????????????2??????????????????????????0??????????1????0?????????????0000??????????????????????0?1????
?????????????????????????
Byronosaurus_jaffei
?????101???101?1100110001011?0??????20220??????????1?100??????0000001??11????000211??01?0?0???????010121???
?????0??02?????????????????????????????????????????????????????????????????1????0?0??0???????21??????????0??
??0????1????????????01000000?1?00??1?0??0?000??0???000000????????????0???????????????0?0????0????0010????????
?????????????????????????????????????????????????????????????????????????????????000?????????1?????
????2??????????000200011??0?????????1?????????????00??100000??2?001?0?0?1?0000010100?000???0??0?????0??0??????
???????00?????????????????????????????0????????????0???????????????????00?000000????????0??00??00?????????0???
????100000??????????1??????????????????????????????????????????????????????????????????000??????????????0??
??000??????????????????????????0??0100?????0?????????????????????????00??????????1?0?0?1????1???????????200?0?
Xixiasaurus_henanensis
????????????????????11000101110??????2?22??????????????????????0?00??001????????000211??01?0??????????????????
?????????????????????????????????????????00?1?????????????????????????????????????????????????????0???00??
????????????????????0?000000???01?0100???00???????000000???00??????????????????????????0?????????????????????
?????????????????????????????????????????????????????0??????0????????????????????????????????????????????
?????????0?0?????????????????????????????????00?0??110100??2?01100?0?1?0100010100000???0??0???????????????
????????????????????????????????????????000??0?????1?????????????????????????????????????????010?0?0????????????
????10000????????????????????????????????????????????????????????????????????????????000??????0?????00??
??0?0????????????????0?????????????0100???????????????0??????0??????????????????1?01???????1?????????????00???
Archaeopteryx_lithographica
????????????????????100???????????????????????????????????????????????????????????00020???00?????????????????????
?????02?0?2?1?????????0?10?1110?????10000010??2???????120?????1?1?22121??1111???0??????0?0??0030?000???00??
1???????0????0???01??????????????????????0??????300???????????????????????????????????????????????????0??0?0?
???????000002?0?0????????10?000?????1???????00000??00?01???????00000??0000000?????0??0000000?????????00000?
00??00??000000?????????0??11?????1?1??????0?000?11??000?0??????????????????????????????????????????????????????
?????????????????????????????????????????????????????????????????????????????????????????0????????????
????????0?????????????????0???????0??0011??1??0000?000?1??000110?????????????0???????0???00???????100000??0???
????0???00?00?00?0????0?????0????1???????00???00?000??0??????00?????????0110???????0????1?????0????0????
Confuciusornis_sanctus
10010???????????????1?000?00??0001???0??2??0??0??00??01???????000010000?10?0001?1?????????0???????????1021?0?
2???0?2????4??111?11010??13111000?11110000001121?1?1??12000?2?111023?2??12??10??11??12021101003O?0000000001
102000??00?0101??11?100011001??????0?????000?123001(0 1)00120??????????10??00??011200??01(1
2)011111000000110000100100012000?00?0000?0??0??010000000?000211??001000000000101021O1011(0
1)?10?000000101000000000101010010001100001100O?0000000(0
1)000???200000110111O?00??1100?10?0000?110?00000??1?00?0000?0?01?0?10100?00??????????1??00?0????0000000??00
0??01?02???00100000?0????????000??00???0?????????????????????????????????????????00010???0?0??00??10????????????
0???????0001?000???0????0?00111?0?1?000?100??????0??0??1?????????0???00?0???00?00?0??100000??0??1??0??????0
?????0??00???????010????????0?????0?0000?0?0??????0??0??????0?0000100?0?0?????01???????????1????
Sapeornis_chaoyangensis
?001?????????????????0?010??11000???00??21?0?00????0??????0????0000010??10?00000020??????00????1???000????0?
211??0210004??100?????21101111010011100000101121??00?212000?201(0
1)00221210????1??01??1001210?10030000000000????2000??0??0100??0111?000???1???00??0???0000??23000000010?????
??????????????????????0?00???0000000010000100????????0000020000?00000?010001000?0?01010?0010000?0???010?1(0
1)10?11100??0(0
1)00?0000?0000?00?000??00?00??000001?00??0?00001000????????001?1?1011?1?11000100000O??1?000000??????????0?0
???????010??00???????????01??00?0??????????00??0???????????0??????000??0?????????000??00????????????????????????????
???????????????00000???0??????0???0????????0?0100???????000??000?0???????0?00111?1?1?000?000???0000??0?01?0???
????0?????0?0???00?0??0??100000?000?1?10?0?0?0??0?1???000000?0???0????1??0???0?0??????0?000?000??000?????00
0000100?0?0?1???00?1????????11?1??
Jeholornis_prima
10????0?????????1???0???0?????001???????????????????0?????????????0000?1???00?00?1?1?????????0?????????0????1?0?
11???02111031??01?0???011031110001??1000001011?1??0??01?0???2???1?221?10???????01????0101101003000000000??0
??1000??00?010????1???000?1?????0???0??0??0??12300?10011????????????????????0????00?00000??00?000000100000?0?
?001???0000?00000?0?1000120001000?0010000?000?0000?00001000010110000?000000000000?00000?0100000000010000010
00?000000001100????????011?1110???1?1100?10?0000?110?00000??????????0?0????????0??????????????????????0??????
????0??00??????????????????????????????000??00????????????????????????????????????????02?00???0??????????????
??????????????????0?0??0000????????0?0011101?1?0???000???0000??0?01??????????0????00?0???00?0??0??100000?00??1
?10???0?00????????00????????010????????0?????0???0??0?000?00???000?????0?0000100???0?????0????????????1?1?1??
Jixiangornis_orientalis
100???????????????????0010?????001????0?0??00000??????0100??????000001????0?0??1??0?????????00?0????1?00????1??
20???02??1031??11?1?000110311100011010000011112101010212000020101?221?10?2?11?001??1?01(1
2)1101003000?00?000?0??1000??00?0100??111?001?1?????????00?000000?12300?0001????????????????????????0?????00
0??00?0000?11?0?10?11?0?????0000000000?0010011210010?0?0000000?000???0??0????0??010?00100??0000?0010000000?0
0??0000??00000100000?00?0000?001100????????00??11????01?1100?10?0000?11??00000??????????0?0????????0????????
???????????????0????????????0??0????????????????????????????????????????????0???????????????????????????????????????????0
0010???0????????????????????????0?????????????????????????????????????0?1?00??00??????????????????????????0??????0?0???
00?0??0??100?00??0?????0?????????????????00??????????0???????????????????0??0?0?????????????????????????00100???0?????
0?????????????1????
Yanornis_martini
?00???????????????????1?010??????0?11???0??2??0??????00????????????0000011???0????000?1???00??0?????1???0????????
```

```
4?1???????04??????110?011031110?011?130010?????????????????????????23?010?2??10??1??0?0121(2
3)0000300000??0001???00?0???????0???21?1?0???????????????????0?????30010001 2??????????10???????1????????????
?????0?0011?00???0210?(1 2)??10100001010?1?11?112100111??0101?0101?10000?0?????021(0 1)101311(0 1)1100(0
1)100?0?1?0??0?00??????0??00?1110(0
1)?1?00??1?0??01100????????01??1????????1100?11??001?11??????0???????????0?0???????0?????0?????????????????0?
?????????0??0????????????????????????????????????????????????????????????????0???0???0????????
??????????????0???????0?0??0?0??????????00111?0?1?00??100???0000??0?01?????????0?????0?0???00?0??0??100000?
?00?1??0????????????????00?????????0?????000?????0????????000?00????????????????00100?????????0??1?????????0?1
??
Apsaravis_ukhaana
????????????????????????0?????????????????????????????????????????0002?1?0??0?????????????????1??11??10200??1???
5?100021??24??????1?010110311000011113003??000?1???1?201000?2?021?23?03?12?010?????1??12130100?00000??20???
1?20?0?????0?00??21?????????????????????????????300?10??????????????????????0?1(0 1)?????1?0????????20010?(0
1)001??21??1????????00000?0?100012101111?01011010(1 2)011111000010102111 0?(2 3)120100?11??20?1(0
1)0010?11?110?101211211111?0000?1?0??01101????????011??????0?1????????0001?????????????????????????????????
????????????????????????????????????????????????????????????????????????????????????????????????
??????????????????????????????????????0?????????01???0?????0??0?001110001000 1?1?0?1?0000????01?010????????
?0000??000????????????0??0??1????????00?00100?????0??????0???????0????0000000????00000????000????0?000?10??
??????0?0?11????0?????????
Yixianornis_grabaui
100?????2?021??1?????0?01????0?1?1?0?????????????????0100??????000?010???0?00?00120???10?01???1???0000??1?0?
40??0???0024???11?11000110311 10?0010130000100021?101?21200302000102 3?23?0211?0??1??????2130100100000??000?0
??1000?20??0?000001????????????0??0??0???0??0?123001000 1???????01??1????????11(0
1)?????1?0?????10?20011000?11021??(1 2)??10100001010?1111011210011 1100?0110???01?000???0?01021(0
1)10?31201100(0 1)100?00100?00?002?101??????11110(0
1)?1?00??1?0?001100??????00011?11?01????0100?10??000??1?????????????????????????????????????????????????????
?????????0????????????????????????????????0???????????????????????????????????????????????0????????
??????????????0????????????????00?0????????00111?0???000?100?1??000????01?????????0?????0?0???00????0??100?00?
?0??1????????0???0????00?????0???0???????0?????0???0????000?00????00??????0??00100?????????0?11????0??1????
??
Neuquenornis_volans
???????12?????????20????????????????????????00?????00?????????????????????????????????????????????????00??????
?????????????????1?11011?1031110?01111000?????????????????????????????????????010???????????(0
1)010030??0????0??????0?00????????????1????????????????????0????????0200?????????????????????????????????????
???????0110???????21?????10110??0100?001?001?0??(1 2)??1???01?0???0?????(0
1)?????????2????20?1??01?????????????????10?1?????????1?0???1011???????0?000???200000110???????????????????0??0
?????????????????????????????????????????????????????????????????????????????????????00???0???
??????????????????????000??0100??????????????????????????????????????????????????????????0111?????0??
?????????????????????????????????0?0???00?????????????00??0??1???0??????????????????????????????2?????????????????0?
?????????????????????????0010?0????????0?????????????????
Patagopteryx_deferrariisi
?0??????????????????????????????????????0010??????????????????????????????????????????????????????2????????
?????????????????????????????????0?1???????????211101???????????????????????2?010001??100121301001?000???????1
????????00?0?????1???????????????????????0?????0???????????????00?1??????00??11111 0000?????????010000000?????
???0????????000????0101?1210(0 1)00???(0 1)?10?0???01000001(0 1)0001?(1
2)00???30???????00?2000000?010120????0?000(1 2)11001100000?(0
1)?0??0?100?1?200??01?0???0?001????????00???0?1?????????????????????????????????????????????????????????
?????????????????????????????0??????0?0??0?110????????????????????0????????????????????????????0020000??00????
??????0?0?00??0001?00000????????00111?00100???????1?0000???????0100??0?0???0?000??00????0??????00??0??1???
???0?10?????????????00???010???????00000000??0?????000000???00?1???00000010??????1???0????0???0?1???10?
Cathayornis_yandica
?0??????????????????1?010?????0?1???????????0????????????????????00???????????????00001???????0????????(0
2)????????3??????2????4???0??11?02?1031110?011?1300?0?01111?0?00?12000?201?1022?23?????????1???0??(1 2)1(0
1)1?0?3000?0???00????0??1??0??0100???111?????????0??0???????0????2300(0
1)0?012??????????????????????????????0???????0????0111??0010?20??1??10110?101????010?012000100101 10(0
1)?01020111110?(0 1)?1?????210120?11?01?0101011?0?000001???1?0?0?1(0
1)1?0????????????0??01110????????01????????01???????????0???110?00000???????????0?0?0100?10100?000????????????
???0????????????0??00??????????????????????????????000??00?0?0?????????????????????????????????????0??00??00???
???????????????0?0100????????0????????????????????00111?0???0??????????0000?????????????????0??????0?0???00?0??0????
??00??00?1?1??0?????????????????????????0????100??????0???0?????00?00????????????????00100?????????0??????????
?000???
Concornis_lacustris
?????????????????????????????????????????????????????????????????????????????????????????????????00?????
???????????????0??11?02?1031110?0?1???0030?????????????120?102??11?23??3?0???1???1???0?1(0
2)11??0?3000?0???0??????????????????001??1?????????????????????????????2300???????????????????????????????????????
?????????0111????10?20??1?0101100101?0?0010001?0??(0 1)001?110??0102?1???10???1(0 1)1?(1 2)??????????????(0
1)????????????00??????0?100??1?00??1?(0
1)1??0??????110??????????????????????1100110??01?????????????????????????????????????????????????????????????????
?????????????????????????????????????????????????????????????????????????????????????????????????
??????????????????????????0???????????00111?0?1?0??????????????????????????????0?????0?0???00???????100?00??0??
1????????????????????????????0??????????????0????????0??????????????????0??0010??????????0?????????????????
Gobipteryx_minuta
?0???????????????????1?01010?0?0???????????????????????????????11?000?0???????????1?1????????????????????????????
????????????????????????2??????????????????????????????????????????????????????????????11???????????????????
??????????????????1????0???????????????????0?????????1100100?00110?10?????00??????0???0??0???1??????????????10??
????????11??10000?0?100012000(1 2)001?1?0110???0??????????????1?121??(0 1
2)0??????1?0??1?????????000?0???10?001111000?1?11?0?????????????????????????????????????????????????00000?????
?????0?1?01????0???0?0???????????????????????????????????????????????????????????????????????0????????????
????0?????????????????????0?01000?000??00???000???????????????????????????????????????????????????????????????
?????????????????????????????0?????????????????????????????????????????????????????0????????????????????????????
???????????????0???0???????????????????0????
Vorona_berivotrensis
?????????????????????????????????????????????????????????????????????????????????????????????????????????
???????????????????????????????????????????????????????????????????????????????12?010011101001112110???00?????????
???????????0??????2???????????????????????????????????????????????????????????????????????????????????????????????
???????????????????????????????????????????????????????????????????????????????????????????10101111 00001?0
00000????????????????????????????????????????00??????????????????????????????????????????????????????????????????
```

```
????????????????????????????????????????????????????????????????????????????????????????????????????
?????????????????????????????????????????????????????????????????1???????00000000?00?????????????????????
?????????????????????0?10001??????????????????????????????????????110?00000010??????????0????0?????1???1??
Songlingornis_linghensis
?????????????????????0?0???????????????????????????????????????00?????????????000?0????0????????????????????
??????????????????11??(0
1)???3?????????????????????????????????????????????????????????????0????0?????0?????00?????????????????
????????????0???????0?????????0?01????????????????????????????????????0???????????????21??(1
2)?000100?010???1?11011?????????????????????????????????????????????????????????????????????????????
????0??0???????????????1??1?????????????????????????????????0?????????????????????????????????????????
?????????????????????????????????????????????????????????????????????????0??00??00???????????????
??0?0?0?????????????????????????????1?1?????0?????????????????????????????????????????????????????????1??
??????????????????????????????????00?????????????????????????????????????0?1??????????????????????????0????
Pengornis_houi
?0010????????????????10010??0?00??????0?12??0??????0?????0??????000?001????????0?0?00??00???01??????20???0???
2??????????4????1?????2?1031111?0??????03??001?1???????????????????2??2???????????1??????211???0?000??0??000?
??0??0??00???0???11?1?000??????????00????00001230000?001?????????????????????????????0?????0???0011??00100?
???????01(0 1)00?00??????0??1??012111(0 1)0?011010001(0 1)(0 1)1?????1??1???10(1 2)(1
2)0??1??1?11??????0????00?0????0??0(0
1)?1?00??1?11??0?0??0?100????????01?????00?01?1001011???1??110?00000????0??0??0?0?0100??0?????00???????????
????0????????????0??000??????2??????????????????????0?0??0?????????????????????????????????????????0?0?0???0?0
??00???0???????0?0100??0?0??0??1?0?????????????00111?0?1000????0???0000???????????????0?????0?0???00?0??0???
???00??00?1??0?0???0????1???????????????0?????1?00?????????0??????0?0?????00?1???????00100??????????1?1??????
??000???
Hesperornis
?0??????????????????00010100?00??????00021?001????00???00????1?000?001???1?0001?021???00??10101110?2100??11?
50100?210?24??11??10??00103111??????????3??0202100?1??01000???021023?03?12???0001??11?1213110010??0?00??01?
1?0000?000???00??2??1?1111????0???????10000??10?1?10?1121200110?1010??1110011100??00?0???101012101100001 2?0
?000100100?0???10?0???00011??0??????????0???0????0?????????????????????????????20?1100001112110211110021111 1221
22002?0?????00??????0001?0???0?000?0100?11???1??01??00000??????????0?1?0100??0?????00????????0???0??0??????
????0??00??????????????????00??0?????????0?0??0????0???????????????????????????????????????0?000???0?????????????
???????000????????0?0??000???????0???01??????????????201??000????01??????????0????00?0???0??00?0??????00??????1
??0?0?0?0???0?????????????????0?????000??????????0?????0000?????00??????????001?0???????0???1???????????000???
Baptornis_advenus
???????????????????????????????????????????????????????????????????????????????????????????2????????
5??????????24?????????????????????????????????????????????????????????????????????????212??????????????????
??????????????????2???????????????????????????????????(1
2)???????????????????????11001??00??1???????????1210110000 12????012?0?????01?10?0???000????0??????????0???0?????
?????01?(0 1)1(0
1)????????????????20?1100001112110211110021111 1?21020?2??????????????????????????????????????????????????????
????????????????????????????????????????????????????????????????????????????????????????????????????
??????????????????????????????????????????????????????????0???????0?0??000???????0???01???????0?????201??00
0????01?????????0????0000???0?????????????00?????1??????0?0???0????????????????0???????0?????????0?????0000??
???00?????????0210???????0????????????????????
Ichthyornis
?????00?????????1220??????????????????????000111????0????????????000??1?????1000??0210??10???1?01111?2100?1???
5?000?21??34???01?100?001031110?011113003??0102?1??10212000????21023??3?12??10011??11?1213110???00?0??20???
??00????0??00????21?????????????0?????????????012300(1 2)0?11????????????10(0
1)1?111011101001020???101?1200111?101(1 2)?2110220101000010 10?111101121101111001011011110100001 01(0
1)1011211112312011 0011?12001(0 1)0010?112110211110021111(1
2)2?100002?0??011?100?20???0110??1??00?00100?11??01??01????????????????????????????0?00?00??????????????????
??????????????????????????????????????1?0?????00?????????????????????????????0????0100?????0?00?0000?00????????
?000?0???????00??000??0?01?0000??????0??00111?00100?0?10201??000???01?0???????0????0000?0?0???0?0??1???00?
?0??1??????000??00100?0???001??01??2?0?00000?00000000????0000?????00?111?0?00001????10?1?0?0?11?0??0????0??
0?
Iaceornis_marshii
????????????????????????????????????????????????????????????????????????????????????????????????????
??????????????????1101?010311??????113?03????????????????????????????????????2??1??1???????21??????????????20???
1??0?????????????????????????????????????????????????????????????????????????????????????????????????2
1?02(2
3)11???1101010?1111011 2101?????????????????????????????????111314011101110200 10??1?1?12110212110021??????????
??????????????????????????????????0100?11???1???????????????????????????????????????????????????????????????????
????????????????????????????????????????????????????????????????????????????????????????????????????
??????????????????????????????????00111???????0?10????????????????0??0??0???????0????????????????1???????????1???
????????00????0???00???01???????????????0???????1????????????????1???0?00?????????????????11?0??0?????????
Limenavis_patagonica
????????????????????????????????????????????????????????????????????????????????????????????????????
??????????????????????????????????011?13???????????????????????????????????????????????????????????20???
????????????????????????????????????????????????????????????????????????????????????????????????????
???????????????????????????????????????????????10000(0 1)010101011?11(1
2)313011?011??????????????????????????????????????????????????????????????????????????????????????????
????????????????????????????????????????????????????????????????????????????????????????????????????
??????????????????????????????????????????????????????????????????????????????????0?0???????????????
????????????????????????????????????????????????????????????????????????????????????0000??????????????
?????????????????????????????????????????????
Lithornis
100??????????????????01010100?00?111??2?02?00?0?????????????????10000?00????02?101?1??????????1?????????2????????
(6 7)?1?????????????(1
2)??11000010311110011?13003??000210101?20200102??2102?????12?01000???11?12130100?????0??200?01?2010???0?0?0
???21???12?????????????00???00000??300?11212100?00011111010110?11(0 1)1101?1111?01?10121012?0111(1
2)121112211 0100?010110111101121011111001 10001(1 2)1110000101010101111113130110(0 1)11102(0
1)0120110?1121102011000211112 2210010(0
1)?000011?1????????011?111??00?????????????01???1????????????????????????????????????????????????????????????
??????????????????????????????????????????????0?????????????????0?????????????????????????????????????????????
??????0????????0?0????????????????????????????????????1??000????????????????????????????????????0??????????????????
??????????????????????????????????0????????????????0000???????????????????????????????????????????????????????
```

```
Hongshanornis_longicresta
101?????????????????11010?????0?11???0????00???????????????????000?001??00????1?1?10???0??0??01??1?0????????
(2 3 4)??????????4???1??11?01110311100011113002 0?0112???01?20????????2??23?23??2??100?1??????21(2
3)01000000000?000?01?1????????0?0?????1?1?0?????????????0????0000?1?300???012????????????????????????????00???
???1?????0?????110????????01?0??11???0?10???21000111???110???2????0?????????????1??2000??000100?0??0?0??000?
???????1???1100??(0
1)?00??2?0???1?????????????????????????0100?11??001?11??????0???????????0??????????0???????0?????????????????0???
???????0??0?????????????????????????????????0?????????????????????????????????????????????0?0?0???0?????????0
????????????0???????0???????????????????01?1?0?000?0?10?????????????????????????0?????0?0???00????0??100?00??0
?????0????????????1???00??????????0??????????????????0??0?0??????????0??????????00100?????????0??????????????1????
Liaoningornis_longidigitris
????????????????????????????????????????????????????????????????????????????????????????????????????
???????????????????????????3??1??0??????????????????????????????????????????????100?1????0?21211003000?????0???
?????????????????????????????????????0??????????????????????????????????????????????????????????????01
1?01???????????0???0??????????????????????????????0?????01???2????????????????????????????????01?1?0??0011111102010
00?00??????????????????????????????????????????????????????????????????????????????????????????????
????????????????????????????????????????????????????????????????????????????????????????????????????
????????????????????????????????????????????????0?????????????????????????????????0?????0?0???00??????????????00??0???
?????????????????????????????0????????????????????????????????????????????????????0010???????????0???????????????1??
Crypturellus_undulatus
10????012?020002?2001010100?00?111?12002100001011100010???1?10000?000??102?001?1?????????1110111122100?0110
7?110??12?24??121?1101001031101101111300 3??001210001?20220112002102 3?23?12?01000100110121301?0???0100020000
1?20000200?0?001021???120??01??????0????00000103002112121(0
1)0100011111010110011011111111110010101210101121121211112?10100021011010111112100111110110001201100001110101
011111031401011111020?120110?11211020211002111122210010110??011?10102000001111110000??1100?10??01??11??????
??????????????????????????????????????????????????????????????????????????0?????????????????????????
??????????????????????????????0??????????????????????????????????????????????????????????????2????
???????????????????0????????????????????????????????????????????????????????????????????????????????
???0??????????????0???????????????????????????????
Gallus_gallus
100???102?021002?2000010100?00?111?120021?0001?1000001????1?100100000000021101?1?????????101(0
1)1111221?0?01007?120??12?24??1(1
2)1?1101201031102001111300 3??00121111 1?2??2001120021023?23?12?0100011011??21301001000100020 0100?20100200?0?0
???21???121??01???0??00???000001030011021212111112211011111111111101100011010111210101120111211112110100021
0111111111121001111011000120110000101110101111113140100121102 1?121111?11211020211002111132220 0111?00?01100
01020?000111111?000??0010110??01??11???????????????????????????????????????????????????????????????????
??????????????????0???????????????????????????????????????????????0????????????????????????????????
???????????????????????????????????????2????????????????????????0???????????????????????????????????????
????????????????????????????????????????????????0??????????????0??????????????????????????????????
Crax_pauxi
1001011?2?021000??001010100?00?111?12002100001110000010 0??1?1000000000000021101?1?????????1000111122100?111?
7?120??12?24??121?1100201031112101111300 3??0002100?1?2??2001120021023?03?12?0100011011?121301001000100020 01?
1?20100200?0?0???21???121??01??????00???0000010300210212121111122110111111111111011000110101112101011201112
11112110100021011111111112100111110110001201100001011101011111131401011211021?111111?112110202110021111 3222
0011010000110 00?020?0001111110000?11100011??01??11???????????????????????????????????????????????????????????
????????????????????????????????0?????????????????????????????????????????????0????????????????????????
?????????????????????????????????????????????????????2?????????????????????????0????????????????????????????????
??????????????????????????????????????????????????????????0???????????????0??????????????????????????????????
Anas_platyrhynchus
100???102?021002?2101001100?00?111?10002??00?1?100010?0???1?10200000100?021101?1?????????101?1111221?0?011?
7?11???10?2410121?110111103111110111130 03??0012000?1?2??2001120021023?13?12?0100011011?121311?0???010002101?
1?20100?00?0?0?1021???121???????????00???000001130021021211111112211021112111111101100011110111210101020 1112
11113120100101010?1(0
1)11111210001110011000120110000101110111111123140101011102 1?111110?11111010211002 1111(2
3)2210010210?0011?10?020?000111111?000??0100?11??01??11????????????????????????????????????????????????
?????????????????????????????????????0??????????????????????????????????????????????0????????????????
???????????????????????????????????????????????????????2???????????????????????0????????????????????????????
?????????????????????????????????????????????????????????????0???????????????0??????????????????????????????
??
Chauna_torquata
000??1012?0210002?101010100?00?111?100021?0001010001010 0??1?100000000??0021101?1?????????1011101112100?111?
7?11???1012412111?1000001031111101111310 3??0012101?1?2??200102?021023?23?12?0100011011??213010010000000 20010
1?20100000?0?0?1021???121??01??????00???00000123001102121(1
2)1111022110111121111111011000111101112101210201112111114010100101011111101112110211100110001201100001011101
0111112314010111110 21?111111?1121102021200211112222001001000011000102000101111110000?11101?11??01??11??????
??????????????????????????????????????????????????????????????????????????0?????????????????????????
??????????????????????????????0??????????????????????????????????????????????????????????????2????
???????????????????0????????????????????????????????????????????????????????????????????????????????
??????????????????0??????????????????????????????
Epidexipteryx_hui
?01?????????????????????1???????00??????0???2??0011?????????????????????100?0?0?????00001020???10000?????????????????0?
(0
1)????1?1?123??10??0?????0101?010?0???????00?1?????????????022??????011?03?0????????????0?????011?0??0?10?000???00?
?1?1?0???00?0?00???0?0????????????1??2??????0????????2?0??????0????????????0??????????????????????????000?0?????00??0?0
???????????????0??0?0???????1???0???????????????00?(0
1)0?????????????????????????????????????????????????10?0?0?0?????10?00???0??????????1??11??1??????????????0?
00?100??????0????????????0??????????0??????0??????????????????????????????????????????????????????0?????0?
????????????????????????????????????????00200??02??????????0????????0?1??????????????????????????????0011??1???
0??????00????????????01???????????0??????0?0???????????0?????0?0?????0?????1???0???????????????????????0????????00???????0??
?0?????0???????????0????????????001?00???????????????????????0????
Incisivosaurus_gauthieri
?00?00?01?001??1??10001110100100 1?010?120000110001010110101111210100001001?1?000210??00?0??????????????????
????????????????????????????????????????????????????????????????????????????????????????????00??00?
?01?0??0?0??????????10000000100010 2?00010?100??????0000000000100001??0000???0000101?1100??0000??????????????
????????????????????????????????????????????????????????????????????????????????????????????????????
???????????????01020?00???0??100?0?0?????????????11?1100000????1000000?0?0000?000?0?000???1000??1??00?0????00
0?110??010??01?0000?00000???00?00????0100??0111000?????????????????0010000000 10000???00200??02?1?000000000?
```

```
????00110????????????????????????????????????????????????????????????????????????????100?????????????0??
0?101?????????????????????????0201100????????????????????????????????????????????0?0?0??????0??????????000?0?
Citipati_osmolskae
?001001001001??221000101111?01011?00010210001100001000100011012112?0?0100010111?1?????????101110110010121100
1??201??002200111?0111200110100100?11000001000211001??02012020??10111111?21010000000000?0000000000000000000001
1020000000?0?001000?000002011???0???(0
1)000020001220001000000001102?1??0000??0000010001010??0000020011000(0
1)0?00?0010000101020??????0????111000?0?0010000?000000000000?00100?0??0?0???0000000????00000?20000000000000
00000002?000?000000000020?000110??00(0
1)10?011011000000011?1100001????1000001?0?0001?11000?001???1002??0???0?0????000?000??000??01?0000?000000000
0100?????100??0111000?????????????????101000000010000????10201???2?1?0000000???0????????????????????????????
????????????10???00?00????????????????????????????0?0?0???00100????000?00??0???0?00??????????0?0?0?00?0???0?0
0211???????????0??00?000?0????????0???????0?0000100?0100????10??????????1?00?0?
Oviraptor_philoceratops
?00?0??????01?1????0??1??111?1011???0???1?0?11???01?0???0?11?121120?01?00?01?1?1????????????????????????????
????0???????????????????12??1?????00???10??00?00??1??0????????????????????????????????0????0????0??0?????00?00000?
???2?00?0?????????????10000?0?0????????0??0???0????00???0?00?????????10?0?00??0??00?00?1?1????00???00?100????0?
???????01010?0?00?0?0????1?100??????1100???0?????????00??????????000?0??00000?????????????????????????????????
??????0??000?????20????1?0???02?0??1101100???0011?1?????1????10????1???0?01????????01?????????????????0??????0
???00??0?0??0??00?????00???????????????????0??????????????????????????????????????????1020????2?1?0000000???
??????????????????????????????????????1???1???0????????????????????????????????????????????100????000?????????
??0??????????????????0??0????????211??????????00???????0??0?????????????????????????00??0??????0?????????????00???
Microvenator_celer
?????????????????????????????????????????????????????????????????????21?20?0??????????????????????011?0?11000121100
???0?1?1002?????????????00?000?11000?????0010002???0000??????????????1110??0101100?0000010????????0??0???00??1
1?20?0??00???0?1??0????????????????????????0???0?2200000????????????????????????????????????????????0?0001????????
?????????????20000?000?01?????00?0??010?00?000000000000010000?????00????????0???0??00000200000000000000???????
?????10??0?????????????????1?????????0????????????00?????????????????????????????????????????????????????????????
?????????????????????????????????????????????????????????????????????????????????????????????????????????????????
?????????0???00??0001?01001??????????????010000?0??????100???????01?01??0000????00???????????????0??????0???????
?1????000?10?000???0010?0001????1??????00??00?10??00000000??000?0??00000???????????1?01??11100??001??????
Caudipteryx_zoui
00010?????????????????0?111??10?0001?10???21000???0?0??????????????21120?0?????????0?1??0??????00?????0??00????1???
0???01?????30?????0???0??0???01?0???100000?000?1??????0201202???1????101?11??????0????01000??1?00?0?000000?1
102000??00?0?001000100000?00????0???00?00000?1(0
1)2000000000???????????0??????0000????1000???0000?00?0000?0?0???????????????20??0?0?000?11??00????????0?0???00
?00??????????????1??0000???0000000?000000000??0?0?00????0000000??0??2000000??0?????????01101100??01?110???0??0
00?10???0000??????0????0?0?0001?00??????0????????????????????0????00???00??0?0??0??0??????????000?0?????????1?????0?
?????????????????????????????????????????00201???2??????????0??????????0??0???????????????????????????????1???????
00??000???0000??????????????????0?00??0?0???001?0?0???00?0???0????11??????0???000??0?00?0???0?0???11??0????00??
??0?000?0000???0?0?????0?0?00100???0???????????????????1?10???
Ingenia_yanshani
?00?0??????????????????1?1?????1????????????????????????????????????21120?01000?0111?1?????????????????????????????
1???01????2?00???1011120011??00000??100000100021??????02012020011011?11101101?0000?00011?000000000??0000??1
1?2000?000?0?001000????????????????????0002?0??2200?1000000??1?????0?0??0??0000?00??1?10???000??0??1??0(0
1)0??02???????0101??0??0???0?0?0101000?????1100???00?0???????????????????????00????0?00?00?000?0?000??0?0?000?0?0?
0??00?0????00?000000?????????0110??00?1?0?1101000??000?1????????????????????????????????????????????????????????????
?????????????????????????????????????????????????????????????????????????????????????????????????????????????????
??????????????????????????????????????????0011000?001?0?01??101000??0101??11??0??????00000???00?????1?000000
010??1?1?0???????10???0???0??0?000????11???0???0100000001000000000??000100?000000010?????????????0??1?0??00?1???
1??
Rinchenia_mongoliensis
?00?0????0????????????0111?1???1?11?00010??00???0000?????00??1?12112??01000??111?1?????????????????1???????????
????0?????220?????????????2??1???00?0???1??0001000?1??????1??????????????????1??????????0????0??0?0?????????0??00??001
???2?00?????????????????0??????00????????00??210???????2??0120??????????10?0?10??0???0??????????????0????????????????????
???????????????????????????????????????????????????????????????????????????????????00???0?00??????????????????????????
?????????????????????????????002?0??????????????00?1?1?00001????1??0001?0?0001?11??0??01???1???????????????0????00
0?000??000??01?00???0?000000?0?????????100??0????0????????????????????????????????????????0??????????????????????????
??????????????????????????????????????????????????1?1001??????????????????????????????????????0?????????????????????
??0???????????????????0?????????????11????????????????????????????0????????????????????????????0????????????0??????????????????0???
Conchoraptor_gracilis
?0010????????????1???00111?1???1?11?000??21000110?00????1?0????121120?010?0?0111?1???????????01010110010??1?01
2?110??10????01?1?????20011000010???????0010002100010102002020??101101(0
1)1?11010000??00010000010?000??000?001102?0?0000?0?0010001000002001????????0?0?0200012???????000000000???????
?10???0100100?????????000??0?010?????????????????????????????????????????????????????????????????????????????????
??????00?00??000002000000000000?0000?002?01??????????0?020?000??0??002?00??????????????0011?1?00001????1??00?1?
0?0?01?11??0??01????0?2??????????0????0?0??00??0?0??01?00???0?00?000?0?0???????100??0???00????????????????????1
0???0????????0?????????????????????????????????????????????????????????????????????????????0?0??????????????????????
???????????0?0????010?????010?????0??????0????????10???????00?0????????21????????????????????0?000000?????????????
???0?1?00????????00??????????????0?0?
Chirostenotes_pergracilis
?????1??01?01101??0???1?110?0???????????????????????????01010???????21120?00000201???1????????????????????1101?12????
1?12???0?????????????????????101?1???????????00?100021?001010221202011110?111(0
1)??01??100???00?100000200000??000?0?1??20?0?000?0?00100??????????????????????????000?????(1
2)????10?????????001????00???????????????01?10???0????0011??00?????????????????????20000?00000????????????????????????
????????????????????????????00000?00??00000?00?0?????????000000?0???0000?????001020?00???0?????????1?????????0?
001??????????????????????1?0?00???0????????????????????????????????????????????????????????????????????????????????
????????????????????????100001000???????00200???2?1?000??0000??????????0????????0?0??00???1000?0?????????????
??0??0??101000?????1?0100?0??0?00??00000?001?0??1?1?000?01?????1?0???????10?????000??0??????02?1???0110?1???
????000000000???00????00??00010?0??0?????1?0??0????????0?1??
Avimimus_portentosus
?00?0???10011?00??0??1?1????????1???1?????00?11??00100110???????2?1???00?0??0111?????????????011010110101?1?00
??100????????????????????????????0100???????????00?211?01??0201202010?011?0?1000100?0???00011110020???00??0?0?01
?02?000000?0?001000????????0???????????00?01??0?02001??????????????????????0??0???00??0???????????02001000??????
??????????????????????????0?????0?0?0010000?000000000??????????????2????????????(0
2)0?000?0000020?0100000000000000??00?01??0???????0????????????????????????????????????1?0?????????????????????????
????????????????????????????????????????????????????????????????????????????????100??0?1100?????????????????????00000
```

01?0?00????????????????????????????????0???????0001000001??????????????00001???????101001??0101?0100?0?0
00??001000??00???????0??0?1001??101????0000100000?????1001101102?????101010000000????00?000???0010000000000
10?0????1??01????0??00?1???1??
Falcarius_utahensis
??01?11100001111010?????1????00??????????00??????0000000??????100?000??0???????001010001?1??000111010121010
0012000100??0000??????00000100010001 0?0000100?0110010102203010101001000100000000000000110000000000000??000?1
0?00?0?000?0?001000????????0?001???00?0?0?0??11?0??000???????000??00???0??00?00100?0?00??0000??0010000(0
1)0??????????01000200000?000000001110?1?0?0010000?00100000000000010000???0100???0000000?00000000020000000000000?
00000000?0000??00000?0?200000??0???00000?1100?00000000???????????????????000?00?00100????0????????????????
????????????????0??????0????????????????01?00????00?00?????????????????????????000000101001 0????0??00000001???0?
?????????????0?0???????0001000001000??1000??1010000000100000000000?0101?010000000001?0000001000?0??00101000
010?1?01?11?10001001000000000011101002?0?1011110000001010001 00000??000001000?000000?0?10?10000?011011002?00?
10?
Beipiaosaurus_inexpectus
0??1??10?10??????????????1001001?100????1??????????
????000??0220?????????0000??0????0?1000000?0000??001???20220??0??0????0??00?0??00??????0000????0???0??00111
???0?0??0????0010?0???????????0???????????0???0??????0???????????????????????????????????????00????001000??????
???????00?00??????????????????????????????????10000????????????1??0100???000000???0??0??0?????0???????00000000
00???0?0?00000?????????????10?????1?1100??0??000?1?0?????0?????????????????????0??????????????????????????????
???0??0?00????????????
?????????0???????0??????????????????????1???0?00??00???00?1????????10?????0?0??????????00???????1?1?0???????
?1??1?????10???000?0?00????????????????????0??0?01000?01010???0?11??10??0?1?0???1?????????????????????1????
Segnosaurus_galbinensis
???21??10?0000?000???0100?001????????1??????????
1?0?0????????????????????0?10?1?00000????0???200111001020202 21??0110201101?11001?00?00?1100000021?0??00?01?1
??0?0???00?0?010?00???????????0??????????00???????0?????????????????????????????????????0?0????0??????????????????
?????????????0??????0????1????1???0010000?00100000?????????????????????????00?00000??10??????00?????0000000
00??21?0????00????????????????????2???????????0???
??
????????????????????????????10?????????????0?00???????21020010?0101??02????????????0?00????????????????0??01??0?
?1??1?????????2???????0??110?????????1???????10100??1?111222101111111112?111201???????????0???1??????????????
Erlikosaurus_andrewsi
?0012???2?0?1?1??1010011100??0001?100000100001000000000000??11112100100000002 0001?001001001??????????????????
??????????????????????????????0???0000?021?0??00??11?
?00?0?00??????????????0?000000100 10??00000?000????0?000002000001???10?0100???0000?0?10000??0000??????????????
???????????????????????????????1?0?0010000?0010000000??000000
00????????0000?0????000?????000?0??????????0????01?0001100????1?10000?0?00?0?10000000 0???0??0?00??00?0????00
0001000000??00?0200?00000101000?00001?000??00?0?00????????????????00000001101????0???0100100020000000000000
0??????0????????????????????????????????0?00??0000???????00??0???
0?011?????????2????????????????11210?11???????1?0?1?????????????????????????1?0100100 0???01???????????010?0?
Alxasaurus_elesitaiensis
???210?100????????????1001001??????????0?0101000
0?1?0101002?0?1????????????0?000??0?10?0000120?11??0??1?20?21???11?????????1????0?????????00000?10000??001?1
??00?0??00?0?0???00???????????0???????????0?????0????0????????????????????????????????????0??00????0??00??(0
1)0?????????????????0?????????0??11??01??????0?0???010000??????????????10?0100???000000???0??0???????????????????
????????????1000000?0?????????0?????????????????????????000??
??0??0020??????
???????????????0?????????????11101?????1??0?11??0?00??010?0?????01??????????2?????????????????200??0????1?1??0
??0????1??1?100???????0000000??1??0???0?00???11?0????01100??11?1?????1111?????1?00???10?1???0??????????????1?
???
Neimongosaurus_yangi
???21????0??????????????0??001?1??000?110101?1?0?
10?2?1?1?02200????????0001010000???????????????111001?2????????????????????????0??00????0??00000021?00????0??1
??00?0??00?0??????0????????????0????????????????1(1
2)200?0??????????????????????????????????????0?????00?0000?0???????????00000200?0?00000?0?11001?0?0?10?0???01
0000?0?00????????????????????????0?????????????20?00???????0?00000000?0210??????0????????0????????????2?1100?000??
??
???0????2????????????????????????0????????0??1??11????????0??01?10?0?00
???????21?2???????????????2?1???1?00??00000?1???0??00????00????00??????100010?2????????00??????1???0?0111?111001
011????1?1121?????111111????10????1??11??0?0??0?100???1?1??
Erliansaurus_bellamanus
???10??1???
???????1?????????????????0?0???10?0?0???00000????1?0?1????????????????2???1????10?00?0?0001?0??00?????????????00???
???????????????????0??????????????????????????0???????200??0????0??????
?????????????????????????????01?0?0?10?0???010000???00010????????100???000000????????????20?00????????0???????
?????????0??????????????????????????????????????000??
??
?????????0?????????????????????????????????????0?0?1?0?01?????????????????02?0???1?000??????????????00100????????0?
????????00???100?????00?11??????????????????011?111111??11?1???0?1?11111011?0??????????1???????????0?1??????
Suzhousaurus_megatherioides
???0101??010
00??0??1????0????????????0010100000???????????200111001?2020?2?1001002011010110 0?00????????????????????0????????1
????????00???010??????????????????????????0?????0?0???20010000(0
1)??????????????????20000?00000?01010?1?0?0010?0???0100000??00?????????????????????????00?000?00?1020000?????????
????????????0???????????????????????????2???
??
?????????????????????????????1011110010000 0?11010?00??????021020010?0101?00201010????????????????????????0???0??
01??00?1????1000?0?2????????00?????????????????11?100011????1112212111110??????????????????????1?0??01102?0?2?????
???
Nothronychus
?????1112??11?1?0?0?????????????????????????????????????00000???????????????????????????????1?????????????10101?10?0
1?1?00?100220?001?????00000?100?00????00000200??10?1?2020221100100201101?1100100?100011000000021?00???00???
???0?0?000?0?010?00??????????????????????????0????1(1
2)200????????????1??????????????????????????????????????0010000(0
1)0??????????00000200?0?00000?0211001?0?0?10?0???010000???00010???????000??00??00?000000?1020??000000000?
00000000?0210??0?000?0????000?????????0???1100?000?000???
??000?01100??????????????????????????

???????????????0???????0?0??1010110???0000?110?00001?0?0?021?20010?1101??02???1?10000?0?000?10?????0?1?0000
010?0??1?11?1?0010020000?00001110?1?2??????1?1110?0001???111122210111111?12101120??0????1?1?0???10?????1???
10?
Enigmosaurus_mongoliensis
???
??111?01?2020221100??0201101??????????????????????????????????1
????????00???010???
???00?000000?10????????????????????
?????????????????????????????????2???
???
???????????????????????????1??1?????????????????????2?020?10?1101?????????????????????????????????0??01????
?1??1?122121100???
Nanshiungosaurus_bohlini
???1???????101?121???
0??
??0?????1???200??0???????
???0???????????????????????????????
?????????????????????????????????2???
???
?????????0??????????1???1??0????????????????????????21?2??10???01????????????????????????????????????01??0?
?1????????????????????????????????????1??????????????11222??11??
Therizinosaurus_cheloniformis
???
???????????????????????0010?0000????0?00200?????????????????????????????????????0??0?110000000021?0???00???
??00??0??????
????????????2000??00000?01?1001?0?0?10?0???010000????010???????100??00000??????????????????????????????????
??????0??0100????????????????????????????????00??
???
???????????????????????????????????00?1010?00100101??001?0????????0
??????????10??0000????????????????????????1110111111????????????????2?111?0?????????1???01????0?????????
Haplocheirus_sollers
?0010???00010?0?12011011101112001?000020100?0?1010??0001?0010000010110110?1000001101010100??10??0?0111201??
0?00001?0???0?00???????100210001210?0?00010???001?00?101002010010?011000?00000000?0000?0000000??00?11100011
00010001?0???0010?01000000000??0000001?00000?102000000000????00??00???0???000000??0??0??0000?000?000????0?
????????????20000?000000010101??????100???000?00???????????0???00000??0000000?00?000100200000??????000?0??
0???0100?000???0?0??????????00?0??????????0?0000001?00001??0?0000000?0?01000000?0??11???0??0?01??01?0????00
0001000000??00??100?000000000000?000????00??0??0?0??????001????????0?0??0?0000????0???00000??00?00000??00???
???????000???????0??1????????????00?1010100??0100?00?0?????????0?01??0??00?0?????0?????00000?00?101000??00?0
??010?11001001000100000110??00??0?101???00000???0000?????????000????????00101???0?1?1?010?????0??0000??1
Alvarezsaurus_calvoi
???01000???0???
0?20?0?2012????????????000?00????????0??1?0000101?00?2??????????????????01?000??0??0??11000000??00????????1
???0?0??00?0?????0???????????????????????0????10???00100???0???
????????????2?000?????0?0?0???0??000?00???2????0000000?000???
00?02???0?????????????0????????0??????????00???
???
?????????0???????0001?00????????00?10?0?0????????????000?000????????????????0??00?????00????????????0??0??0
????????1000???????10?????101???????1????00??????????00000??????1???0?000?10??????1???0?0??0??0?????????
Patagonykus_puertai
???1?01?112????
012010?2?2?????????????00210???210?????1?0???1????1010?????20????21202??11000000000001210??0????001??0????
???0???????0?????0??????????????????????0?????01???0?00100???????
????????????20000?000?00??????0?0?0000??0?0010000???0??????????1????????????0???0????1002000000000000??00?0??
?????10??0???????????????????????????????????0???
???
??????????????????????00001?01100?0????000?1100??????11???0?0?01?01?1?000?10??1????0?00?????0????00?000?0?
?1???0??1001?101??1?0?1111111????????????0?00000??0?????00??0000?00?0?00??1?????????10??1???0???0????1??
Achillesaurus
???
?020???2??????????????????????????????????????10??01?2???????????????????1??????0??1?01000??0???00????????1
???????????0?????0??????????????????????0??
???0???????????2????0000000?0??0??
0??
???
???00?0??????????0????????00?0????0??????????????????????
????????11????????????????11?????????????0????????????000???????1???0?00?????????????0?????0????????????
Mononykus_olecranus
?????00???????112????????????????????????????????????100????????????????????????2????00???????1?1?11102001?
??2?10?2??????1???1000?000200030210?02201100??1????1?201000?2?????3??0??0210100111011212000030000001??00???
1??0?0??00?0?0???00??????????????????????????00011???0?0010?0?????2
10???00?????2?010?0?0?0?010?011?0?0001000?001000000000??0000???30000???0???0??00???????2000000000000??0000?
?0?00?0??0??000????????01?0?????0?0???????1102???
???
?????????0???????1001001000????????1010100000100?????011???0???01?010000010101?100000100???0??????00??1??0
???021?1110010111111111101011???????0100000000000?000?0000??000010000?000?10????????100?10100?0?01???1??
Shuvuuia_deserti
?00101002?010111120110001011?01111?10020100001010010010???1110?00101001002100??0211??000??0111111011102100?
0?201012012110100?1000?00020003021??0220110000101001?201000?2002203??03?02101001110112120000300000011000001
100000010000?00??001000000001?010??000000000?000100000000?101000?10000110?0111000??0(1
2)0????0100?0010000(0
1)0?0210?0?00?????20010?000?010101011?0?0001000?00100000?000?????????30000??000??00?000?00?1020000000000000
?0000000?00100000?0000020?0001?01?1010001???????1110200?000?000??0?1??0000?0?00000?00000100???0??0?00??01?0
????0?????0??000??00?0200?000000??0?0?0??00?000?001?0?0????????????????????000000000????????00000?000?0??000
000??00??????0?0???????00010010001011?0001010100000100??0?01110000???01??1??????????0???0????00001????1??00
??1??00110210?110010?1111111??0?01002?0??00??0?0000000?000000000??000?????00000010101?0??0?00110????00?1101
?0?

Parvicursor_remotus
??10?????
????1??2?????????????????????????????????????1????2?1000???02203??03??2??100011?11211000030??00????????
1??????????0?00??0????????????????????0?????0??0?00?00???????
???0????????1?200000000000??000?0
00?00?0??????????????0??????????????????11???
???
??????????????????????1000??????00???????????????????????0???01??10??00?0?01??000??100?????????00??1???
?????1?111??????????11100010???????????0??????????0?????000??00000000010??????????0???1?0????1???1??
Albertonykus_borealis
???
???????????????????????????????211?????1?0??030????????0???
???
???
??0??02??
???
???1?????????????????????????????0???00????0???????????????????
?????????????11???11??1???0????0???????????1??????????????????
Albinykus_baatar
???
???0???????????????????????????????1101??121100300000????????
????????0000?????0???
???0??????0????????00000000?00000
00?00??0????00???????0??????????????????11???
???
???0?010000??00??????????00??1???
???00000?10??????????0?????????1??????
Bonapartenykus_ultimus
??112??0?
??????????????????????000210??????????????????????01????????????212?2??1??????????????????????0????????
???0?0???????0??????????????????????????????0??00100???????
????????????20000?000?000??10???100???????????????????
??????0??
???
?????????????????0?1000??1?????0?010?010?????????????????0?0?01???????????????????00?????00???????????0
??????1???011???????????????????????????0??????????????????0?????0???????????????????10????0????????
Ceratonykus_oculatus
?0010???2??10????????????????11???10?201?0?0?0100??0????????????01?0?????????????????????????1?1???????
?????????????????10????0?2???0???1????????212?0003???00????????
???????????0?????0??????????????????0??????????????????????00???????1????111??????????????????????????2
1?????0??????0000?0???01??????????????????0??0000000??000?0
00?00?0???????????????1????10?0??????????????0??0????????????????????????????????0????????????1?0????0?
????0??000??0??02???0?0000??0?0?0??00?000??0????0????????????????0??0?00?????????0?0???????????????????
?????????0???????0001??0?0??1000???????0???????????????
??1?????1?00?0????????????1??????????????????????????????????????00?00001??????????01???????????????
Linhenykus_monodactylus
??111?101?1??1?0?
??2010020?2???????10?0???1?????????0?21110?????????2????????????????0?1010001????2?2?0?030?0000???0????
1??????????0?????0?????????????????????????01??0?0012?0?????2
10????0?????20??0???0?0?0?????????????????10000???0??????????31?????00??0?????????1?200000000000??000?0
00?001?????0?0????????1???????0????????????02??
???
?????????0???????0001?01000?????0?????1????????????????????????0?0??00?0?0???000??00?0??????1??0???????
?????1011????????1111?1???0????????????0????????00????????????01??00?00001?????????0?1?110?0????????
Xixianykus_zhangi
??102?00?
21201??0???????????????????????????????0?01?1??1?200000?20022?3??03?02?010011101121211??3???000???????1
1???????00?0?00??0????????????????????0??0?0010000?????
??00?000000?1?200000000000??000?0
00?0????????????????????????????0??
???
??????????????????????1000?0?????????????????????000110000???01?010??00?0?00010?0????????????????????0?
?1???1011???????????111??11????????????0??????????0?0000??00001000000001??????????0???100????1???1??
Nqwebasaurus_thwazi
?0???????????????02????2010????????0100?00??1?????0?00?????????????????????02????1??????00?11001???1???
??????????????????????0102?000??0?00?10110???????????????????????00?????0?0000100010000000?000?1??00???
???0?0?0?????0???01?00??00?????????????????10200???????????????????????????00????????????????????????0?
????????????20????0?0???0101?0??????10?0?????????????????????00000??00000?????????00???????????00?0????
00??0?0??00000???????0??????0?0?????????0?001?????????????0?0??????0???0?????????0???0?????0???????????
???????????????1?????????????????????000??0??0?0????????????????????00?????????????????????????????????
?????????0????????????????????????000??01?0?1?0?0??????????????????????0???00?0???00?????0?111?0???1??0
??012?????100??00010000100001??????0????????????0????????????????0?000010??????????0??????????1?1???
Shenzhousaurus_orientalis
???0??????????????21000??10?0??1???000??00?000?0?????????0?00000000??0??0?1?12?0??1???????????000??1???
0???00000???0?????????????????????????010000000??11000100101?000001100??00001?0???????????????0??1??1?0
011?????00???0010??10000010????????00??0?00???0???00?000????????????????00?????0??????0?00?0?100?0?0?0?
??0?????0?00000?00000?0002?000?????????????
??????????00?????????????????00000????????01?00??00000??0?0000?00?0?000000000??00???0??0??1???1????????
??10???????0???????????????00?00??00?00?0????0???
??????????????????????000???????00??????????????????010100000?0001?00??0????????????01?????0?10??00??1?
?00?2?0000????????100?0????????00?10????00????????00000000???00????????0???0??0???1????????????1???0
Ornithomimus_edmonticus
?00010?1101101?101021000?0101010110000000000001000000?????00000000010?1001?1???????0?001?10110000111000
10100000000100100??????011200120000000?20200100000011000110101100000110010000011000100010000020??00?01111111
0121110000?0?0010001000000001?????0001?0000000002100000000?????????0?0?10???000010110??????000000010000(0
1)0?0???????????????0??0?0?0?0?01?1001?0?00?000???0000000??00??????1??00000??0000020?000?000002000000000000?
0??0?????0??0??000?1???????0???0??0000000????????00010000?00000?00?0000?01?0?0100000??0??00???0??0001??01?0

????000001000000??01?00????0000101?0000??000000??0????0????????1??????????1????????????????00210???0?00000?
010?????????????010?00?00001000011????????????????????10?00???1??????????????????????????1???????0111100111111
111?11000???????100??0???00?01????101?0???1??0?0000?10000000000????00000000000000100?0????????1???????????10
?01
Archaeornithomimus_asiaticus
??00?10110000111000
1?100000000?0??????????010200?20000?0110(1 2)0???000?0110001101011000001(0
1)201000001100??000?0000020??0000?10??10??1?1??00??0?001000??
??????????????????????????0?001000?(0
1)0???????????????20?00?00000?0?0??01?0?0010000?00000000000000010000??00000??000??00???00000002000000000000?
0000??00?0?10?000??????????????0??????0?0????????00001??
???
???????????????0???????0??1?00001?00??00000?00020010?010?010100000?01011?00000000000?000001000????001?101?
001?11?0????0000100000001100001??011???????110?000001100000000000??000000000?000?10??????101?0?1?000?000????
1??
Anserimimus_planinychus
??1????
?????????????0??????????1?200?2????00?20200100000011000110101???001?001????????????????00002???00????11??1
0??1?1??00?0?001000??
?????????????0????????0??1???????????????????????????????????????01000??00000??????????????????????????10000??
00??0??0??00?1????????????????????????????????001??
???
???10?0??1?1???????????????????????????1?0??????????11011011001??1
?0?????????100???01?00??????????????????????000?10?000??????????????????????010???????????????????????????
Struthiomimus_altus
?00010?110??0??1010210002011101?1100000000000000010??0001?01??0001000001020001?1?????????001?10110000111000
10100000000100100??????011200120000001201001000000110001101011000001?00100000011000100010000020??00001111111
0121110000?0?001000100000001??????00?1?0000??2210????0?????????????0?0?1????000?????0?00???00?0000?0000(0
1)0?0??????????????200?0?0?000?0101001?0?0010000??00000000000?100000??00000??0000000?000000000200?0000000000
0000??00?021000000?1002200000?0??0?00?00?????????0010000000000?00?0000?01?0?010000000000000???0??0?01??01?0
????0000010?0000??01?0000??0000101?00?0??000000??00?0?0????????????????????1000011010?00????00210???0?000000
000?????????????00??00?00001000011?????000000000200?110101?10100100?01011?00000000000000100010000001110011111
1?1?110000??000010000001100001000110100???1??0?0000110000000000???000?000000000100?0?0?101?1110000?0000?10
10?
Gallimimus_bullatus
?00010?11011010101021000201 1?0101100000000000000001000000 1?0100000000000001020001?1?????????001110110000111000
10100000000100100??????0112001200000??20100100000011000110101100000110010000011000100010000020??00000111111
0121110000?0?0010001000000001?????0001100000000221000?0000000 1000000?0000??00000?0?10200??1000000010000(0
1)0?0??????????????20010?0000000101001?0?0010000?000000000000100001??00000??0000020?000000000200000000000000
0000?000?021000000?1002??0000?00??0000000???????00001000000000000??0?0000?01?0?010000000000000???0??0?01??01?0
????000001000000??01?0000?00000101000?000000000?000?0?000???????????????0010000111100000???00210?0?00000000
0000000????????000000?00001000011(1
2)00000000000020011?0101010100100?010110000000000000000100?1000111011111011001?110001??0000100000001100001 00
0110100???1100000001100000000000??000000000000000010000?0010101110000 10000?1010?
Garudimimus_brevipes
?000?????01101????02?00020101000??000000000000000000?00001?0100000000000002?001?1???????0??0111????0001?1000
1?100??00?????10??????????????????????????????0000001100????????????0??001000001?000?000?000001000000?01??111
0?2?1?0?00?0?0??000100000000??????0000100000010???00?0000?001000000?0000??0000010110000??000000000 10000???0?
???00?000000000200000000000000000000
00?021?0????0000???00???0??001000????????00???000000000002?0000?00?0?010000000000000???0??0?01??01?0????00
0001000000??01?0000??000000000000000000000??00?0?000??00?010???????001000000010???0???00210???0000000000000 0
0????????0?0?00?0000??00011100000000????????????????010100100?0101?0000000?000000100?10001111??????001000?1?
0001??0000???????????000010110100??????000??????????000000??000000000000000010000?0010??01??0011??00?111?0
Pelecanimimus_polydon
?00???????1????????2100?2?1??0000??000000?0000???????????????0?000?0000???????000211??0001??000???0?0?111?00
???????????????0??0?00???120????00??0?2010??1001010??
??0?????0?????0????10000??0?1?0????00????0000?0?10???0?0???????????0?0??????????????????????00???0?10??????0?
?????????????0??0?0?0???0?????????????????????????????????????1??00000??00000????????????????????????????????
??????0??000????????????1?????0?00????????????001?00??00010??0?0000?00?000000000000??00???0??0?01??01?00?0?00
00011??000???????????????????????00??0?000???????????0010000????0???????????????????0??00??00?????????????
????00000000?10???????0?0???????????????????????0?01???010?1??111??????0??
??0?2?0?????000001100???????????0?1101???????????0?000??????????????????????????1???0??????1???????????111??1
Harpymimus_okladnikovi
?0???????????????????2100??????0??????000000000000??????????????000000?0000????1?1200??1???0???1???0?00??1000
1?100000?00?001?????????0?1?0012000000000010?10??00???????1??????????????00?00??????0??0?01000001 0??00000101 1??
??1?0???00?0?0???001??0000??1?0????00??0000??11?10000000??????????????0???????????????0000??00?00000?0000(0
1)0?????????????????????????????10??01?0?0010000?000000000000???0?010?00000??0000000?0?0000?00?????00000000?
00000?00??11??0000?0?????????0???????000??????????0?001?000000000????0????0??0?0?????0000?000???0??0?01??0???
????????????????0???1?00??????0?????????????00000??00?0???00210??000??????
??0??????????????0???????000??0000?1??0????0000??2001?00?01?1??0010??????????0????????????00?0??0001100100011??0
??0?11?00????000???000001000????011???0??01???00000110?000000000???0?00???0?000?100?01??1?1?01??00??00???1?
???
Beishanlong
???
????????????????????????010200120000????0100??????????????10???1??00??????000001100?10001000?01??000?0???1???
0??1?1?????????01000??????????????????????????????210??0??0???
????????????20010?0000000101001?0?0010?00?000000000000010????????????????????0???????????200000000000?00000?
00????0??0?0?0?????????0?0???????????????????00?01??
???
???????????????????????????????????000000020011?????????????????????00?????0?00000?0???00?????00??1?0???0??1
??????????1000000?1??00?0?011??????????????000100??00?????????????0000000001??????????1???10?0??0??0???1??
Sinornithomimus_dongi
?0001?????1?0????1?21000??1010001?00000000000000000000?000??0???00000000?00????1?1?????????0001?0?10?0???100?
1?1??0?00?0?0?100??????010200120000?0110100100000011000110101100000 1?00?00000110001000?000?010??00000101110
0121?1??00?0?0010?0100000000 1?????00001000000?021000000000?????????????00??000001?1?0???????0000001?000?0?0?
????????????20010?00?00?0101001?0?0010000?0000000000??0100001 0?00000??0000000?000000000200000000000000000??
00??1100?0000?????????000??000000????????0?0010000000100?00?0000?01?000100000??0?000???0??0?01??01?0????00

0??10??000??01?0000??000?????00000000000??00?0?0?0??????????????????10000????????????00210???0?000000000???
?????????0???00?00001?000?????0?0??000000200?100?01010100100?0?010000?000?00?0??1?0?1?00111?1001110?1001?11
?00???00001000000110000100?11??00???11000000110?000000000???00000000000001000??0?101?011?000?0?00?101??
Qiupalong_henanensis
???
??00??1100????????????01100???????????0??000100002???00???????1
????????00?0?0???0??0????????
???20?0?0?00000?????0000000?0000?0
00?02?????????1?????????0???????????0????????00??
???
???10100?00?0001??????????000?010001??0???????????1??110???
?0?????????????????????1??01???????????????????????????0000??000??0000?00001??????????01??????1???????1??
Huaxiagnathus_orientalis
?00?0????????????????0001???1???0?????00??0??????????????????????00?0010????????00010?1010?00??0???1????????0?
?????00???0?002010????000000000?00??010000000020?0??000100201?000012?0???0??????0??0?010000000?0?011??000??
??00?0??00?0?0010?0100000?0?1?00????0????0000??200???0000??????????????????????????????????00?00?1??0?(0
1)0?0?????????0000020?00?0?0?0?010100??????10?0???0????????????????????010????000??00?00??00000?????000?0??0
0??0??0????100000000????????000????00000?0?00??000000?01??00000??0?00?0?00?10000000000???1?????????????????
?????????00?00??????????????????????????????????0??02?00???0???????
??????????1?0?00???????0?0??0000??????0??0001100???1?0?000??00000??0??????????????0?????0?0???0?0?0?00?101000
??01?0?00?0?00001000?000??0????????0?????10?????00????0?0?0?0000????0???0????0000100??????????????????????000
???
Sinosauropteryx_prima
000?0?????????????????0001???1???0?????0000??????00??0?????????????00??01???????1?0001001010?000?01??100????1?0?
0????00?110000201??????00000000?10??010000?00020??????0100201?000?11?0?1?00?0??000?0?0100000000?011??0000?
?000?0??00?0?000??010000000?1?00?00?????000?0??20000?000???????????????0???????0101????????0000?0??0?00(0
1)0?0????????????????0?00?0?00??010?000?????10?0???00?00??????????????1??0100???0000000?00000??0?2??????00??0??0
0??00?0???0100000000????????000?10???000??????????0000?01???0000??1??1????0?1?0?00??0???????0?????????????????
?????????00??0?????????????????????????????????????0???02?00???0???????
??????????000100???????0?0??0010??????0??00111?0???110?000??00000??0?0???0??0???0??0?00?0???0?000?00?11100?
??0000?00?0?0?001000?0?0?0??????010????1100???0000???0?000?00000??000???????0000100?????100???????????????000
???
Compsognathus_longipes
?00?0????????????????00101?1??00???00000????000????000???????0?00000100?1?001000010010101000?01??1010???1?0?
0???000?0120002010?????0?000000?10????0?000000??????0?0100201000012?0???????????00?0001000000000001100?00??
??0?0???00?0?0010001100000001?00000000?0?000??020000?0000??0?0??0???????0???0000????01?0??0000000010000(0
1)0?0?????????00?0?20000?0?0?0?010100????0?1000???0???00??????????????????010????0?0??00??0?000?00???????00??0?00
00?00000?00100000000????????00????000000????????00000?001?001000?1?0100?0001000000000000??0???0??0?000?00?0
????0000000?00?0??01?12?????????000????????11?000???????????????????????????0???????????????????02000?0000002000
0?0????????1?0000???????000??0000?0?????0????????01???1????00????0??0?0?0???0???????0??0000?0???0?000000?101000
??00?0??0?000?0010???0?0????0????10????1100??0000????0???0?00??????00????????0000100?0010100??1?0?????????001
???
Juravenator_starki
0000?????????????????00010??11000?1???00000?0000?0??????00??????0?0000010???0????000100101??00??0???1????????0??
?????00??10000201 0????000000000000????00000000000?01100??????????????????????0??????00???????0?0??000000?10?000?0
??0??0??00?0???????010000000?1?00?0?000??0000???20000?000????????????????0????????????????0???????000?00???00??0?0?
???????(0
1)00002???0????????0101000?0?0010000??000?000?000???0?0????100???0000?0???00?000??2??00??????000??0?0000?001
00000000????????00???00?0?00???00??0?0000?011000?00?00?0100?00?1?00000000000?00???0??0?00??00?0????0000000?
?000??01?10????000??00????????11?000??00?0?????????00??????????0????????????????????0200???0?????0???0????????0?
010?????????????????????????????0000??00??1?0?000???????0??????????0???????0??????0?0???00000?0??101?00??00?0??0?0?
??0????0?0?0??0?0??????0????0?0?????000???0?000?0????????0???????????00100?0?????00?1???????0???00????
Sinocalliopteryx_gigas
0000??????????????????0001??0???000??00?000?000??0????????????0?0?000001????????1?0001001010100?01??10?????1?0?
?????00??100002?0?0?????0000000??00??0100000003?0?0??000110201?000012?0??????????00???0??000??0000?011??000?1
??0000??00????010?01?000000??00?0000???00000??20000?0000?00?????0????00??????0?????????????0000001000?(0
1)0?0?????????00?0?20000?0?000?010100??????10?0????0??00??????????????1??010????0000000?000000002??00?0????00?
0??00?00??0100000000?????????00??10?00000???00??00?000?01???0?010?0?0000?000??00000000000???0???0??0?00?????0
????0????00?00?0??0???2??????00?????????????11?0????0???????????????0??????????0??????????????????????2?00??00?00????
????0??????1???0000??0??000?00010??????0??000010????1?0?000??00000??0?0???0???????0??0??0?0???0?000?00?100000
??01?0?00?0?0?0010?0?0?0????0?0???0??0?0?00??0??0???00?000?0000????00?????????000101?????10???1???????????000
???
Mirischia_asymmetrica
???0?
?0?0???0????????0001?02000???0121001000101 10????0???????????????1????????
??????????????0010???0?1?0????????
???0???00?0?000????????????????????
???
???
?????????????????????????0???000????????????????????????1??????0?0?00?000?1??0?0?????????????????????????0???????0?
?0?????0?????0?????????????1??????????????????????????????000?0?????00??00???????????????????0??????????????0?????1??
Ornitholestes_hermanni
?0002???0?0?00?1???0?010?01110001?100101?0??1000001?01011????0000001000?0?000010?00101001?????011?010121000
0??000?0010??1????????????????01?00???????????00001??1?0?0100101000001??0?1????????0????????00?00????00000?0010
?00?0?0000?0?0000?0100000001?01?00001000002?112000000010?0??000000?0?00???0000?0?0000???0000000010000(0
1)0????????????????????????????????????0?0?0010000?000000000000??0??0????1000??0000000?000?00000?0000?????????
0000?000?001??00?0?????????00??0???0001?0???????????00??00?1?0000000000000000?000000000??00??0???0000?000?00?0
????0000000?0000??01?0000?00?0000100??00001?000?0001100?00000?01000?????000000000000???0???020000000002000
0?00000?00000000???????0001000002?10?00?0??????10010?01??000000000???0100????000????0?00?0000?0000?????????
??001??1010?0000???0???0????0?00??001000000?00???000000???000000??000?????????0?1000?1001?0001????0??0?1010
?01
Coelurus_fragilis
??0??01001000121000
?????0?0002?????????????0?0??0?10001????0??????????????????????????????01100?000001?0?0000110?0?0????0?00??00???
0???????????0?0????0??????????????????????????????11200??001000??????
?????????????2???????????????01000?0?0010000?000000000000010000???0????????0000????????0020000000000000??000??
?????????0000?????????????0??????0?????????????0??

Tanycolagreus_topwilsoni

Tugulusaurus_faciles

Zuolong_salleei

Bicentenaria_argentina

Kileskus_aristotocus

Guanlong_wucaii

Sinotyrannus_kazuoensis

Proceratosaurus_bradleyi

Dilong_paradoxus

Eotyrannus_lengi

????????????????????????000000010????????0?0???0???00000?0?00???00?0??
??00?0?????0?????0?1?000?00??10??0121???111?0?211?0000?0????????????????0??00?00100???00??0???0?0010?0??0???
????????????200?0?0?000?0?0?0?0?0?0010000?0000000?0000???????????00????????????????0????????????????????????
??????0?????????????????????????1???????????0?00?????1?00101???????00?0?01????01000?1010??1??0?00?00???????
????????0??????????????????????01?1??0??????????????????001??????0?00????????????????????000?1002110100?????
?????2??00???00???00????0???????????00??011011?000???????????????????????????01??00?00100?000?0???0??????1?0
??0?00????1000??????0?00????????0000?00???0000100?00??0???????????0000???0?1????0??????011??????1???0?1?1
Juratyrant_langhami
???0?00?0000001?10??
00000??0?????????????????????????????????00?00?01000011010110000011?01???0??10????0?????????????????????1
????????00???0010?????????????????????????2????11??0?00100?0?0???
??00?000000000?0?00?000??00???????
?????1??????????????????????????1?0??
??
?????????0?????????00?100011?00100?0??????????????????1000000110010000?????1100001?????????????????????0??01??1?
?1?????000??????????????0??????????????0000?0???????????000000??000??0000?????????????1??1??????11??0????1??
Xiongguanlong_baimoensis
?0002???00000?????1?000220???0000?001101000?21000000?0001??000???????????????00000?101??200000000000000111000
??0?12?01000?????????????????????0000110???????????????????0???????0?
00?????000?????????1?000000???00?0?1121?2102011???0??0000?00?000??????00???0??000????????????00?00100???????
??00?0000000??20000????????0???????
?????????????????????0???????000100??????????????0010?10001????1?00?01?0?01?0000100??0010?0100??0??0??0?????0
???01000?0???0?0100???001?111110010????100?1?11??00?100?????????????00100100001 0?1??????????????????????????
?????2?000??0000000110000 11????????????????????????111??001????????0111012????????????????00??0?????????????1??
1?010?10???????????????00??????000?0??00001????????????000000?????000000????????10????1??????????1???0?0?01??
Dryptosaurus_acquilunguis
??????????????????????????20???0?0?0??2????????0000101?1????????????????????
?????0???00???????????????????10????????10?0?????????????(0
1)?0?0?2????????101?01000100010001000??2???0????????????0?0?????????0?0????????????????00????????????????????11????0
????????????????????????????????????0???????????????0??????????????????????????????????????0?0?0010000?00?????????
???????????????????????0?????????00200000000000??000??0???00?01???????
??????????????????0???
???212?1?1??10???????????
??????????1?0???012?1?0111?????1????0??????0???????????????0?????????????????000000??????????????????00?1???00??
???????00??0000?00001????01???????????0?1??00?0?0??
Appalachiosaurus_montgomeriensis
?????????????????????0?0?201110??????120???????????????????????00000?000?0????????0000101 0?2????????????????????
?????0?0?00??????????????????????????????????????000010120?10???10??01000100010001000002?0?00??????0??
??0????????0?00100?11000000?1???1?021???????????????000??0??????000?????0?????????????0000???0?????????????0???
??00?????????0020000000000000?0000?0
00?00??00?????1????????000?000?01?010111?101??1?0020?01?10??0?0?????????
???0000000101000 10?00??????????????????11?110??1??????????0??1
?????2?0???????????????????????????0???????????????????????????????????????1?01110???111111111021?0000?????????????0???
??0?0???00??????????????0000000???00??0?????0???????????????????????00?0??00000001???0???????01?????1??00000??1
Bistahieversor_sealeyi
?1102??????????10?220000 2?01110000?001201000?21100000?????????00000000?20??2?00000010101 2??0???????????????????
??0???????????????2????????10??00?
?00?0??0????????????12000000 11?00?00213?0?112??????0000000??????????10??0????00001???0?0????00????????????????????
?????????????????????????00???
?????????????????11???????????0?????????????????????0?1011001000?1010101?01011101010101002010001001???10000??00
000020000211000010000??1111111?1?10010110012111111?01000?010011111??????11?111101?101111111100?11212101100112
?10??2?00????111??????????????????0111?1??????????????????????????????011?????01101111?12001000 0?????????????1??
1?0?0????????????????????????????0??0??11001??????1????????????000?11
Albertosaurus_sarcophagus
?1102??000000?1002200000220111000000001201000021100000?000100000000000000020??200000000101012 0????0?10?001?100?
0????000??0????0????????0000000010000???011001031200110000000101200100011 0??0?00?1000??00100000020000000010000000
000000?000?0?0010?0120000000 11000?00213101112102011000000000???00000100?00??000000100100000??0000000010000?0?0?
???????0000020000?00000?0001001?0?0010000?00000000000000010??0?????000???00??00?000000000200000000000000000000?
00??0100000??020100?000??0??001100?0110?000000101110110010000(0 1)1001(0 1)1001011101020111002 11(0 1)1(0
1)1101?001000000010001020100200110010001111101111111111101011001111111000(0 1)000111(0 1)(0
1)111100001011011111111011111111001112121111100?12?10?121011????????1??????????????????1111102011111?1021111110
211101??1??1???1111111111122010000000??00000101?011010?100010?000??00?000000100?000000??0?00??110??00000000?
?0000?00000000001011001111010111????0100000011
Gorgosaurus_libratus
?11020?00000011002200000220111000000001201000021100000100010000000000000002001200000000101012 0?0000010000101000
000?000000000000?0000100000000010000000101100103120011000000010120010001101001000 1000?00010000000200000000 1000000
0000000000?0?0010001200000001100010021310111210201100000000000000000100000??00000 10?10000??00000000010000(0
1)0?0?????????000002000 0?00000?0001001?0?0010000?0000000000000001000010??1000??0000000?000000000200000000000000000
00000000?0010000000002 0100?000100??00110000110?000000101110110010000(0 1)10010100101110102011200 21101(0
2)1?01000100000001000102010020011001000111110111111111101011001111111000100011111111??00110110111111110111111
1001112121111100112?10?121011???????1????1101????1?0?011111020101111102111101021110 1?011?1?2?111111111?22010
0000001000000101101101 0?100010?00001000000000100000000000?0000110?000000000??0000?00000000010110011110 1011
110??0?00000011
Alioramus
?01020?00000011002200?0?2011100000000120100002110000010001000000000000000200?20??00001010 1?0000000010000111000
000?00?00?0??000??????????????????????????????120011000(0
1)001012?010?????001000100??0?01000?02??000??10??000000?0?0000????010??1100000001 10001?0213101?12102????000
?000000000000100000??00000100?0000??00000?00100?0?0???
?????????????????????00?0???000??20000000000000000000?0??0?1?0????0020110?00???0??0011000????????0????00111?2
????0011101111110?0111010100120121001021110101110001000010200001000000010110111201111111100101100111111?1011
100100111010001101101111011011101111001112122111110??10000???000001000011110?1012210 11111??????????????????11
11010??????1?111112 1??00?111?12?0100000??????0???0?1?1?010??000????????????0????01?0000?000000?0?????????????
0000??0??00???0?000?1??1101111?1?1??1011??0?000?1?
Teratophoneus_curriei
?1?0???0????????0??2???????0111?00????1201???????0000????????????00??000??????????00001010 1??1?????????????????
???0???0??????????????????????????0??
??0???????????????????1?0000?01??????????3??????????0???000?????????????10??0???00?001???0?????0??????????????????????

??????????????????????????????0?????0000??00110????????????????????0000001000??000000??0000000???????????
????????00???????0?0??00?????????????????????0???????????????????????????????????00000?000??0????????02??0???
0??0????00??01??0000?0?1??01?01?00?0?????????????0?0??????????????????0?000?10?0?10?0?0?0?????????????0??0?
Saurornithoides_mongoliensis
?00??1?1??1101???0?110001?1000????????2??????????????????1?010?100?0010??1????0001110101?????????1???0??1???
??100??1???0201202020?010??10(0
1)1?11110????????????0?0?11?01??????0??1?0????????????010??01000??001?01?01????0?000??????0??0000????0?1000?0
??0????1??????0000???0????00100?0???
??????00????????0?0????000000000010000?20?0210?000000000201001?10???1110?1????????????00?0100000??3??11?0?0?
1?0100010100??00???0??0?????0??0???????????????00???0?????????????????000
?????????????????0??????????????????0????????10000???????????????0?????????0?0????????????????????????????1?010
???????????00????00000????????02??00????0?0???00????????????1??????0??000?0?????0?????????????????????0?00????
???0?101?0?????????1???0?????????0?0?
Zanabazar_junior
?00101?12?110100?001?000??100000????2022000?21??0??11100??????100?001???1????0001110101000?????????????????
1?1000?1020?1???2????????????????????????????????011????2?????????????00?
?00???11????????0??01000000001000001???1??00???????00?000?????001??0?00??????1??????0000??0?00?????????0(0
1)0??00010000?
?000??2????1??0???00000201001?11???1110?1?????????????00??100000??3??11?0?0?1?0100010100?000???0??0?????0??0
?????????10??000??00?0?????????????????????????000?00011010????????????????????000?00000????0000???000?001??????
?????0????10000???????????????????0???????????????????????????????????????0???????????????0?0?????????000?????????
???0?????00???0??????????????????01?00?0100???????????????????????????????????0?00????100110?????????????1????200
?0?
Bambiraptor_feinbergorum ?0010??001000012010(0
2)00?010111000?1100012111?1000101?00011?0?0?000?0100?1111000?010010100??1110?1100?1??100?0?1100(0
1)1011??2????010101101110?001?100000110?211?0101?202302?111022100???1110000000001000110?100000000000110000
0000011?0010?0211000?11?110??0000?000000122000?00000?0??00000??0000??0000000?1?000??000000000100??0??0?0?0?
0?000000200000?00000?011?000?0?0?1000??000000000?00010??????00000??0000000?000?00000000000000000000000000?00?01
1?100000000121?000110??00011001100?10000000010100001?10?0110001?00000100010000000???0??0??1??00?0????0000010
00000??01?0000?00000001??1?0?????000??001101???????????????????0?????????????????0?000??00?1120100??????????
???0000000?0000100010110000?000001110101000010?00100000110?01?010000000?00000?000000000?0001?0002?00001?10?0
?100010?100?????????????????0?000?????00??00????000000??0000100000000000100?0???100001101002000?10001??
Graciliraptor_lujiatunensis
??020???1??????????????????????
?????0???11?12?????????????????01011?1100001???0??0?010?(0
1)1111??0??0??00??????????????0???????????????????00???????????????200??
??0??????10?0???000??0????????????10?0000??00?000??????????????
???????????1?????????????????10??????????????????????????????????000???
??
???????????????????????????0??????????????????????????????????1????00?00??????????????????????????????0000????0
0??????100??0??0???????0?????????00?0?00?????01???????????????????0???00?????????????????0?000?10????????0?0?
????????????????
Utahraptor_ostrommaysorum ???????????????????(0
2)00?0???????????0?001??0????0101??1????0?1100?1??1????????0??011???????
??????101?1????????????0?????????0?01????????????11?????0111?00??0?001000100???10????????11??0????????0?????0
???????????1???0???????0???10???0???0???00000???????????????????????20000?
000000??00???????0??0000000000000?0000?????0?10???????????
????????????????????????????00?????0000?1??????????????????????????????1???0??00010?0????????????????????????????????
??
???01?????????0?0???????????0??0?????0????????????????
?00?????????????0???????????????????????????????????0?0????????????????????1????????????????
Saurornitholestes_langstoni
??????????????????????????????????????111????????????11????0?????????????????100101?00?11000110011121011
011100?1011?1?1?????????????111?????????000111221?1?1?1?2?0??????????????????11??0???00??001101??00???00?0?1
??00?0000010?001000?????????110011??????0????1220???????0????????????????????0000????????????0??????????????
???????????????????0???00??1??0????????????????????????????????
??????0???00???????????0??????00111????????00?00????????????00?01??0?0?0?000?00??????????????????????????????
???????????????????????????????????????000??00?1???0?000???????????????????????????????????0??0000000????????????
????????0????????????????1?0???00?????0??2???????
???????0?????????????????1??01?????????????0?????????00????????????????????????????11????????????????????0????
Dromaeosaurus_albertensis
?0??0010000000000010??0???0?01??01110????1111????101?1001100??000000100111111000?0000101001?????????????????
??1??11?1?0????00?????
?00?0?00??1??????????1?00??011000100?0???????????????0???0000?00000??0000??0000000?00000??00???????????????
??00??????????????????????????????????????0?
???0??????????010121?000??0???00?0?????????0????0??0??0???0??????0?0100?00?10???????????????????????0????00
000100000???????0???????0001001?0?0????00??00?????0?0?10?????????????000?100000010????00000000000112010000000
0?0?00010???0??000?0???????????????0??
0?010??????????????????????????0200000???0?1?0??110??????????????????000?0?
Deinonychus_antirrhopus
?0010????1???????1??0000?0111000111000111111100?1??00001110100000?0100111?1000?0100101000?110001100?1121011
????0011011112I??????1?11011100100111000001102211101010202220?01111211001?111100000000010001101001000000000001
100000?00010?0010002110000011110110000??000001220000000000?0????000????0????????????00000??000000000000?(0
1)0?0??????????????20000?000?000111000?0?0010000?000000000000000101?0???00000??0100000?000?000000000000000000000
00000000?00110000000????????0?1????00111?????????0000?????00001?10?0010001?000001010??00?0????????00??0?0??0
?????00001000000??01?00?0?00000001???????????????????????0?0?1001000?000?00???????????????????000000000001120010
0?0000?0?????00000000?00001000100?????00000?1101010000100??1?0000??????????????????00000?000000000?00?100?02
??0001?1??0?000010?10000000000010?010??00?00000000000000000000000000??0????0000000000100??1101?000110???200?1000
1?0
Velociraptor_osmolskae
???????????????????????????111??010??01????????????????????????
??
????????????????????21?00000???00???
??
??11??01?00100?00??01????????????????????????????????
??

```
????????0??????????????????????????????????????????????????????????????????????0??????????????????
????0????????????????????????????????????????????????????????????????????????????????????????0?0???
Tsaagan_mangas
?001001001000012011200001010100001?10001211111000101100001001??000000100?1111000101001010000110??1??????0???
??????????????1????????11?111??????????????????????????????????????????????????????????00??00?
?00?0000???????????211000001?0(0
1)?0000000?00001????0000000????000000?0000??0000000?00000???000???????????????????????????20000???0?0?0??10?
??????????????????????????????????????????????????????????????????????????0????????0121?00???0??00
011?0?????????????00?0100001?11?0010001?0?00010101000?00???0??0?01??00?0????00000100000??0??0000?0000000100
1?000??0000??001101?0?0?0??????????????000100100000000000000??00?1120100000000????100000???00?00001?????????
?????00?110???????????????????????????????????????0001000?????????0?10?010?????10??????????????????0
2?0000000??????????????????????????????????????000?1?1????110????0???000?0?
Linheraptor_exquisitus
?00100?0010000?2??1200001010100011100012111110001011000011000000000100111??0001010?1010?001100????????????
?????01?0?1?0?011?????????????1????????00????????????????????????????2100?????????0??00010?0?101???0??00???0?
?00?0?00?????0?????(1 2)110000011?0(0
1)??0000?0?000????000000000?0??000000???00??0000000?00?00???000?????????(0
1)0?00???????????????????????????11???????????0???????0?????????????????????0????????????????????????????????0?000?
00????00??01???????????????00?1?0??00011?????????00???0010100001?11?0010001?0000010101000000???0000?01??00?0
?11?000001000000??00?0000?000000010010000??0000?0001101?000??0010???000?0?0001001000000???00000?0?0?122010
00000??0??100000????0??01?10???????????00??0??????????????????????????0?????1??????0?00000?0???0000010????????
??00??0?010????0?????????????0?0?01?0200000?????0?????????????????????????0000001???0?1?10???1?????????1000
???
Atrociraptor_marshalli             ???????????????????(0
2)00?0??1010???????????????????????????????00??010????????0?0000111001????????????????????????????????????
?????????????????????????????????????????????????????????????????????????0????0????????????????
?21100??0??111?????????1????????????0????????????????????????????????0????0???????????????????????????????????
????????????????????????????????????????????????????????????????????????????????????????????????????????
???????????????????????????????????00001?11???1???0?0?000?01??????????????????????????????????????????????????
???????????????????????????????????????????????????????????????????0?????0?00????????????????????0?????????
???????????????????????????????????????????????????????????????????????0?0?????????????0??????0?????????????
???????????????000????????????????????????????????????????????0??1??????????????????00????
Achillobator_giganticus
?????????????????????????01?1???????????????????????????????????????????????????0000101??????0?01100?11210??
?????0??011?11??????????101????????????00??10220??11010102102?011011?001?21110?0????00?000?101????0???????1
???0????001??00100021100??0??10(0
1)????????0?????????????????????????????????????????????????????????????0000???????????????????20000?0?0?0?0??10?
???????????????????????????????????????????????00???0?00000??000???????0?0000????????0?????????????????0???????
???0????????????00???????????00?001???0?0?000??1????????????????????????????????????????????????????????????????
?????????????????????????????????????????????????????????????????????????????????10???????????????0100???
????????????????????????100000??0101?0100000?1000??????????0?????????0??01?????1??0??0????????????????01??0???
??????0??00?????????0000000???0000100???????1????????????????1?1?????0?00??
Adasaurus_mongoliensis
?0010?????0????2???????????????0??????0?1??11?1?0?101??001??0?????0????0?2???0??????????????01100?11?0111?10?1
11(0
1)100??011?1?1??????1?111111???????????????10221110101002?2202?1?11221001?111000000?000?11010010010??00??0011
0?0?0?0001??00100?????????11????????00?0????1??????????0?????????00??00???000?0????????????000?0010000(0
1)0????????????????200?0???00??01110????????????????????????????????????????????????????00?0000000000000000000000
0000?002??11?00???00???21?000??0??0001?1??????????0???0??0????????????????????????????????????0??????????1??00??
????0000010??000??0??00?0?0?00?????????0???????????0??????????????????????????0?????????????????0????????11201?
?????????????????????????????????????????????????????????100000??0?01?????????????????0?0???00?0?????????002
?00????10???????????????????????????00??????0??00????????????000000??0000010000??00010???????????01?????????????
???
Velociraptor_mongoliensis
?001001001000012011200001011100011100012111?10?01010000111010000000010011111000101001010000110001100111121011
111000110111121111010111111110010011100000100221110111020220201111112(1
2)120111110000000000011101101001000000000011000000000011?001010(1 2)1(0
1)0000011100110000000000000112000000000000?000000?0000??0000000??0000??0000?00000000(0
1)0?00??000?000000200000?000?000111000?0?001000???000000000000010100???00000??010000000000000000000000000000
00000000?0110000000010(1 2)21?0001101100011(0 1)00000?100000000?0100001?(0 1)(0
1)?0010001?000001010100000000???0??0?01??00?0????000001000000??01?0000?00000001001?0?0???000??00110100?0?0001
000?000?000001001000?00000000000??00?112010000??0????10000???????????????01001000?000001110101?0?0?00?010000
0110?01?0100000000000000000000000000000100002?000?101010?0000100100000000010?010020000000000000000000000000000
??000010000000001000011?10?001101002000100100
Kuru_kulla
?????????????????????00?0???????????????(1
2)?????????????????????????000?010??2??????0??00010100????0???1?01111??????????0??01(0
1)???????????????????????0?1?10?0001????1??????????????????????100?011110?0?????????001101?0?????00?0?11?0??????0
01????????????????????????????????????2????00????????????????????????????????0?0?000???1?001000???????????????
??????????????????????????????????????0000????????????????0000????0???0??????00?000000???????????????0???????1???
0?0?0??????????????????????????????????00??????00001????????????????????????????0????00??????????????????????????
?????????????????????????????????????????????????????????????????????????????????????00000000112000????????????????
??????????????0100??????????????????0??010????????????0??????00000????????????0?00?00????????00??00?????0?????0?
?????0?0??????0??????0???0?0000000????0?00??0???0??????0???????????????0???10???????1??1?0????????0????
Shri_devi_holotype
????????????????????????????????????????????????????????????????????????????????????????????011000110001121011
(0
1)?100??1????1?1?????????????????????????????00?211?0111?20220201111?2?100???1110000??0001??0110100100???????
1????????00???00102????????????????????????????????12????????????????????????????????????????????????????00000000???-
?????????????????????????????????????????????????????????????????????????????????0000000000000000000000000?00?0
0000?01????????00?????????????0????????1?1?????????00?????????????????????????????????????????????????????????????????
???????????????????????????????????????????????????????????????????????????????????????????????????????????????????
???????????????????0001000100????0000?????????????????0010000011??01???0000000?000000000000?????????????02??0?
???1????0000???????????00?0?010??0????000000?????????000000???0001?0000000010??????0??00???100???01???1??
'ZPAL_MgD_I_97'
?0????????????????????????10111???01?0001??????????????????10?100??0?0100??11?????010010100????????????????????
????????????????????????????????????????????????????????????????????????????????????????????010?011010010??0???0??
```

??0???????11??????2?111??????1?001?0????0???3?????????????0?00???????????????????????00????0?????????????????
???0000?00
00?01???????00????????0???????????????????00???????????????00??010???0??00?10????????0????00???10?00?0?10?0?
????0??00???0?0??001000?000?00??????????????????0????0?00????????0??0
????????0??00000000000????????0???0???
??0?0???????????????????????0?0?????00???????????????????????????????????0?000?10???11?????01???????????00???0
'Shri_980_and_97'
?0???????????????????????10111???01?0001?????????????????10?100??0?0100??11?????010010100?011000110001121011
(0
1)?100??1????1?1????????????????????????????00?211?0111?202202011112?100???1110000??00010?0110100100?0???0?
1??0?????0011?00102?111??????1?001?0????0???3?12?????????0?00??????????????????????????00????0???00000000?????
??0000000000000000000000000000
000?01???????00????????00???????1?1????????00???????????????00??010???0??00?10????????0????00???10?00?0?10?0
?????0??00???0?0??001000?000?00??????????????????0????0?00????????0??
0????????0????????0001000100????0000????????????????0010000011??01???0000000?000000000000000????????02??0??
??10?0?0000????????????00?0?010??0??00000000??????????000000???0001?0000000010???11?0??001??100???0100?1?0

Data matrix modified from Power et al. 2022:

```
Archaeopteryx_lithographica
01?000010??0001110000000000002200001?00000??0?000??0?00??????0?1??000010100000000120??100?0001?0?1000?000000
00000?00000011000100000000?0000000001000100000?010?01000???0000?00010
Acheroraptor_temertyorum
????121111101001???????1??0201001?1??????????????????????????????1010101??1??1000101000?100????????????????
????????????????????????????????????????????????????????????????????
Achillobator_giganticus
????121111001100???????1??0201001?????????????????????????????????????????1??100?1?0?0??0????0100111?1???1?
01???0???????????????11000111002001110002111100???10?0???????1?11???
Adasaurus_mongoliensis
????????????????001????????????????????1??1110?1?01??100??1?????????????????????????????0??10011?1???0?11?1
?10???01??????????????10100100000011211?011100??11110001101111?011?0?
Atrociraptor_marshalli
???1121011111001?????011000?01101?1??????????????????????????????1000101??11?1010101100 0100????????????????
????????????????????????????????????????????????????????????????????
Austroraptor_cabazai
1???12??0???0100??1????0???222110?000?0?1???00?0??????????????????00?111?????100020??010?00?11???11??01????
????????11???????????????????????????????????????????????????1?00???
Bambiraptor_feinbergi
0??1000111111001112??001000?1100101?010?0?00101111100???010?1???1001011?1111010101100010 01001?011111?0111
02?110110100101010011100000000000112001201100101?0100000010100110 11?
Buitreraptor_gonzalezorum
1????????????11101?1???????2??100010??000??010???000???????????????00110??0??1?002???????0011??1100?00?00?0
11?010?011010?????????????0111????1?01001000??00?110?00??0??????????
Deinonychus_antirrhopus
???1001111011101??1?1011000211001 1210??1???010110??01?01????????100001011111010101011000100100110111 0110?11
021??1111100001010000110000000002011?011011110?0110100001010100 11010?
Dineobellator_notohesperus
????????????????????????????0??1????????1????????1?????01????0??????????????1?0010001??2?????????????????11
0???????010??0???????????????????????????????0?10?000????????????1??
Dromaeosaurus_albertensis
????1?00???1????0011011??0?110?1?????211?00???101010101?0000000000000101111001000110100 0000????????????????
??????????????????????????????????????????????????10??1?11?101?11???
Halszkaraptor_escuilliei
0100?0???????001100??00010??22?000??01?01000100???????????????????000010????0?10002???100?0?00?00?100???1???
?011???????0??111??011??0?0000?????????????????00?11?0???000101?0?0?
Linheraptor_exquisitus
00?012001002111001111011110220110010011111?111111000?10???0110??1?111010111?1?1000100000000 20010?1????1??????1
?2?1????1????????????????????????0112?????????????????????0?????????
'MPC-D_100_982'
101000011000100101111001110200010010010111110?0?111001???111?1?0??110101011111000 10??000100???10101?110???
??0111?10101001010000100001 0000?10?2????????0?011?1000111101001101??
Saurornitholestes_langstoni
0001001111111101012110110001010011110101110010 11110????1????????111001011111110001011000100100110111111 0111
02111?11010000101010111100000000001120012011001010010000000101 0011010?
Shanag_ashile
????01??0??11101???????1??0012100?1???????????????????????????????000001?????1100100?010101????????????????
????????????????????????????????????????????????????????????????????
Sinornithosaurus_millenii
0??101010??11101011??001??0?101?001?00001???10?10?????????????1???00001011111?11001001010100???????0??000???
?2?1??0001?1100101111???0?00??1120100010010 0??00?1?1?00?10?00?00?1?
Sinovenator_changii
?1?011000??000111010?11000101110 1???1?100??0?????1000010?00?0111?0110000???0?000?1?0010?2?1?1??11000?0000??
??????11?????0???0???????0??010?0011000101 1?000101001010001??0?000??
Stenonychosaurus_inequalis
????1?100??011101010???0??10??11????1?1[0 1]0???1????0110010?0001001?0101000??200000[0
1]0011111111?110110010?1101?111??????000?????????1????0000?20001?10011100?010?00110000101101001?
Tianyuraptor_ostromi
00???000???1?010?????01?????11?01??????0??????????????????????????????0?????????0??01?0?000?00?0??????????00???
01?1?0?011010000?1?1?011??0000110??201?011100??0?????0????0????????1?
Tsaagan_mangas
?0?012001002100011?110011102201100000111111111100?01???0110??1?01110001111?1100010000000 20010?1???????????
????????????????????????????????????????????????????????????????????
Unenlagia_comahuensis
??????????????????????????????????????????????????????????????????????????????????????????????????111001???
?????0??111??????????0001101111000110200110?001?0?????????????????0?
Utahraptor_ostrommaysi
???1001110011101??????1?00?011010?????????????????????????????????00????????101???1?01???0??00???11101???1?
02????11?????????????????00?0100??????00?211?100???1000111?01?????1??
Velociraptor_mongoliensis
0010000110001102011110011102000100100101111010111100110 1?1110100111101011?11110001001000100100 1101[0
1]1?1111110201111111010010100001000010000?0112111011110?0111100011110100 11010?
Velociraptor_osmolskae
????100010011100??????????0?00110?????????????????????????????????????????1??100010??0??10?????????????????
????????????????????????????????????????????????????????????????????
Zhenyuanlong_suni
00010000???111111????0010?021110111?01?????????1??????????????????0?0???1???????0????000?00?????????????1???
????????1???00?0???0???0????00?011?????01??????0???????????????????1
Kuru_kulla
????????????????????????11???????????????????????????????????????100?101??1??1??01?00???100??011?11????????
02????????????????0???????????????????????????????11?0011?10010110???
Shri_devi
????0?0110001?020???1??????2??11?????????11?????????????????????0??101011?1??1000100000?200?10110111111????
??0??????????????????100001000?00112??1011?10??1101000111101001 1010?
```