

Supplementary Information for:

**A new basal bird from China with implications for morphological diversity in  
early birds**

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**Supplementary information includes following files:**

1. Phylogenetic nomenclature
2. Additional anatomical description of STM9-9
3. Differential diagnosis of STM9-9
4. Supplementary Table S1
5. Supplementary Table S2
6. Supplementary Figures
7. Phylogenetic analyses
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## **1. Phylogenetic nomenclature**

In this paper, definitions of higher-level theropod taxa follows ref.1,2,3

-**Avialae**, the most inclusive clade containing *Passer domesticus* Linnaeus, 1758

but not *Dromaeosaurus albertensis* Matthew and Brown, 1922 or *Troodon*

*formosus* Leidy, 1956.

-**Scansoriopterygidae**, the least inclusive clade including *Epidendrosaurus*

*ninchengensis* Zhang, Zhou and Xu, 2002 and *Epidexipteryx hui* Zhang, Zhou,

Xu, Wang and Sullivan, 2008.

-**Pygostylia**, the most inclusive clade containing *Confuciusornis sanctus* Hou,

Zhou, Gu and Zhang, 1995 but not *Jeholornis prima* Zhou and Zhang, 2002.

-**Ornithothoraces**, the most inclusive clade containing *Iberomesornis romerali*

Sanz and Bonaparte, 1992 but not *Sapeornis chaoyangensis* Zhou and Zhang,

2002 or *Confuciusornis sanctus* Hou, Zhou, Gu and Zhang, 1995.

-**Enantiornithes**, the most inclusive clade containing *Sinornis santensis* Sereno

and Rao, 1992 but not *Passer domesticus* Linnaeus, 1758.

-**Ornithuromorpha**, the most inclusive clade containing *Passer domesticus*

Linnaeus, 1758 but not *Sinornis santensis* Sereno and Rao, 1992.

## **2. Additional anatomical description of STM9-9**

The vertebral column is poorly preserved and incomplete. The neural spine is fused to the centrum (Supplementary Fig. S1a). The cervical vertebral foramen is more than half the vertical height of the centrum. The synsacrum is estimated to comprise 7–8

vertebrae. The prezygapophyses of the first sacral vertebra projects further cranially than its centrum (Supplementary Fig. S1b). Two free caudal vertebrae are recognized (Supplementary Fig. S1c). The caudal vertebrae are considerably shorter in proportional terms than in *Archaeopteryx* and *Jeholornis*. The transverse processes are caudolaterally directed, exceeding the width of the centrum in length. The prezygapophyses project beyond the cranial articular facet by a distance approximately half the centrum length. At least five pairs of gastralia are present. The bones are slender than the preserved ribs, curved, and taper at their cranial and caudal ends.

The furcula is more robust than in many other basal avialans and more advanced taxa such as enantiornithines and ornithuromorphs. As in *Archaeopteryx*, *Xiaotingia* and *Confuciusornis*<sup>1,4,5</sup>, the furcula is boomerang-shaped without a hypocleidium, but the interclavicular angle is smaller. The bone is weakly curved craniocaudally. As in other basal birds, the acromion process is absent<sup>4</sup>. The left coracoid and scapula is exposed in medial view and jointed at an angle of 90°. The scapula is fused to the shoulder end of the coracoid. Whether the coracoid is strut-like cannot be determined.

The forelimb is slightly longer than the hindlimb as in *Confuciusornis*, but proportionally shorter than in *Jeholornis* and *Sapeornis* (Supplementary Table S1 and S2)<sup>6</sup>. The humerus is stouter than in *Archaeopteryx*. In contrast to the condition of non-avian theropods such as *Xiaotingia*<sup>1,7</sup>, the humerus is longer than the femur as in most Mesozoic birds<sup>4,8,9</sup>. The humerus is curved over its proximal half and straight distally, without the sigmoid shape present in enantiornithines and ornithuromorphs.

The deltopectoral crest approaches the width of the mid-shaft of the humerus. The ventral tubercle is not developed. The left humerus is exposed in dorsal aspect, revealing that the dorsal condyle is primarily located on the cranial surface.

The ulna is approximately of the same length as the humerus. The shaft is bowed over its proximal fourth length and straight distally. An olecranon is absent. As in other basal birds, no quill knobs for attachment of the second remiges are developed<sup>4,5,10</sup>. The radius is straight and robust, and its midshaft width is approximately 83% that of the ulna, proportionally wider than in *Jeholornis*, *Sapeornis* and *Confuciusornis*. The ulnare is rectangular with littler differentiation into the ventral and dorsal rami.

The major and minor metacarpals are fused proximally to each other and to the semilunate carpal. The alular metacarpal is only proximally fused to the major metacarpal. As in *Archaeopteryx* and *Sapeornis*, the cranial margin of the alular metacarpal is slightly concave over its central portion, but the proximal and distal parts of the cranial margin are level in cranial projection. Whereas, the proximocranial margin surpasses the distal articular facet in cranial extend in *Jeholornis* and *Confuciusornis*<sup>5,11</sup>. The extensor process is not developed. The alular metacarpal is longer relative to the carpometacarpus than in other basal birds. The major metacarpal is robust and straight. The minor metacarpal is strongly bowed caudally, forming a wide intermetacarpal space with the major metacarpal, resembling that of *Jeholornis*. The first phalanx of the alular digit is slender and gently curved as in *Jeholornis*. Although disarticulated, the preserved length indicates that this phalanx reaches the

distal end of the major metacarpal as in the basalmost enantiornithine *Propteryx*<sup>12</sup>, but shorter than in *Archaeopteryx* and *Confuciusornis*<sup>4,5</sup>; by contrast, it terminates proximal to the major metacarpal in *Jeholornis* and *Sapeornis*<sup>6,11,13</sup>. The first phalanx of the major digit is straight and robust, close to the craniocaudal width of the major metacarpal. As in *Sapeornis* and more advanced birds such as enantiornithines and ornithuromorphs<sup>14</sup>, the penultimate phalanx of the major digit is shorter than the proximal phalanx; by contrast, the proximal phalanx is longer in most non-avian theropods and basal avialans, including *Archaeopteryx*, *Jeholornis* and *Confuciusornis*<sup>1,15</sup>. One manual claw is preserved closed to the major metacarpal. The bone is recurved with well developed flexor process. Its affinity cannot be ascertained.

The pubes are retroverted and have an oval cross section. Distally, the shafts converge and form the symphysis; although the preserved symphysis is short, the braded medial surface indicates that the symphysis is longer during life. A pubic boot is absent.

The femur is approximately 88% the length of the tibiotarsus. The bone is gently bowed craniocaudally. Proximally, the femoral head protrudes medially, and a distinct neck is not developed. The femoral head is badly preserved, preventing the observation of the pit-shape fossa for the capital ligament. The patellar groove is lacking.

Contrary to non-avian dinosaurs and basal avialans such as *Archaeopteryx* and *Jeholornis*<sup>11,16</sup>, the calcaneum and astragalus are fused to the tibia, forming a true

tibiotarsus as in *Confuciusornis*, *Sapeornis* and more advanced birds. The fibula is more than 70% the length of the tibiotarsus, failing to contact with the proximal tarsals as in non-ornithothoracine birds except *Archaeopteryx*<sup>17</sup>. The proximal end is expanded and the shaft rapidly narrows distally to a splint form.

As in *Jeholornis*, *Sapeornis*, *Confuciusornis* and enantiornithines<sup>5,6,11,18</sup>, metatarsals II–IV are fused proximal to each other and to the distal tarsals, but the three major metatarsals are separated along their distal lengths. As in *Archaeopteryx*, *Jeholornis*, *Confuciusornis* and *Sapeornis*, metatarsal V is present. The proximal margin of the tarsometatarsus is straight, and an intercondylar eminence is absent. The proximal articular surface of the tarsometatarsus is wider than the combined width of metatarsals II–IV at the proximal end. The tarsometatarsus narrows below the proximal margin, and reach its narrowest point one fourth of the distance from the distal end; at this point, the shaft begins to widen. Metatarsal III is the longest, closely followed by metatarsal IV, which projects distally well beyond the proximal margin of the metatarsal III trochlea. As in *Archaeopteryx* and *Confuciusornis*, metatarsal II is shorter than metatarsal IV. Whereas in *Jeholornis* and *Sapeornis*<sup>6,14</sup>, these two bones are subequal in length.

The left foot is complete and remains in loose articulation. The third pedal digit is the longest and approximately of the same length as the tarsometatarsus. The second digit is slightly longer than the fourth digit as in some enantiornithines<sup>10</sup>, contrary to *Archaeopteryx*, *Jeholornis* and *Confuciusornis*<sup>5,11,13</sup>. The non-ungual phalanges are spool-shaped with well formed distal trochlea. The non-ungual phalanges of the

fourth digit are shorter than these of other digits. Phalanx IV-1 is longer than its following three phalanges, which are subequal in length. The unguals are recurved, with well developed flexor tubercles, and excavated laterally by the neurovascular sulci.

### **3. Differential diagnosis of *Chongmingia***

*Chongmingia* differs from *Archaeopteryx* in having a robust furcula with a smaller interclavicular angle ( $68^\circ$  compared to  $83^\circ$ ), a fused scapulocoracoid, a robust humerus with a large deltopectoral crest, an alular metacarpal proportionally longer, a strongly bowed minor metacarpal, a proximal phalanx of the alular digit that is subequal to the major metacarpal in distal projection, a penultimate phalanx of the major digit that is shorter than its preceding phalanx, the calcaneum and astragalus that are fused to the tibia, and the distal tarsals that are fused to the proximal ends of metatarsals II–IV.

*Chongmingia* differs from *Jeholornithiformes* in following features: the scapula and coracoid are fused; the procoracoid process is lacking, but present in *Jeholornis curvipes*<sup>13</sup>; the furcula is robust than in *Jeholornis prima* and *J. curvipes*; the proximal margin of the humerus is concave, a feature absent in *J. prima* and *J. curvipes*; the mid-shaft width ratio of radius and ulna is 0.83, compared to 0.64 in *J. prima* and 0.54 in *J. curvipes*; the alular metacarpal is proximally fused with the major metacarpal, but completely unfused in *J. prima* and *J. curvipes*; the alular metacarpal is long relative to the major metacarpal, with a length ratio of 0.32, compared to 0.25 in *J.*

*prima* and 0.17 in *J. curvipes*, respectively; the proximal alular digit extends to the distal end of the major metacarpal, which terminates proximally to the distal end of the major metacarpal in *J. prima* and *J. curvipes*; the proximal phalanx of the major digit is longer than the penultimate phalanx of the same digit, but the opposite is true in *J. prima* and *J. curvipes*; the proximal tarsals are fused with the tibia, but are unfused in *J. prima*; the second pedal digit is longer than the fourth digit, in contrast to *J. prima* and *J. curvipes*; in *J. curvipes* the penultimate phalanx is longer than other phalanx, but this feature is absent in *Chongmingia*; the ratio of forelimb (humerus + ulna + the major metacarpus length) to hindlimb (femur + tibiotarsus + metatarsal III) is 1.07, compared to *J. prima* (1.3), *J. curvipes* (1.23), and *J. palmapenis* (1.2<sup>19</sup>).

*Chongmingia* is distinguishable from *Jixiangornis orientalis* in following features: the forelimb is proportionally shorter than in *J. orientalis* (the length ratio of forelimb to hindlimb is about 1.34); the proximal margin of the humerus is concave in *Chongmingia*, but is convex in *J. orientalis*; the proximal phalanx of the alular digit fails to reach the distal end of the major metacarpus in *J. orientalis*; the penultimate phalanx of the major digit is longer than its preceding one in *Chongmingia*, but the opposite is true in *J. orientalis*; the alular metacarpal is proximally fused with the major metacarpal in *Chongmingia* but not in *J. orientalis*; the pedal digit II is longer than pedal digit IV, whereas the fourth digit is longer in *J. orientalis*.

*Chongmingia* differs from *Sapeornis* in following features: the furcula lacks the hypocleidium; the interclavicular angle is smaller ( $68^\circ$  versus  $108^\circ$ ); the coracoid and scapula are fused; the humerus lacks the fenestra in the deltopectoral crest; the distal

margin of the deltopectoral crest is concave in *Sapeornis*, but not in *Chongmingia*; the forelimb is proportionally shorter (the forelimb are about 1.5 times the length of the hindlimb in *Sapeornis*); the minor metacarpal is strongly bowed in *Chongmingia*.

*Chongmingia* is distinguishable from *Confuciusornis* in having a robust furcula with a smaller interclavicular angle, a smaller humeral deltopectoral crest that is imperforated, a minor metacarpal that is strongly bowed caudally, a proximal phalanx of the alular digit that terminates to the distal end of the major metacarpal, and a proximal phalanx of the major digit that is longer than its following phalanx.

**4. Supplementary Table S1.** Selected measurements of *Chongmingia zhengi* gen. et sp. nov. holotype (STM9-9). Lengths are measured in millimetres.

Element	Length
Scapula	44.6
Humerus	72.6
Ulna	77.8
Radius	74.2
Alular metacarpal	9.6
Carpometacarpus	30.4
Alular digit-1	17.0
Major digit-1, 2	18.9, 15.7
Femur length	61.6
Tibiotarsus	69.4
Fibula	54.1
Metatarsal II	33.3
Metatarsal III	37.3
Metatarsal IV	35.6
Metatarsal V	4.1
Digit I-1, 2	9.5, -
Digit II-1, 2, 3	11.5, 12.1, 10.9
Digit III-1, 2, 3, 4	11.2, 9.6, 9.5, 9.3
Digit IV-1, 2, 3, 4, 5	7.3, 5.4, 4.8, 5.7, 7.6

**5. Supplementary Table S2.** Comparative measurements of *Chongmingia zhengi* gen. et sp. nov. and other basal avialans. Lengths are measured in millimetres.

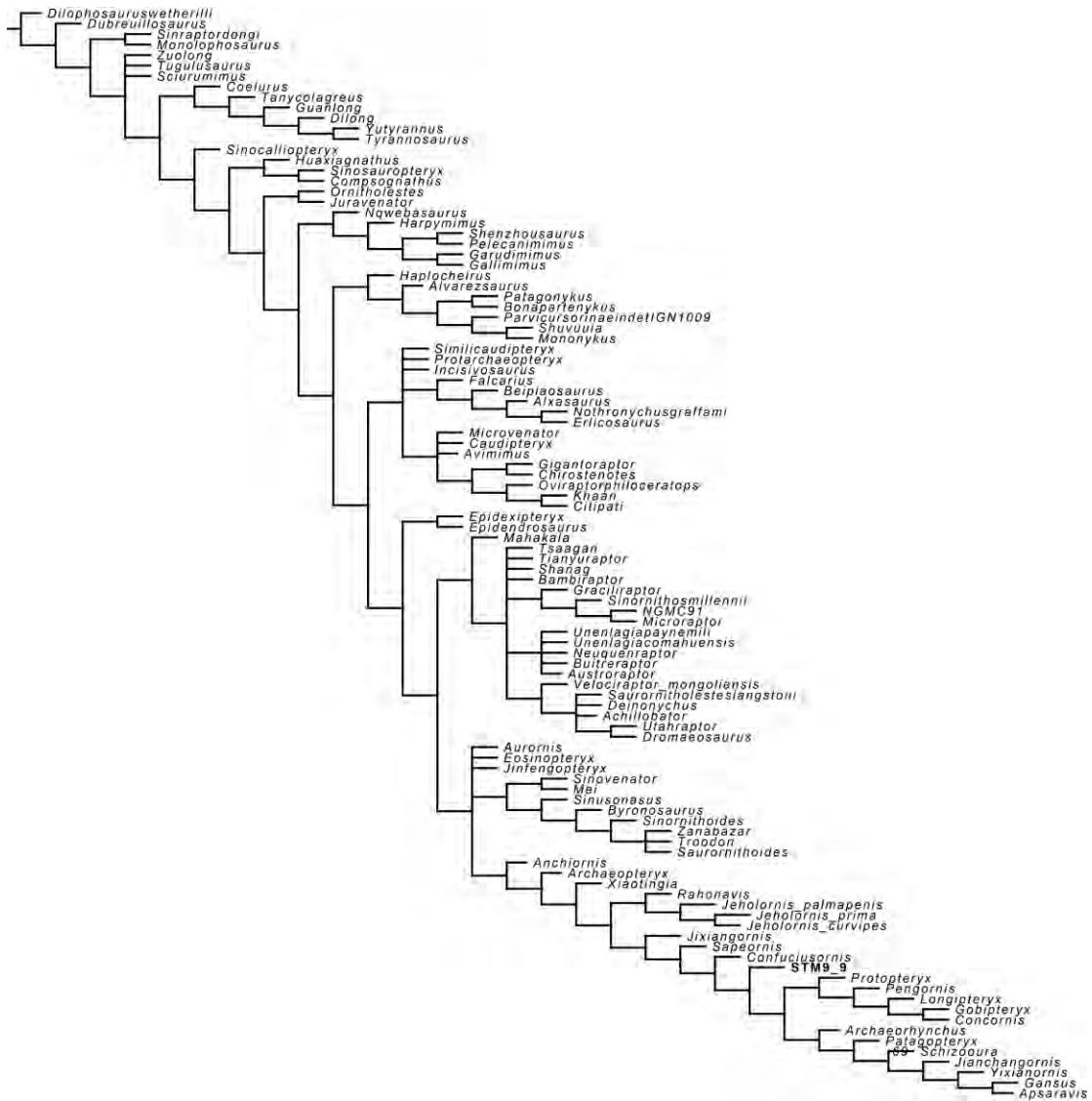
Element	<i>Chongmin gia zhengi</i>	<i>Archaeopteryx siemensii</i>	<i>Jeholorn is prima</i>	<i>Jeholorni curvipes</i>	<i>Sapeornis chaoyangens</i>	<i>Confuciusor nis sanctus</i>
	STM 9-9	WDC-CSG-1	IVPP V13353	YFGP-yb	IVPP V13276	IVPP V13156
		00		2		
Hu	72.6	57.8	88.6	102	121.5	61.3
Ul	77.8	51.6	90.2	108	123.5	55.6
Al	9.6	6.9	9.6	10	13.6	8.4
Ma	30.4	25.1	46.2	59	59.3	30.5
Fe	61.6	51.4	63.4	76	73.2	53.4
Ti	69.4	76.5	73.7	94	85.1	60.4
Mt	37.3	40.7	36.1	48	41.2	31.3
A/M	0.32	0.27	0.21	0.17	0.23	0.28
F/H	1.07	0.80	1.30	1.23	1.52	1.01

Data of *Archaeopteryx siemensii* (WDC-CSG-100) is based on illustration in ref.4; data of *Jeholornis curvipes* (YFGP-yb2) is from ref.13, and the alular metacarpal is based on image therein; the rest data is measured directly from the corresponding specimens. Abbreviations: Al, alular metacarpal; Fe, femur; Hu, humerus; Ma, major metacarpal; Mt, metatarsal III; Ti, tibiotarsus; Ul, ulna; A/M, alular metacarpal length/ major metacarpal length; F/H, humerus + ulna + major metacarpal length/ femur + tibiotarsus + metatarsal III length.

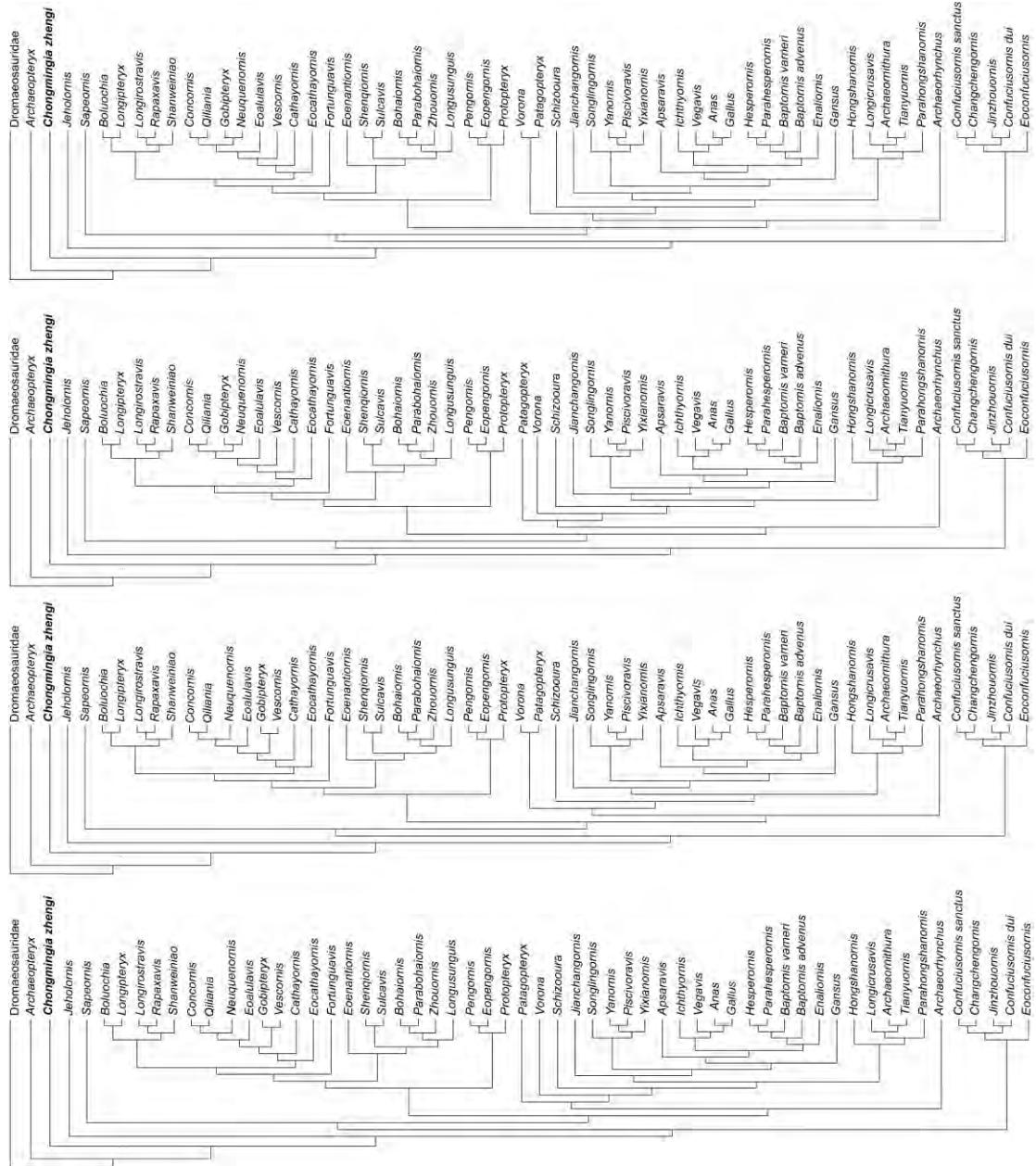
## 6. Supplementary Figures



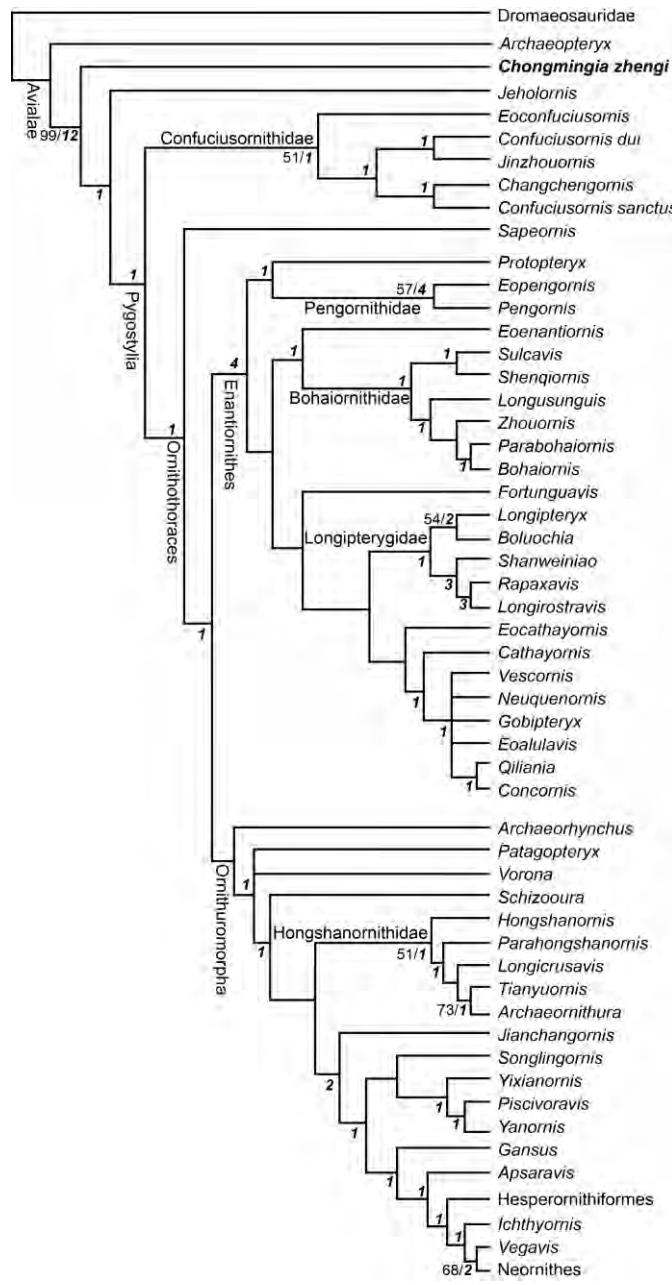
**Figure S1. Axial skeletons of *Chongmingia zhengi* (STM9-9). (a)** Cervical vertebra and gastroliths; **(b)** synsacrum; **(c)** caudal vertebrae. Abbreviations: ca, caudal vertebra; cv, cervical vertebra; ga, gastroliths; gs, gastralia; po, postzygapophysis; pr, prezygapophysis; sy, synsacrum; tp, transverse process. Scale bars, 5 mm (a,c), 10 mm (b).



**Supplementary Figure S2.** The strict consensus tree of 630 most parsimonious trees of 4523 steps (Consistency index = 0.266, Retention index = 0.578) resulted from analysis with addition of STM9-9 to a matrix on coelurosaurian phylogeny<sup>13</sup>.



**Supplementary Figure S3.** The four most parsimonious trees (Tree length = 1009 steps; Consistency index = 0.363; Retention index = 0.683) resulted from analysis with addition of STM9-9 in a matrix on Mesozoic avian phylogeny<sup>19</sup>.



**Supplementary Figure S4.** The strict consensus tree of four most parsimonious trees of 1009 steps (Consistency index = 0.363, Retention index = 0.683) resulted from analysis with addition of *Chongmingia* to a matrix on Mesozoic avian phylogeny<sup>19</sup>. Bootstrap and Bremer values are spelled out near the corresponding nodes in normal and bold italic forms, respectively.

## 7. Phylogenetic analyses

Matrix on coelurosaurian phylogeny after ref.13.

## Dilophosauruswetherilli

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Anchiornis

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# Archaeopteryx

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## Archaeorhynchus

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## Austroraptor

Avimimus

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10?????????????1?0?0?0?0?1?0?0?10?0?0?1?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?  
?????0?0?0?1?0?0?1?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?

?????0?110010?1?????00?????0?0100?????????????1?0?????????????000????11?00??1??0????  
1?11?????????????00002?????????????1?????0????1?????1?????00???????

## Bambiraptor

000000010001?0?0?2?1101000101020?00010110001??01101000110111100110020101??10100  
?0001200000??10010020??101?110?110?001110??????1???002000000[01]0000??000????10?0  
11?????0011??10?????1?1?????1?2??1?2?1?10?01??1110[01]?0?011??????0022010?1111?0?2??1  
2]0100010000010211000[01]0000?0211112010??010100120210?1112?01?2112?0100031?1??0  
21242??????1??2?0?0021?10000?10010120100210?12?10022?0210010102100100112200110011  
0000?0?01?0?2??2023??010?1?01?1011?0100?001?01112010??????00?1?01001?010?000010?  
021110001??0?00?0?00101001??010?1?0200001?000000002?1001?0000001?2111?0?00?00?0  
001?1??2001?000011?0????01?01010002000?0???00?0??1000?00????0000?1??00?00000?0?00  
0?0?0?0110001111110?01?????0?100110?00?101?0001?0?00110100?100?????11?00000?0?0?0  
10??10?0?????10010?00?00110??0?010??0001?001????1?0?0?1??01??0?0?2?0?2?01?????1?????0?  
0??????0??????1?1?????10000100?0?????1?????????????01?010????1?????????00000?0?0?0  
?0?????000?1?0??????0?00????0010?00????00?00?00?1?????0?000100??0?00?10???1110?12  
0?????00?00?00

## Buitreraptor

20??0???0?????????10???101?2[12]????200?00010?00?????????1?0?1?12?0?1010?0?0?  
?0120?100?????0?0?0?????????????????????010100022202????000?????10???1???  
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0?211?00??11??02?????????????0?????????????????0?1?0?????1232??10?????1?0?00 11  
0?01?02?0?????????1?1?12?10??001001210010011020011?0?0?0?????0?[12]?????2?10  
1?00?1111011?0?01??1??1?????????????01??01?0?0?0?1?12?????1?100??0?0?1?1??  
??00?????0[12]00??1??0?1?0?????0?0?1?210?????0?1?????????20?????0???10?????2??  
0???0?0?0?0?????????0?????????????????00????1??11??1?00??11110?01?????0?0?  
00??1?????????11????00??10????0?????1?????0?0?0?0?10?????1??2?0?0?0?0?0?0?  
?0?0?0?0?1????0?????1?01?????1??2?????????11??1?01001?0001????100?10?1?1?110??  
10?1?????0?????1????0?0?0?0?????????????0?????????00?????000?00?0?0?0?0?0?  
00?????00?????????1?0?0??0?????????1001?????0?0?12??0?0?0?0?0?

## Caudipteryx

1110?1111001?200??1011??11??1??0001001?001011?0110?100?0?1?1000??0??1110?0?000?  
0012?0??0?10010010????????????????????????0011?12??????11?1010??0200????1??  
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?1?????3??000000?0021?0?101?0?010100110210?111[01]?0??20010?00031?0?0??30121??00  
1000?00100001000001100002011??11?11?10001?221001011200?1001?2?01?1??10?00?????0  
1[12]?0??230001100?1110011?011002?1110000110110100100?01?010?0?00????1000?10?11?00  
1?0?0?0?200????0??0?10????2000??0?00011?0?0??12000?0?210??0?00????00?110??200  
1?0000????????????0?00?01?00?0?00?0?010?0?????01010??0????000??1?00?1?0?110001  
00110?????????001000????11?00001????001?????????01??1?000000?0????0?10?0?0?????  
0010??0?0?1??00?0?100?00010?????0?0?0?1100?????0?2?2?1??01??0?0?1000?1000?0?????0?  
?010?0?00?10??1??0????1?????????????2?110????1?001?????????10000?0?????0?0?0?1?0?  
?0?0?0[01]001000?00111000?0?00?00?0?0?0?0?0?0?0?1?00?1?0?0?1?0?11?0?0?0?  
?00?

Chirostenotes ??????1?????????????0110??110?0000001?2????????????????????????????????  
?????????????????????????0101?2????10?11112?2????0??000?120?????012101011  
10200?1[01]?011?1100?0?????????0??110??10?1?112111?????????11?????????????10002  
0?1000?????????????????1???1??0?21000?0??01?021?????1???2101?????41010011?????  
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??11??100??23000110011100110011002001?????1?????????0?????0?????00?????0?10????  
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1?0?11?0?0?11?0?0?0?0?0?0?0?1?1?0?1?0?1?????1?0?1?0?0?????0000?0?0?0?0?0?0?0?0?0?  
0?0?0?????????0?0?10?????????????0?????0?0?0?????0?0?0?0?1?1?0?0?0?0?0?0?0?1?0?0?0?

100????0?1?????????00??0?????1?10??0?0?1?????????2?????????0?????????1?  
?0?0?????1?0?001111????0?????1??1?0?10011?????????00?????????20?011?1  
11100111?????1???00?????00?0?002?????0?0???1?0????1?0?0?0?0?0????0?  
Citipati

Citipatti  
110201

1102011111120??11??01102101111?0001001020211000110110020111000000000011010101100  
00001011000011010000010012100?100?1?01[01]?2110000110101??12??????1211010011020  
00100112?10100?1?0??????1110?1010?1010?1??1?100??0??111111?1012110011?110002001?  
0?001010?0002110?????00?021?11201??2010100120110?10100?2?210?[01]?????41?1?????2012  
00?10?0?00000100010000211010020101?01110110011?221001011100010000220?????????????  
?????????????????0?001?0011?01?002?????????1?????????0101?11000?00010?0000?0001?00  
01?01?0000?0?0?10110?10?1?00?2200?00??1?011100?0???200000?0?1??00?1?1?0?20  
01?0000?0?????????0?0?0?00?00?01?11?0?01?0?0?2?00?1?0010?0?0?1?010?00?1001?0001?00  
00?0010?0?00?2?0?01000?0?101?0?2?0?0?1?0?0?1?0?0?1?0?0?1?001?0001?00  
00?01?0000001?11?0000?11010000?0?1?1?0?0?0?1?1?0?0?10000?0?1?0?0?0?0?0?0?0?0?1?0  
00?01?0000001?11?0000?11010000?0?1?1?0?0?0?1?1?0?0?10000?0?1?0?0?0?0?0?0?0?1?0110  
1?00111?0101?10000010?010?0?0?0?01000?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?  
0???

Coelurus

## Compsognathus

0010?002?0?0??2??100?1000110?11[12]0010100??0?0??10100011?11??0???00??11??0??  
00000?0??????0?0?00?0?????0?10?????????????010000000[12]0?00000000?????00?  
?120001??20?0?0?1?????10?00?0?10001??10?00?1?01??0?0002010?000?00?10?120?00  
?????0?3?????20011??0?012100??110?0?010210?1112?0??2001?????0?????0?[01]0111?0?01  
?0?0?0?00?0?1?????1?????2?????11??0?23?[01]?0?1011100000100?????????????00?  
11??12?001100?0??0011?011?201110000110?0??0?1?????1??0?00?01?010?10?11??0??00  
?0?0?0?????0?0?????1?110??0?0001?????0?0[34]000?0?210?????1?10?1?0?2?2001?20  
?????????0?[01]?0?0?01??0?0?????1?010?01?????0?0011??1?????000?00?100?1?000000001  
10000?0?0????000?0?0?00?10?0?0?1?0001??0?????0001??000?000????01?1?0?0?000?????  
001????0?0?????00?0?000?0110????0????0?0?0?10?????00112?1??0100?1?0?0?0000000??0?  
?01?0?0?010?????1?0?0000?0?0?????1?????0?0?0?0001?0?0?000?100000?????000?110?  
??00?0?00?0000?000?0?00?0?000?0?0?1000?00?0?0?000?110?0020?00?0?0?0?  
000

Concornis

Confuciusornis

001002010110???01??01101111011??11010012000?11?1110?0002?011110001?000?1???101000  
00002000?1?0?1110?????1?????????????????????0001?12?????1110010?1?1300??0?1  
0010?00?0?0?????????0???10?1?????0?0?11?110?0111101?0?00120110111110002??2?1001102  
00010111?10101010021?112010?0210110121100?1110000?20011110005??2?0??0412?30?????0?  
0?0110??11?0?0?000??120??1?12011??0?00?0220?2010221?10010[12]?011???11??0?1???111  
?0?????0111[01]11?0??1111?011002101101001101101101000?1?01?00?000?0?00?01?0?10011???  
0??1?010?????00?11010?1??21000??0?0001??0?0?10000?0?2?????0?00?200?0?1?01?2011?0  
?00?1?????????0?001?0200?00?0?00????10?0?2???101012?1?00?00?001?001?001?0011000???  
11?????00?????110111?0???11??0?111??0100101?????????0?????100000?0011?10?????0?0?0????1?0  
1?00??001??000?01000000101001????011100011?1??00??2?1??0100?1?0?0011110011?011  
?101?1?0??1?????????0?001?????0?????????????2?010?????1101121??1???1120000?0????0?0?100?  
?????????0011?????0?111100?0?00?110001????1?0??0?10?????11101?1???1?0?0?20?1110?00????  
0?

## Deinonychus

000000010001??001??1100000??10200001?001001?0?10110?00001????1[01]0?????2??0?????10  
?10101?????????10020?0001?1????1?1????1?02?1??01??200010000010000??000??111?2011?  
01?001?0?0100111112011120011210101010?111012000011??11??101221100100111001001000  
001010001021100000011?0211011010000111000[12]12101111111?2112?????4?????2012420  
00101102?000021010000?1000120211210012110??1?1210?0112000101102220111?0?00000?  
0?110110011220[01]0100110111011000001101101012010?????????0?01001001101??000010?02?  
?1?001010200?01000?10010?001001?02000000000100002010?100000?10211?000?00?00100?  
101??200100000000010?001?01000?02?00?00?100?0?010000?0?1001000?1?0???0000??0?0011  
001?011?00?0?1110?20100?10010110??00210??0?0010000?0000????100?????10?000??001111  
0001010001011000?0100?1?1000000?0?000?01010001010?00000?1 ???0?1100112?1000011011?  
00020100??00010021101?0?0?2000010000?00?01?0?000????0?0011010?0?2?110?1211111010  
000?0?????2000?1000?0?1???0?00????0?00?00?0000?????000??102??0000100?000?000100?0  
11?0?2?1100000?00?01?0?

Dilong

0001000100??020?201101100??10200001201010200001001111011111?10101020001?000102  
?000120?0?1?1?00010?01??01?100??20?10?????2?????10?000000000000?000000????210101?  
110?0?1??11?0?????1??00?10?00222?00??0111?00?200?10?????0[01]10000000?0000?????1?0  
00?0?2??0?0310?????????????0???10?0?0?01001?0210112201?2?2001?????????????0?2?????0?



## Epidexipteryx

## Erlicosaurus

Falcarius

Gallimimus

1000100001000??01??1010001011??000?1000000101000001000111111?00??100110000000010  
000002001?000?0020010010001011010010101?02??0?00110??0??12?????????0010??1010000  
10??00010000?1?010?11?01110100210111100110100010?010010000?0120100000010020010  
00000000?10020000001010?100??102001001010010021011010001?2000??????4100??01?0121

0?00100110?002001010121100?12010020111011002112[01]00001210010010012010221100  
01100011002?00123?00?20012110011001100????1100?11?????????1001101?001000111100?10  
00?0010?100?000000?11000??0010101110000??000000?1001000101000??201?110?00?000010  
??0??202101000000????0?1101100000000?00?000?00010?0000110000000?0000?000000001100  
?0?0010001100100???1001?0001010????0000000010?00?000?0?100?????01?10?000?0?0?10?1  
0001000?0?00?020000?001???000?0?000??1010000?00???0?0?1?0011000112?1?110?00110?  
001000000000?0??010?0111???0?1?0000010111?00010????1120??010?0?01????2?????????100  
000?0?00?0?100000?0?000010???0?00000?000000????0010?000?0?00000?00?001000?111  
00?020001000?0000010

Garudim imus  
1000100001000?01??110?0001011??00001000000101?000010000101111001000011000000?01  
00001201110?0100200100??0?0?1??0?1?1?????????1?0?001??12?????????001000?101100010  
10000??000??0??0?100??10?10?1?111??0110?000?0?0?0?10??0?01?????????????????????????  
????????????????????????????????????????????????????????????410?000?????00?0?0????????  
0??010101211002020000201111010002112000[01]?????????012010211000?01100111001?0?1  
23000110011110011001?0020101?0??110?????????0?1?01?001?00?101?????0?10?1?????0?0  
01?11000??00101?1110??0??00?0???200?00?1?0000?0?1?001?00?00?0101????200????0?0?????  
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?????0?0?000?0?0?0?0?0?0?0?0?0?0?1?0?0?201????10?1?0?1?0?0?0?0?0?0?0?0?10?0?10?0?  
?????00010??0?00?1?????????????0?????????????0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?  
00000?00?????????????1?000?0?0?0?0?0?1000?0?1?0?0?2?0?1?0?0?0?0?0?0?0?0?0?0?0?0?

Gigantoraptor  
1????????????????????????????????????????????????????????????????????????????????????????????????????????  
????????????????????????????????????????????0001?12??????1221?1011?2020????111?11?0??  
????????????????????????????????????????2201?1????????????10?01?0??21??2010  
00????11?1201??01?10?0????????0?2101????????[23]0120?1?0010000?01000??  
????????????????1????10?1?????????022?0?11?011??0??2?0?10??23100?[01]00?[0  
1]?1?????02????00?01?????????0?????0?????1?10????[01]?0????0?0?0??  
1?????21?0??0?0?????0?0?01?0?0?0?0?0?1?????1?????0?0?0?0?0?0?0?0?  
?0?0?01?0?0?1?????0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?  
?????01?????0?0?0?01?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?



## Huaxiagnathus

?1?0?????????00?0???00?0????00?????????0110??00?0???0?????0?????0?0?1?0?0?0?11?????  
?0?????10?1?0???0?????0?001???1?1?000?????????????0?0?1?????????0?0?????0?0?????0?0  
?????0?1?1?1?????0?0?0?0?????0?0?????0?????0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0  
00?0?????????1?????0???011?????????00?????????0?0?00?0?0?000?00?001?0  
1?????10?????00?1?????1?00?0?0?????00?0?0?001?0?1?0?0?0?0?0

Jianchangornis

Jinfengopteryx

0100????1?000?2?0?00010??1??1?2000?0010??0?0??1?0?????0??1??0?1?0??0010?0????00  
0?20????0????????????????[01]?????????????????????0101?001021200???0?????????1?1????  
?????00?????????????????0?????1?????1?201??11?0?[01]21110111?1?0?????1?1?0000?0  
?0?????0?0101010021?01[12]01????1010012?210?111?[01]?1?2?1?????????????31233????1?  
110?000?2100?????????????1??1?????0?????10?20?????????????????????????012????  
?????1??1?[01]????11??0?????????????1??10??200?????????000????101?????1?0?0?????01  
00?????????0?????????????0000?????00?????10?????????0?2?2?1?000?????0  
?0?0?0?????0?0?????????1??20?????1?????????????1??1?0?20?011??0????????  
?101????1?????0?1?????0?????????000?????0?0?00?????01?????01?????01?????0?0?????0?  
?????0?0?1?????????????0?1?????00?2?21?0?0?0?????1??1?0?????????????1?1?0?0?????0?????  
?????????????????0?????1?????????????0?20?0?????1?????0?????????????1?1?0?0?????0?????  
?00?2?0?00?2?1?????????????0?20?0?????1?1?0?2?2?1?1?0?0?????0?????

Juravenator

Khaan

1110011011?20??11??11?2101111??0000001000101000110110020[01]1110000000000?10101?1  
00?00012011????0?000000?????????????????????0101?12?????12110100?0200?1  
?111010100?1?0?1111?0?11??1020?10101???1?1?000?11?01?0012110010?1100020?1?000  
0?01?00003??00?00000021?011010?0101000[12]0210?1110002?2101?????04??0?1?????0??  
?????????????0100000010??0001???01111?001???2?010111000100?0220?01?1?10??0?????1?0  
11?0?????001000?01?0011?0120?20110000010?????????0?01?11???1000??0000?000110101??  
0??0?0?00?0?????0110?1??20000?1000000?1?0000?10000?0?21?????0??0?0?0001?0??2001?  
0000?????????0?000?00?00?0?0?1??010?0?????11010??0??0?0100?0?100?10001100001  
0010?????0?????0001000?????10??0?0?0?0?0?01??1?????0?????100001?0?0010?10?0?0?????????  
000?????0?011?1?000??1010?00?????????0?0?0?1?01??00?2?1???0100?0?110?????0?????  
1?????100010?????1?2?0?????11?????????????1?????1100?110?1211111?1000?0?????0?0?0?1?0?  
11101010100?0010000????00?0?00????0?0?0?00000?0?0?100??1?0?0?010?00?0?0?0?0?0?  
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Longipteryx

201??????0?0?200??0?????2?????????????0??0??????????????????????????????????????????????1?  
????????????????????????????????????????0?01?2002?0?????0??0?0?????????????????????????0?  
?????????1??10?????010?????????????11?????0??2011????1?0??212?0011011?0?011??0  
?01011021?11[23]0???210102?01110?1102????20011112116????1?4?2?0?????????11?????  
?????????????????2?????21?0?20?[12]?10120?100?????????????????211?????111[12]1  
?0?0?02011?01?0?101?????1?1?????1?0?????0?????10??2?1?10?0?????0?????1?0?????0?????  
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?20?0?0?1?????1?????????2?????????00?????0?0?0?0?11?????????1?0?0?  
1????1?????????00?????1?100?0?01?????0?0?????0?0?0?0?1?????0?0?0?????  
?????????1?????11?????????1?????????1?????????1?????0?0?1?????????1?????????1?????????  
?????0?????0?????1?????111111?11?00?????00?????????????110?????11100  
?????1?????????01?????0?0?2?1?????????

Mahakala

Mei

1?11100100?1?200?0??0?111?1021110??01?000?11?0110000?0111110011?000?0010101?00  
??001????10120100????[01]????????????????????01[02]?00010212?0?1000????11?11?  
????001????0?0??201?10?10?1?010?1?10?????11??1110?0012111?1???110020?1?10?  
?0?0?0?31????0?010?021???[12]01???01?00?2?????????????20?????03?000???[12]12320??

## Microraptor

000000010000?2?0?0?101001??1???100?001?00?0?0?0?0?1?0?1?2?0????????????????????????????????????  
?????????1????????????????????????????????002?000[01]0[12]1100?2?001?????0?1?????01?????01?????  
?????0?????????????10?10[12]?2?01?2?0011?2?0?0?01?11?1?2?001[12]011011112?2?0[12]?1  
001100000102??00101000021?01201??2?010100111210?1112110?21?1101000[34]??2?001?3124  
30?????1?2?000021000000010000120111?001?2?110?2[01]?2?021001010211?1001?0[12]01110?1  
??2?00?0?1?2?01[12]?0??231101000111000110211010011[01][01]111010111101110?11?0?0?0?0?0?  
??1011?02?11?001??2?01?1?0?0?1?2?00?0?010?1?2?20000[02]?2?0101000?01??1?0?0000?1?2?110?0  
?0?0?0?0?1????1011?0?00?????????0?0?2?110?02?2000?????0?0?2?010?0?0?????101?????????0?0?  
?00000?1?2?0110?0?1?2?1110?0?????101111?0?10?0?????0?0?0?0?1?????0?0?2?111?0?0?0?0?2?1?2?010?1?  
????0?0?2?1010?0?????0?200?????0?1?????0?0?0?0?0?1?????0?0?2?111?0?0?0?0?2?2?1?2?010?1?  
0?0?0?100110?0?1002010000?0?0?0?1?1?0?0?0?2?1?2?00?0?0?0?1?????0?0?2?010?0?0?1?2?1?2?00?  
?0?0?0?0?1?0?0?0?100?????1?????000?00?0?0?100?110?110?0?2?0?0?0?1?????0?0?0?0?1?0?0?1?0?0?  
?0?2?0?1?????0?0?0?0?

Microvenator

## Monolophosaurus

00000001000110?0000?1001110000200100201221200000101101110110111100020?100020101  
0011000100010?00200001001112???10?10??0?????100[02]00000000000000000001???100  
110?1000010?01?0100111100011?1?2001?01001110010000110010?0?0[12]?????????????????  
????????????????????????????????????????????????????????????????????30000?????????0110?  
1?0?????0?0?0111101100202100?100011001001?0000100101000?0?0?????????????????????  
?????????????????????????????????????????????????0?0?0?0?010000?0?01?0?0?1?00????????  
0000?1?????0100?0?????0?000?0?0?0?000?0?????0?0?11?0?1?0?000?00?0?0?0?0?1?0?  
??0?0?1?0?0?00?0?0?10?0?0?011?0?0?1121?0001?0?0?110?0?10?0?01?000?0?1?0101?  
?????0?0?0?00?100?0?1?0?0?010100?100?0000?0?0?0?0?0?0?10000?0?0?0?0?0?0?1?0101?0

?????00?????1?0????0?????1?????????1??0????0 112??1????1011????0?????????????????00????0  
??1??000?0???0?0?0?00????1?0????0?????????1000?????????0?0?10??100?0000????  
?0100?00?????????100?00?0????0000?0?001?0?0?1?0?0?

Mononykus            ?????????????????????????????????????????????????????????????????  
????????????????????????????????[01]?0?????????????????????1????20????????????  
?????????????2?????01?[01]01102?11010001100?001000100001?0??1[01]2110000  
?01000000100000112000114100021002??020?0?01001111?110????1?????????10000??2?  
?????????0000?10?0?01?0?01000??000020?2?????1????21?????0???02200010001  
10?00110212?2000113010120012110011001100?0111000110?????????11?????11?????0?????  
0?01?1????10?01????0??100????1??211????0?01?0????0??110??1?????0?0?0?1?  
??2?21?0?1??00100??1?110?00?0?1?????????0?0?010100????00?????0????0?0?1?  
?21?0?????100?00?1????012?2?????????????00?1?0?00?0????01????0?0?01?0?0?  
10?1?1????0?1????00?1????1?100011?11?00000010?0?0?000010??0?0?010?00000  
000?000?0?????????0?1????10?001???1?2????01????000??10?0????0000?0?????????  
?1?10000????1?????????110??11?????????000?????0[34]101????0?????????11?0?????  
1??1?

Neuquenraptor    ?????????????????????????????????????????????????????????????????  
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1101110??01?01101011?0?????????????????????2?1?????1?0?????????0?0?????  
?????????????????1????00?1?????????????????2?0?????????10?????????1?????????  
?????????????????????????0?????????0?????????1?????????????0?????????0?????????  
?????????????????0?????????0?????????1?????????????0?????????0?????????  
?0?????????????0?????????0?????????0?????????0?1?????1?????????????0?????????  
?????????????????0?????????0?????????0?????????0?????????0?????????0?????????  
?????????1?????????????0?????????

NGMC91

0?10?0?00?1?2?0?20?10?010??10?00??00?0?????0?0?0[01]1?????0??0?0?0????????  
001?????????????????????????????????????012?0001010100?10?????????1?????????  
?0?0?0?????????????????????????????1?????????01??11?1?1?????2??01?00?01?2?  
?00?01010021?1120??0?010100111210?10121?0?211?????0?????0[23]?4?????1?2?00?2  
?????????????????????0?????????0?????????0?????????0?????????0?????????0?????????  
0?1?0?11?1?0?00?10011[12]01?11?10?10?????1????010??10?????11?00?????1?0?0?0?????  
?????0?????00?????000?????1?000?0?1?0?1?0?0?0?1?1?0?0?0?1?0?0?0?0?0?1?  
1?????0?????0?1?0?????1?0?0?0?1?0?0?0?1?0?0?0?1?0?0?0?1?0?0?0?1?  
?1?????0?????0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?  
?????????0?????0?????0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?  
?????????0?????0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?  
11?????????????1?????????1?????????0?0?0?

Nothronychusgraffami ?????????????????????????????????????????????????????????  
?????????????????????????????????????????????????????????????????????????????????  
?????????????0?1?????????100????0?11?1?0?0?0?1?0?0?0?22?1100????10?1?1?1?

Ornitholestes

1000010100?1?210?11101210?0102001011010?00?00?001011?0[01]12111100000?0??20100?01  
0??0000200010??2002?000??001?1?0??20??0?1?????????1??000000100[12]0?000000001?1113  
00??11?001??20?????????1120001?101??201100?00000001??11???01?1?????????????????????  
?0000100010311?????1?????????01?00010??1?????????000?????3100??0?0021??200  
1010?0?001101010100101012010?21001101100??020001010100100100?????10??0?0?0?????  
?????????01[01]?0?000010101?0?????1?0??1?0?????????0?1001?0??00?0000?0?10??1100?  
1?0??01000?10?1??2010?1?0??000000000?011100?0?200?0?11100??00?200?00?20?200?0  
?00?0?????0?1?000000?00?01??0?00?10??000?0111?00??0?000010000?1??0?000001  
01000?0?0????0?0?????0[12]00?0?0?11?0000000000?0000??1????0?0?0?10?0?0?2000????  
1000100??0?0?????10?10?000??0?000?010??0??1??0?0?21?????00?00?00000000??  
?00001??00??????1?000000010?010000?????00?????0?001??0100??1000?????????001??0????0?  
00????00000?00????0000?00?0?????????0?10011??0??0?0?0?????0?00?????001??0????0?  
00???

Oviraptorphiloceratops ?1?????[01]1?????????11??01111?0??00?2?2?2?2?01?00102111?  
?000?????11?????0?????????????????????????1??1?????0?1010??12?????12  
11010??0?00?1??11?1?????????????????????????????????????????????211?????1  
?????????1??0?????0?00??21??1201??0101?0120?10?1100?1?2102????????????  
????????????????????????????????????????????????????????????????????????????  
????????????????????????????????????????0?????1?????00????0????1?00?????????  
?????????????????0?0?2????00?????????10?????????0?0?0?0?0?0?01?0?00?????  
????0?0?????0?1?0?0?????10?0?????????1?10?????????0?0?0?0?0100?0?11?????????



Pengornis

0010? [01] 010000? 200? 0?? 0? 111?? 20 [23] 0100? 0? [01] 00????? 0? 101? 0? 1????? 1? 0? ??????????????????  
???????? 01?? 1????????????????????????????????????????????????????? 010? 1? 010212?? 0? 0?????????????????  
????????? 0????????????????? 1????????????? 0????? 0? 201? 111?? 1? 0? 2?? 1? 2011102?  
10101011? 0? 010? 1021????????? 1?? 10????? [01] 0????? 2????? 1? [56]????? 41? 3?????  
?? 11????????????????????????????? 1? 0? 20????????????????????????????? 1? [01]? 1?????  
?? 1111? ??? 111? 1? 1?? 1? 1? 001? ?????????????????? 10?? 1? 2? 1?? 0? 1? 0? 0? 1? 0? ??  
????????? 1? ?? 11????????? 0????? 02? ?? 0? ?????????? 0? 0????? 1? 1? 0? 0????? 0? 0? 0? 0? 0? 0? 0? 0?  
?? 0? 0? 2? ?? 0? 0? 0? 0? 0? 0? 0? 0? 0? 0? 0? 0? 0? 0? 0? 0? 0? 0? 0? 0? 0? 0? 0? 0? 0?  
01? 1????????? 00? 0? 0? 0? 0? 0? 0? 0? 0? 0? 0? 0? 0? 0? 0? 0? 0? 0? 0? 0? 0? 0? 0? 0? 0?  
?? 0? 1? 0? 0? 0? 0? 0? 0? 0? 0? 0? 0? 0? 0? 0? 0? 0? 0? 0? 0? 0? 0? 0? 0? 0? 0? 0? 0? 0?  
????????? 1? ?? 1? 0? 0? 0? 0? 0? 0? 0? 0? 0? 0? 0? 0? 0? 0? 0? 0? 0? 0? 0? 0? 0? 0? 0? 0?  
111? ???? 1? ???? 1? 1? 1? 0? 0? 0? 0? 0? 0? 0? 0? 0? 0? 0? 0? 0?

## Protarchaeopteryx

## Protopteryx

001??1?20010??0?????1??11????????????0?????0?????????????0?????????0?????????????0[01]  
]2?0?0?2010?????????????????????????????0?0?102?0?????0?????????????????0?????????  
?????????????0?????101?????????0?0?0?1?0?2?201111?1?1?2?0?2?10011011?0101?  
0?0?0101?021?1130????210100101210?1112????20011112015????1??412?30?????????11????  
????000?????????0?????1?0?20????02????01?0????11????1?????0?0[01]?[12]????????111[  
01]????????111?111?21?1101?011?111?1010?????????0?????10??1?0?20?0????????1?1?????  
?0?1?0?1?21??????????00?????????12000?0?????????????????1?102?01?0?200????????1?0?  
000?2????0?????????1?????????0?????????????00?????1?000?0?11?????????????10??  
?????????????????????0?????11?00?0?1?????????0?0?0?0?01?????????1?????0?0?0?1?

???0?00?????????????11?????00?2?2?????0?????????????1??1?11??1?0????????????????????????????  
?????????????????????1?????????????1?1?1?????????????????????????????????101?00?11  
1?????????1?????????11?1?????????????0?1?????????0?????

Rahonavis ?????????????????????????????????????????????????????????????????????????????????????????????  
????????????????????????????????????????????????????011?11000?0?1?11?1?01201?111?1?????????????  
?????10[01]11?01010????????????????????????????????????40210?0?12[23]2???10  
01?0?002101010020000120101112012?10121?0210?10002210100110?0001?0?10?00?1011  
112?01?22?101010?01011?01001201110011010?1?????????1?????0?????????11?02?????1??  
02?0?1????1?0010?0?1????021?????1000?????0?1?000?1?21?0????0?????????1?????2?????  
?01?????????2?0?00?????????????0?????0?????1?????????????0?????0?0?????????1?00?1?210?  
?????100????0?????????00?0?1?????????????????1?????011?????1010?????0?0100????  
0?????????0?0?0?1101?????00?1?????????2?1?0?1?????10?0?1?1101?11011100101????  
????1201?????0?01?0000?????0?????0?????1?????????????2?????0?????????111?????1?  
?????????????1?????????????????1?????????????101?????1?????????001?1?00??????

Sapeornis

0110?1010000?20??110???11?????301???0??000111?????0?????1?????0???1???10?????10  
0?????????1?0?10?????????????????????????0011112?????010?????1?00?0?0?0?10  
?0?0?????????0??10?????010?????0?0?0?0?1201101??1?0020?1?1001000000100  
11000101010021?1130?0??2101101[01]?111?0110????2001?????05??001??[34]12?3??0???0????  
110?010000000000120[12]10?11012??0021?02200201022????01?[12]20?110??00?????1?0?1  
????????111[01]01?0?00011?0110?2101???011?????1???0?1?????0?0?????0?01?0?1?0?1?0?0?  
????1?????000????10?1??21?0?????0?001???0???02000?0?1?0?????????????1?0?20?2011?0?00?  
1?????????0?002??200?0?????????210?0?0?????0?01?????????0?????????00?????11000??11??0?  
????????1??101????11?????????????????????1?????100?00?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?  
?1?????00?????0?????0?00?????1?0?????01?????0?????1?0?01??011?0?1?11111?111?????1?0?1  
????2?????????????????????????0????1?????????0?10100?00?????0?0?00?0?0?0?0?0?0?0?0?0?  
?1?????1?00??11000?????1?0?00?????1?101?????1?????0?0?0?11?00?0?0?

Saurornithoides 200110010001???0???010?001101?21010?10000001?100??010?01??1???0???  
????1????????????????????????????001???11?????110???0?0???001?1111???010??  
????10????????????????????1????????????10??0????????????????????41?0????????1?0??  
????0????????????000????00????00????00????00????00????00????00????00????00????00????  
??1??????0011?2?????0?1??011?1????????0?0??100?0?02??1??11????0?10?1?  
?????0?0????21?200?????0?????1?0???0?12?????????1?0???0?0????0?????2??  
?????0?00?0?????????0?????010????0?0?????0?????11?????0?0?????0?000?0?0?0??  
?0?1????1????0?????0001?????0?????????????0?0?1?????????????1????????0?????  
?0?????????0?????1?????0?0?????1?0?1?0?????????????1?0?1?1?????1?  
1?????????1?????????000?0?????0?0?011?????1?0?0?????  
?????????????1000?????002?????11?0????

Schizooura

0112??2?101?0????0?????0?101??1???010?0010000?10?1?101?0?2?1010?1?0?????????0?????0?????????  
?20????0?????????????????????????????????????????010??12????????00?0?????10?????????  
?????????????????????????00?????????????1?????????201?????110?0?2?200?1?2?20?0?1??  
??01010?21?1130????210110101101?111?????2000101?11[67]???01??4??3?????????11????  
?????0?0????0?????????0?????1120????0?????????????012?????????111?0?  
0?011?0?0??111?0?011????10?????0?1??1??0?0?0?0?10?1?0?11?11?????0?1?0?????????0?0?  
?????10?????????21????????13100?0?????????????1??1?2121??00?????????2?0?0?2?0?  
?10?????????10?????????????2?????????????00?????0?0?0?11?????????????1??1?1?????  
?1?????????1?1?0????100??1????0?0?0?????????10?????????0?????1?1?????????  
?????????11?????00?????????01??1?????????1?????????????????????????????????????????  
?????????????1?????????1?????1?????1?????????00?????????0?0?11?????????110?????  
??1?????????1?01?????????0?2?11?????0?0??

Sciurumimus

Shanag

Shanag ??????????????????????01011?1101?2010?1[01]010????????????????????????????  
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?????0?1??1????????????????????????????????????????????????????????????????????????????????  
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?????????????0?????????0?????????0?????????????????????01?????????????????0?????????0?????????  
??0?0?????????0?????0?????????????2?????????0?????????1?????????????????0?????????0?????00?0??  
??0?0?????????0?????????00?0?????0?????????1?1?????????????????0?????????0?????????????????  
?????0?????????????????????????1?????????????????0?????????????????0?????????0?????????????????  
1?????????????????????????????????0?????????????????0?????????????????0?????????0?????????????????

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## Shenzhousaurus

000010000100????0??2010?0001011?000?2001000101?0??01000010?????0??01??000??2?00  
0?????0?????????????????????????????????????0????0101102??2???0?0?001?1?000????0??  
1?????????????????????????????????????0?0?01?200?0?0?1?????????????????????????????????  
?????????0?????????0?????00?021??10[01]0002?2000?????3?0000?01[12]00??0?0?010?0  
01?010101011000?201??01111?11021?1?00?10101??10?100??001??00?1?????????????  
?????????????????????????????????10?1?????0?0?0?0?0?1?????010?????????0?????1?????  
?010????110?00?00000?11?0?????10?????0?101?????00?0?????0?0?????1?10?0?????????1?????  
?00?0?0?0????0?0?0?0?0?0000?????????????0??1?00?0?0?010?????1?????0?0?0?0?0?0?  
?0?00?????0????00?00?0?????000?0?????0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?  
?0?1?????????????10?????????0?2?2?1?????1?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?  
?001?????1?2?2?2?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?  
?0?00?????????????0?????????00?0?1?0?0?0?2?0?0?0?0?0?0?0?0?0?0?0?0?0?

Shuvuuia

00011001?001?0?0??1001?110?32000?1000000101?0000000001011?000100000?001000100  
0000110000101101001?1001101[01]?01?10020011?12?10?1??101011101020?0?00??000??1?1  
001??00?????02?????????01]?01?01102?01010001110?00100?100001?0??01?01]?110000?2010  
00000100000112000114110021002?????0?0??0?????????0?????????2?????????10000?520000?0?  
?1220?00?0?10?0??2010?101000?0?000020020[01]111?00100?0220?211100000?0?0220001000  
1?0?00110212?2000113010?20012110011001?00?????????1?????????111?11010??0000?100?  
?000?0?????1011?10100?1100?1?0010?1??21?110?0000?1???0?0?10[01]0?11??1?00?0?00??1  
?00??0??21?????0??00?1??20?0??0?00010??10?00????0?0?0?0?????1?00100?00??0101?0?1??  
10?00??02111000?0?0110??100?1?0?0?0?110?20010????000?2000?0?0?0?0?0?0?0?0?0?0?0?0?  
?0?10000?????12??000?0?????00?0?100??01?0?1?11?0?0?0?0?0?0?0?0?0?0?0?0?1?0000  
0100000?0?00?????011?????????0?0?100?????????1?20?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?  
?????????001?1?0?????1?????00?1?110?11????001010?11?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?  
?0?0010011

## Similicaudipteryx

11120?1100?1?210?12011?010??1?3000000?1?0?0?00?0?0?0?2111?11?010?0?0?111???1????0?  
00?????????01?100????????????????????????001?01?21?0?1?1010??0?00?001  
1?0?0?????????1?10?1??10?1?11?10??00?11?00?0121?0?001?????0?1?0?0?????  
31?????0?1?02????2?????01??01?????20?1?1?1?0?031????13?2?0?????0?0?011?0?0  
1000?311000020100?11?1110?1????0001??100?10010[12]?0?????0?0?0?0?1?????001  
2?0?1?0?11???1?0?011?000?11?????????10?????11?????????0?00?0?1?0?0?0?0?0?????  
????10?????21????2?0?????0?1?0?0?0?0?0?100?????????0?1?0?200?0?0?0?0?0?0?0?0?  
0?????0?0????0?????10?????????0?1?0?0?0?0?0?1?0?0?0?1?0?0?0?1?0?0?0?0?0?  
?????????????11?????????00?0?0?0?1?0?0?1?0?0?0?0?1?0?0?0?1?0?0?0?0?0?0?  
?????0?0?0?0?0?0?0?0?11?0?0?0?0?0?2?1?0?0?1?0?0?0?0?0?0?0?0?0?0?0?0?0?  
?????????1?????1?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?  
?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?

## Sinocalliopteryx

0000?0010001?0??20??01[12]00??10200100100?000100?01?1101?2011??0??0??????0??0??????  
00001????????????????????????[01]????0????????????????0????10?0?011000?0??????11?0?1?

1?00?1?????00?0?????????0?00????000?1??0???1??0?00?0?02110?001?000?20?1?0?0?0?  
[12]?0??31??0?00010020?11101??110100120210?1220101?2001?????1??????00[01]110??  
??0?00000?1?010?0?0111?02010?10?11????02?[01]?0?1011100?0110????????????????????  
0?1??????0011??0????11?0?0?[12]?11?0????1?100000000?1??1?00?0?0?0?10?10?11?010  
?0?????000?????00?0?10?????????????0?0?0?0?000?0?0?110?????????1001?????2?01?1  
000?????????0????0?00?0?????????1?000?????010[12]0????1??1??????1100?????10??0?0?  
00????0?????0?0?010?00?10?0?0?1??0?000?????0?0?0?11?0?0?0?0?0?00  
10????0?00?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?  
????1?0?0?1?????????0?????????????0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?  
?????000?00?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?

## Sinornithoides

Sinornithosmilleffi

0

Sinosauropteryx

000000010001?200?00?10?000??1?200101101?00?0?01010010?0[01]0?1????201100?0?????????1?  
000?0120?1????00000????0?????????????????????????????0?0?0000010?00?00?0?0?????????????  
?????????0?0?0?????0??10?00?0?1000100?10??[01]0?01??01??10?000211?010?1000?0?10000  
0002?001041??02?01[12]?0020?11210?0?01110101021010010101?20010?????????????00110??  
??0?000?100010010000001010020[01]0??[01]1?11?0?02?0??001011100?001002[12]0?02[01]?  
??0?2110??1?001?0?2?13000112010000011?0?011002011100?0110100000001?1?1?2?000?1?00?2?001

Sinovenator

100010010001?20010?110?100101?[12]10100[12]00000????0?011????????????00?0?0?01101  
?????????2?1?0?????0?????111?1[12]?00100010001??2?????????010?000102?200?0?10?????1?  
1????0?10?????0?????????1?10?10?1???10?0?1???00?10?11?????012111?111100?2?01?1  
0????????01?????????01]?????0?0?1?????0?0?1?????????0?0?0?????????310000?21[12]????  
?11?0?2?0?1000000000?002021?211?1110001?02100201?211?1000????0110?110?00?0?02  
?0?2?0?12????0?10011101011021001[12]????0?11?????????????1?????0?0?1001??1?02?????01  
?102?11010??1?00?????10?????200?0[02]?0000?0?0?0?0?0?0?1?21?????0?0?????????0?2?2?  
?????????????210?1?????00000?0?0?0?0?0?0?0?0?0?101?????????1?????2010?1?????10?011  
0?0?0?0?????0?0?0?0?10?10?0?0?0?0?0?0001????0?000?0?0?1?????001?0?0?0?0?0?0?0?  
2?1?0?0?1?????0?0?0?1?????1?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?  
10001?????010000?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?  
0?0?0?0?1?????1?0?1?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?

Sinraptordongi

00000001000110100001100000000020000120020010000010112111001001110000200000001111  
01001100001010100100101001112?0?0101100001010010010000000000000000100100??111  
00100100000001210110011211002101120111001001110010000010010?0000310??000000000000  
00?00????????????????????0?????10?????00??????01011????1200110000?30000?0?????????  
10?100?????0?0[12]112201100002[01]010100011?011022[01]10111010101001[12]0012010220  
000011110012000110101000110010000010100100201100000110?????????000?001000?110000?  
?0?101?11?0000010100?00000110000?00000?00100?10000000?011000?00?00000?10?001??10?  
02000101??20001?0??1?0?00?101011??00?000000?001000??010001200?1011?00001?0000??  
0?0?0?0110?01?0000?001?0101010??0?????001100001000??0?000000000000000001?0??00001  
1000010000??????0?0?0101000000??1?10???100?110?0??001000?0??01??00?00?0112?110001  
10100??000000000?????????10?0001??000?1??00000010?0?100?000?011?0??0?0?0?0?0?0?????????  
010000000????0000?01001?101100000??00100?001?0?000?????0101000?00?000?0?0?0001  
0000010?0001?00000?0?0?01?0

### Sinusonasus

1000?00100?1??0?2?110?100??1021000?201000?1?0?0??0100002??1??0????????????????????  
????????????????????????????????????????????????????????012?000102?100?0?????????1?????????  
????????????????????????????????????????????????????????????????????????????????????????  
????????????????????????????????????????????????3?0?????21[12]320??1?1?0?000?2?????2?  
????????????????????????0200?001?220?????1?????????1?012?????2011?1[12]10  
?11?2?00?20111011?1?????????????00???0?00?0???1??010????1??000?1?????????0?  
????21?0?????????0?????1?0?000?1?2?0?????????????1?0??200??0?????????????1?????00  
?0???0?????00?????1010?0?????1?????????1?????0?1?????0?0?????0?0?????0?0????10???  
?0????110?00?2?????000?????????????0?????0?0?????0?0?????0?2?????1?0?2?????0?????????



????????????????????????????????????????????????0??010????100000?????????0?0?  
?????0?0000?1?????0?01?????0?????0?0??0?00?????????1??0?0?10?0?1??0?0?  
?0?0?????00?0?????????00?00?00?????00????1000?0?0?0?0?0?1?0?0?0?  
0?0?001????0????01?101??0?1??0?0010?100?000?????????0?0100?0?????0?0?0?  
001?0????00?0?0?0?????1?0?0?????1?0?0?0?????0?1?0?2?0?????0?0?0?  
?0?101????000?0?????????1?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?  
????0000?00?0?0?0?01?????0?0?10?????000????1?112?0?0?0?????0

Tugulusaurus ?????????????????????????????????????????????????????????????????????????????????????????  
????????????????????????????????????????????????????????????????????????????????????????????????????  
????????????????????????????????????????????????????????????????????????????????????????????????  
?????????????????????1?1?11000?10????0????????????0?????????????1?0?????????0?1?????  
?????????????????????????????????????????????????0110?0211000?01?1?012??110?101?????  
????0?????0?????????0?????0????0????1?????????????????0?????0?????????0?????0?1?0?????  
?????10?1?????????1?????????0?????0?????0?????0?????0?????0?????0?1?10?????0?  
?????????????0?1?????0?????????0?????0?????0?????0?????0?????0?????0?????0?1?????  
????0?????????01?????????0?1?????????01?????????01?????????01?????????01?????1?  
?????0?1?????????1?????????0?????0?????0?????0?????10?????????0?1?????????0?1?????  
?????1?????????0?????0?????0?????0?????0?????0?0?1?????????0?????0?????0?  
?????????0?0?

# Tyrannosaurus

?????????????1?????????????????????1?????????????0??0?????

Unenlagiapaynemili ?????????????????????????????????????????????????????????????????????????????????????  
????????????????????????????????????????????????????????????????????????????????????????????????????  
?????????????????????????????????????????????010????1??11????????????????????????010?????1  
000?010??0?????????????????????????????????????12????????????????????????????????????????  
?????????0????????????1?1?0[01]?012[12]11200????????????????????????????????????????????????  
????????????????????0????????????1????0????0????????????0????????????????????????????????  
?????????1?0?????????0?1?1?????1?????????0?0????????1????????????????1?0?????1  
00?????????????0?0?????????????0?????????1????[01]?0?0????1????????????????????  
?????????????????????0????????????1?????????0?????????1????????????????????????  
?????????????????0????????????1?????????0?????????1????????????0?????????0????????  
?????????????????????0????????????1?????????0?????????1????????????0?????????0????????  
?????????????????0????????????1?????????0?????????1????????????0?????????0????????  
Utahraptor      ?0?????10001101??0?????0?????????????????????????????????????????????  
?????????????????????????1?????????????????????????????????1?????????0?????????????  
?????????????????????????0??1??10?2????1??11????02?????1?????1?0??0  
?????????????????????????0?????????2?????0?????????0?????????10??1?0?  
0?????00??1?????1??1?1??[12]?1??0?101?10?00??[12]200?????????011?00??1  
23?????1?0?1?????0????????[01]?????????0?????????0?1?????0?????0?????  
0?????0?0?0????20????0????0?????2?????210?????????0?????0?????0?????0?????  
1?????????0?????0?????????0?????????0?????????00?????????0?????0?????0?????0?????  
?????????10?????000?????????0?????????0?????????0?????0?????0?????1?????????  
?????1?????????0????1?????????????????????????????10?????????0110?????  
?????????1?????????????0?????0?????????????????0?????????0?????????????????00?  
?????????????????0?????1?????????????????0?????????????1?????????????

Velociraptor\_mongoliensis

0000000100011?00100110101010102000011001000100101101001011100110120101101010  
0101021000000010020020000011?00110010101?010?1101110021000010[01]0000000000011  
1?01100????1?0?0?0?????2?11120?1021?10101?1?11?010?001111110?012211001111110020  
?10100010[01]000102????000011??21??12010?0011100120210?111112?211200100041000010[  
12]024200010?102?0000210100[01]0011000120111210012110001?[01]21001010200010111120  
0120?1100000?1?1?0120011230101001101011001001101101012010?????0001?01001100????  
0000010?021110001?102?0000000010010100100200001?000100020100100000001021100  
?0?001?010001010?2001?0000?00010?00?00?00000200000?100?0?01000000?11011000????  
0?00?000110010011000011110?01000100?011000002101?000010?00?0010010001000?11?1  
0?00000?001111000101000??11001?01001001100000?010000100100101?01000011?10?1100  
??201?0001?0?1000020100100010021101000?010101100000?0110000?1??1?12?0?00?0000  
01?????????0?00?000?????00001?00000101?00001?00000010000?0000010100001110200?0000  
100?0?00001000??1?00?112000000000?0?000

Xiaotingia

0112??11?0?0??0?0?11?00??23000?10?110?0?1?????01?0??1??1?01?????????????????????  
?????0?0?????????????????????????????????000?0012?1?0?1?0?0?0?1010?????001?0?  
00?0?????????????21??10?????0?0?1?0?0?10?00200?101?11?????????1?????????20??  
???0101??21??1[23]?????101?012?21??1002?12?01?2?????03????11?????????1?????????????

1??0100??120101?1??110?2??????2?????1????0????????????0?????1?????1?????1?????  
?????????011?1?0111?1????1?????01?????0????1??0?00?1?001?0[02]?0?0?0?????????  
1?????????2????0?0?0?0?1?00?2?0?2?????0?1????1?1?2?11?01?????1?????????  
????0?????1??1?????????1?????????0?????11?????10?01??11?????????10?????  
?????????????01?1??1?0??0?1??1?0??0?1?????10?0?????00?1?????????  
?????0?????10?0????0001?????1??0?10????1?????????0??0?0?????2?????????????????  
?????????????????????????????0?????????00?00?????1?????????1110?0?0?00?0?????  
?????????0????????1?1????001?1?????????

Yixianornis

??????211?11??2????????????????????????????????????????????????0?0?001?????????????  
???1???1????????????????????????????????????0?0?101?021????200????????????????0?0?  
????????????????????????1?????0?????1?????200?201?111?10102002?1011?2?0?11?10  
100011021?11300??210112101101?121?????20011??2017?2?????????????????11??10??  
0000?????????11?11?0?00?0?20?2010201?00?0?00?0?1?????????2?2?2?2?????1210??111?  
011??00??11?00?011?11?100?0?????1?00?0?0?????0?0000?1??10??0?0?0?????1????1?1?  
??2111?????0?10??0?????3110?0?????????????????0?12101?0?00?1?????????0?000?20?  
?1????0?????010?0?2?????0?????????????????00?????1?00?1?11?0?????0?110??????1?  
?????????????????????1011101?100????0??0?0?1????001?????????1?????0?0?0?0?11?0?  
0??????11?0?111????00?2?1??01??1?????1?????1?1?11?0?????0?0?????????????????????  
?1?????????00?2?1?????????0?11?1?00010?????0?????????1?????????1?11?00?10??  
?????????0?????14?1?1?????002?11?????0?????

## Yutyrannus

Zanabazar ?0011101000102[01]01??010?001101?21010?100101010100?1??0?01?1?1?  
00??00011011010100?0101?????????????????101012111?00??1100?2?????????000100010111  
0?0010??????110????????????????????????????????????????????????????????????????????????  
????????????????????????????????????????????????????????????????????????????????????4101?0?????  
????111??????0????????????????????????????????????????????????????????????????????????????  
?0??23010??????1?????1?1????????????????????0?0?10?00?100?????1?0?0?1?????1?  
?0?1?00?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?  
?0?2?1?????????00?0?????0?????0?????010?????10?00?0?0?11?????0?11?0?0?0?0?1?0?  
?0?0?0?0?10?1?00?110?0001?????01?11?????????1?1?0?0?1?????????0010?0?????  
10?????????1?????????000?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?

Zuolong

0000?00100?110100001101?000?10?000??0?1?????????0?0?0?10?????0?????20??111111?1?0?  
0?????010?0100?1000?????????????????????1?????0?????[01]0[01]0?????????????????????  
????????0?0?0????1?11000?2001?0?0?21?0?0?????????????2?????????????????0?21?  
0003????0000?????????????????????????01?????30000010?0????010?10?00?0  
????01?10?????02??0011??11????0?0?001?????????0 1100?200000?101?02?????1?????0?  
??01000101?0?1?0?????????????????0?????0?0?00?0?1?????0?0?0?1?0?0?0?1?0?0?1?????  
?????0?1000?000?0?0?0?0?0?0?0?0?1?0?0?20?????0?0?0?0?0?0?0?0?0?1?11?  
00?0?0?0?????????0?0?0011?????0?1?001?0?0?0?0?0?0?0?11??1?????00?0?0?  
?11?001?????001?0????10?????0?00?????????0?1?0?0?0?0?0?0?0?0?1?????0?0?1?0?  
?0?0?100?????0?????0?????0?????1?1?????0?1?1?????000?????10?0?001?????0?0?0?0?  
1?1?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?  
?????????10?????????????0?????????????0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?

## Eosinopteryx

010??001?0?1?2??00????0??????00??1?0?????0?22??1????????0????????????  
????????????????????????????????????????010?1001022?1?????0?????1?0?????0?????  
????????????????10?????0?0????????0?201??1??11?????1?0?0?0????[12]??  
??0001?0?1?0122??0?0101?0120210?111?1??211?????0?????31223?????1?0?002?2??1  
??200??000?0??11?1??10?0????1011200?11010?????????????????2?????01[01]??  
1??011?0?002?11?0???1??1000?120?????0?????1?10?0??11?001??2?????0?????????  
?????????0?????????0?0?????00000?0?2?0?????????1??1?????2?01??00?????0?????2?????00  
?0?0?????????1?????????1?????????00?????1?0?0?0?10?????????0?0?????10?  
?????????????????0?????1?0000????0????0????0?????2?????????0?0?0?????  
?????????1?????????0?????0?0?????0?0?????0?0?????0?0?2?1?????1?????????  
?1?????????0?0?????00?????1?0?0?0?0?????1?0?0?0?0?0?0?0?0?0?0?10?  
?????0?0?????????1?????????02?11?????0?

Aurornis

Jeholornis\_prima ??????????1[01]????0??0????????????0????????????????1?0?????????0????0?  
????0????????????????0????????????????????????????1?0?????????02????????  
????????????1?0????????????1?0????0?0?01?0????100?[12]1?2?  
??1???200?100?[12]00?0?[01]000??1?0?21????211?1010?[12]10??1????????2????14????[01]?  
?3??[34]????????1?1?00?010??0?20001112020??1002??001?0?20?1010221????????1?0????  
????????1[12]?1????21?10?1?0?00?????????1?1?1?1?1?10?????0?????0?0?????1?0????  
??1?1?[01]1????????1?0?0?0?1?0?????10????????[01]1?????0?100?0?1?00?0????????????  
?1?1?1?1?10?0?0?0?0?0?0?12[01]????1????0?1?????0?0?0?1?1?00?0?0?1?00?0?  
?0?0?1?0?00?1?????????0?0?0101?????1?0?0?0?0?0?0?0?0?0?0?0?1?0?0?0?1?0?0?1?  
010?1?????100?????????10?0?0?0?10?0?0?0?0?0?0?0?0?0?1?1?0?0?0?1?0?0?0?0?  
01?????????????1?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?  
0000?0?0?0?0?0?1?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?0?  
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## Jeholornis palmapenis

Jixiangornis

0002?1?1?1?0???0?????????11??????0??0100????1?????????????1?0?????????????????????????  
????????????????????????????????????????001??12?????1[12]??10?????????????????????  
????????????????????10?????????????1?????????????11?1?0?????2?10011?1?0?20?????  
0?0?01?021??130????21010011?110?101?1???20011?10005??01??[23]1??30?????????00?????  
?????????????????0?????????????1?????????????????????????????1?????????111[01]?00  
?0?011?0?00?????1?01?101?1?????0?????????0?????10?????0?0?01?????1?1?????????10??  
0?????00?????????10?????????10?00?0?????????????1??02?01?0?00?????????0?0?2?  
0?0?0?????????1?20????????0?????????????????00?????1?0?0?1?1?2?0?0?1?0?2?0?0?1?0?2?0?

Matrix on coelurosaurian phylogeny after ref.20.

## Dromaeosauridae

## Archaeopteryx

00000000000000?0010010?00?000?0?000??000000?1000?100000?00000?00020001?????0?0  
0?0000000000?0000?0?0000000?????????000?000110000000000000?00000000?00100001  
000000000000002000000001?0001?010002?10?00000?0001?0?0?0?000000000000?0?00?000  
100?0100000?00100010

Jeholornis

[01]?23111?????????????0?????????????00?????00?00?1??0????00??10000???010000?????01  
001?00001??1201?0?2?1?2?0[12]?????????????0000000000?0[01]00?20101110?000001211001  
0000100020000100130000000011?101?01001????0??0?0?0[01]0?10??1100000000?00?20  
0?0010?00?1?00100101000?0

Sapeornis

1010010[01]?0?????0010?1?0?????????1?0????00?0??1???100[01]01??10010?0024000000?0  
0?00?011000000?020?0???10002?????????????00?0001100000??0100111????00?2110001  
000?0020010101030000?0?110101111?001010??0100?1000?0?111?11000000000000?0000?001  
1???01?0000000101010

Confuciusornis sanctus

10231111?0?????00010110000120??11?1121010?1100?101?101[01]01112001000024000?00001  
?01?0?0?0000??020?0?0000002[12]10??011210000001000210?000001010000100210001210?  
000?100?00000002100200000000?101011110003101120101?1?0010000?111000010001?210000

00001100?00?0000000000110

## Changchengornis

1?231111?0?????????1??????0?????1?11?0?0?100??[12]?????????2?1??024?0?0000?01  
?0?0?000???020?0?0?000021?0?01??10?0?0?0?02?????????????01?????0?????0?0000?0?0?  
00000021002??0????????????[12]??03?????????0?????????110000?0?0?2??0100?0011?0?00  
?0?00?00100110

Eoconfuciusornis

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[12]?231?1[01]?0??????0?????????????????1?01?0000?100????0?0?000?0?1?0241?0?0?0?  
00?0????00000?020????0000?02[12]?????????0?00000?100?0???000????01?????0??01?0000  
1?0?0000000210020?0?0?????????1000[12]?????????0?????10????0?000000002?00200?001  
000????0?00010100100
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Jinzhouornis

0023111[12]?1??????00??1?????????1?11?010??10??????0??0?1110??????240[12]0[12]?00  
0??0?0?????????00????000?02[12]10??0?1[012]10?00000?021020[01]0???11?0101??[01]?  
??0?01????01?00?00000021002?????????????0?012??10??100??0010??110000[01]00??  
0?1?0200?0?10?????0??001000011?

Confuciusornis\_dui ??23111?????????????0?????????1??????0??1????????????????[012]?  
??14?10?0?0??0?????????????????????????2[12]?0??0??10?0?0?00021?????????????01??  
?0??1??0[01]00?00?000?0021002?????????????????0[02]????????1?????10?????0?  
0?????0[12]00?0010?0?????0?0?1000011?

Boluochia ?1[12][02]????????????????????????????????????????????????????????????????????????????????????????????  
?????????????1????????????????????????????????????[12][12]?[12]?????20????????????????????????????????????  
????????????????????????????????????????????????110101??02?????????0?????????0[01]?100100  
002??3200?0011??1?????????20?????

Concornis ?????????????????????????????????????????????????01??11????????  
0?01????????11110?02?11?00?1?????1112221222111?20?00111?0[01]0211?????1????1112??  
?????????0?0?30010[01]0122?????????11?1?[12]?00?0????????1111?????1110?0010?0?  
[01]?0000?001??01131110?0?2??1?

Cathavornis

[12]0[12]0??0?????????????????000??00?1??1?1?0??11?2???240?0?0111??1111?0??20??000001?0111?322122311??20?0011?1?010211[01]0101111011???110?31100010?[01]00013001010122000000??11??????100????12????1????[01]?????1?1????????????????????????????????222220211111112222222

Eoenantiornis

[01]010?????02?????????????00?????????1????????????[012]????24020?????1?  
0111101012110002001??1112[123]????1102200021??12000?????????????11?????10231?2000

0?0000012001010122??0????????????[12]?2001????1????????????????11?0?10?????0??1?0?1  
110011[23]1011?[01]?1?0???

Gobipteryx

10[12]3101200021?10????????0???0?1??1?[01]0???10???10?????1????????[012]10??[12]401?  
????????1111?010?1??0?0010??111[23]????????0?????0?????0?????11??11?????  
????0??0?01?00?????20?????????10?03????????10[01]10?011?110010?100??11?0??1  
?1????????2??1????????

Longipteryx ?122111????????????????000????00?01?1?1011????????2????  
24??0?01?11?01?1110100???000?000?11132[23]?2111?20?0110?0002??[01]?0?011?1?11?  
?????0?01100000100?0120010001130000????111011[12]11001?0?[12]1?10????0?????1?1?0?  
1000000001?32000001??1?1211?1?22????0

Longirostravis

[01]022??1????????????????????00?????00?01?1??1????0????01????24??0?01110?011  
1????002??00000?0111[123]2[123]?224110?20?01??1?00???[01]????????10?????0?31??  
10?0?[01]01012001??0122?0?????1?10?1?11????0?1?????1?00?????1?11[01]?10010?0?2?0  
100?00????0?1?11?1?1????0

Neuquenornis ?????????????????????????????????????????????????0????11????????  
?????????1?1????021111000????1?111230[12]?1?1????0????11?????1?01?01????11?1?11?  
?31?10?0?[01]0001????????????????????????1110?????1?????10??0?1?1?2?00  
?011001[12]????1??2[12]0???1?0????

Pengornis

00[01]01101?0?????0?????0?1?????000???0?0?0????11?2??1??0?1?10?1????240?0[12]???0?  
?01?11??00?????0?02??11?2?????????001?0100101??[01]?100?1???11?????1[02][23]11  
1????0?01001?0010?0?3?????????????02?01?????1??[01]?01[12]11?010010010010120  
0201?00?????011?101?[01]011?021

Eopengornis

0000110[012]?0?????????0?????00000?000????1?1?10?0?00?????24??0?1????  
1211101000??000?02?00111321?110?1??10?0010010000?10?0001????10?????0??1[01]?00?0  
?010012001010103?????????000?????100?????0???0001????1?0101?0012?0  
00111101?1011102?

Protopteryx

[12]?[12][02]1??[012]?????????????????00?????00?0????1?1?10?????01????14????0  
??1??1111?0?01?[12]?200?00?0111322111011?[12]10??1????01?????????11?????????  
1?0000??[01]0001100000010??0???11?????????0[12]????1?????0?????00?0001????1?0101?0012?  
?0[01]01?001110011?0100?[01]101121?

Rapaxavis

[01]022??1[012]?????????????????000???0?0?0????1?1?10?1????1?01??11?1?2?024??0?0?110  
?01?????0?0?[12]?0?001??11?322122411??20?0100?0000??[01]0???1111?10????1?0?0?11?  
00?010000130011?01230000?0??111101?111?0100?????0?0[01]?0?11?100?10000?002?01  
00?0011??0?121011?10110210

Shanweiniao

[01]?[12][23]?1?????????????????0????00?01?????1?????????24?????1?1?  
?01?11??000[12]?000000?011?22[123]?211?[01]?20?1?????00?????11??11????1?????  
?????????20?11?????22?????1?????1?????0?????0[01]0?1?????????110?0000?0001?[01][

01]?0?0?1[01]?10?12?111?1011?210

Vescornis            ?0??????2????????????????0000??00[12]001?1??21?1?0???1??2??  
?2??????00?01?1?0?02?[12]?000001?011?322120111?20?00110?0101?1[01]0??11111  
1?????1[02]011010?00[01]0?0130010[01]01220?0?????????????????0??[01]?????  
?00?0010?011?[01]201?1011?11121[01]11?[01]1110?00

Vorona            ?????????????????????????????????????????????????????????????????????  
????????????????????????????????????????????????????????????????????????????????????  
????????????????????????????????101120111?000111011111[12]000100011?21000000?  
????????????11??????

Schizooura

0123111[01]?????????????????????11?0????10?01??0?[12]1?00?00?1??0[345]?1??[12][34]?  
[12]0[12]?000?01011?0?1001??[01]2?00????11012[23]0[12]?011??1??1?000??0[12]0010[01]0?  
?01?0?10????00?31?0000?001?0[23]001010103?0??1[01]1??0101?1?0103????[12]?0?????[  
12]?????11?010?0001[01]2?011000010?1?01?1110?10000001

Jianchangornis    ?????????????????????????????1?????????1?????????1?????010?200[234]0??  
????????????0101110010020?0200?0?0121?02[23]031001??[01]?010000010010000001?011  
1?????0??1?01?200000002101010103?01?[01]????????[12]?000?????00??0?0?10??1120  
?00?0?????0100?00??01010001110000?0?1

Archaeorhynchus

1013111[12]?????????????????????1?00?00?00?1??0????0??1???2000??[34]0111?????  
01011?00?0?20?[01]20000?0?21002[23]122211?[12]5??1000??010????0??0110?10????101?01  
?000?0??0?21010??230000????101100?[12]10001?????????0?0[12]00????211[01]010000??  
?0?0100?00????001010110000?01[01]

Songlingornis    ???[01]?????????????????????000????0?????1?????????2????????  
?????????10?????101??2???0???21?02301231[12]?51????????????????????????????????  
?????????????????????????????0????????????????????????????????????????????????  
?????1?10?01?????????

Apsaravis          ??????????????????????1[01]?????1?1????1?????021?1?201?200?4??  
0?24?10????????1011100001111121102001????[12]30??1?????1100100010111000011111110  
121101?311001110110??1?????10001111?111012??113101[12]?110??1??20121??11[12]?1  
11001?1?200100?00?????1??12110??0????

Yanornis

10[12]11102?1?????????1?????????1000??1?00?01?1?0?0????01??2003?0?????????01  
011110100?0?220001??121?02301121[12]?51011001?0110[01]????0100011?0?11?0?31100  
000000102101012310100?11?10100?11?003??1?????1?0??0?0?111011?00[01]?12?0100  
?0011?0?101001000000000

Patagopteryx      ??????????????1?111000111?????????0??000?112110110011003110  
1??120????????101110000?0?1210010?????2[12]????10?????1001??1000?0?0000100?0000  
?0?0????????0??1?1?20?00??20?0001000001110121?013?0??20????1001?0?01111201010011  
10000?0001????10??110100000?0

Yixianornis

1121?????????????0??1?1?0?0??110?????1??1?1??2011?1003?0?24????1000[12]001  
01110010010?220001001210?2301121[12]0?51??10??1?0?0?11001?0?100021?0?3110101  
00001?210101012100?1?00?01??11?003??1?2?101?100?????11[12]01?0001110?0010??

011?110101011?0000001?

Gansus ?????????????????????????????????????????121?1?201110040010  
24?2021000?1101110010020?320??0012100230210100?10?11001??010130?1??01001110011  
1?0?312?01110001?13101001321?001110101011210003001[12]?1101?100[12]2?0?0?2112011  
10010102?020000011??001?10110?01000?

Ichthyornis

21[12]???0?????????11111?1111?01001??1002101111[01]11012011120?[34]?0102401021  
000??101111010010?2210110012?002300??1212?01100110010120210?101000110021101?31  
2101210100103111????310?01011?1101121?11?101221101?10022110?2112011202?01?2102  
00000?????10101001?1????0

Hesperornis

11231103?1021011?11111000111?1?10100??100010101?02100121112004010?130202100010?  
0?01?00?0010?020??000200?21?0?0011?00?0????0?????1000000????????????????????????????  
?????????10001211011100121011310212201110122111121120112?21013223220102?????  
??01?020?0?0?0

Parahesperornis

1123????0?10??1?111??00111????01????1?????1?02100121111200????1?????10001??0?0  
1?0?0010?0?????????2?????1????????????????????????????????????????????????????????  
?????????????????????????102122011101221111????1201??2101?223220002?????????????2  
0?0?0??

Enaliornis ??????????????????????????11?????????????????????21?0?0?1????2?????????  
????????????????????????????????????????????????????????????????????????????????????  
?????????????????1?????1?????2?????1012212011101221111????1201??1101??0120000???  
?????????02???????

Baptornis\_advenus

1??3?????????????11??00?111?????0?0?1?0?101?021001?11112004010?13020?100011?00  
01?0010010?0?????0?????2[12]????0112?0?????????1000000????00000100?????????????  
?????????01000121101110012101131011212011101221111211201?2?1101322112001?????  
?????02???????

Baptornis\_varneri ??????????????????????????????????????????????021?01?1?1?1?????????  
????????????????????????????????????????????????????????????????????????????????????  
?????????????????10????1???1100?21013????2201?101221111211201?2?1101?221220001??  
?????????2???????

Vegavis ??????????????????????????????????????????2????????????[56]???  
?????????????1011?00?001??[01]20?00?????????????????1?0?????????????????????????????  
?????????????????01??1????01??2?????0112110??1?02??2?1????12011??3?1????1?  
??0?????10?01???????????

Anas

2123011310111111111111112112111?102100001011?10211012111000601202402021000201  
101111010020?220100001210023111001134011100111100030111101000010011101231201321  
11111031011??12311011110101112101131011211011100222011121120112013013210220000  
101110101121010100010

Gallus

1123111311121111111111112112111?102000001011?102110121111001601202402021000201

121111010020?22110000121012311010112201110011100030111111000110011101131201321  
02101131011??121101121101101112101131011211011100222011121120112013013220120100  
101110101121010100010  
Fortunguavis ??????0?????????????????????????????00????0????0?110200??1?000??02  
[34]??0??110?0111101001110020???0111122??2??1??300000?10000??1??0001?1??11?????  
112211000001001012001000?120?????????01011110012?0????????1??10???1?110010010000?  
0?02?100011??11?10?1?1100111  
Qiliania ??????????????????????????????????????????????????????????????????????????????????  
?????????????????????????????????????????????????????????????????????????????????????????????  
????????????????10????00?10101?2?0003?0??11100?00?11000?11100?001001?11?[01]?20?0?  
1[01]?????????1?120021?  
Shenqiornis  
[01]0101102?????0?????0?1?????000??000??1?1?11?0?01??11?????0?????01?  
11?0?01?[12]??010101??011?[23]2[123]?[12][12]3?1??20??01101?000?????1??11?????  
01??001010010120010101130000?????01?111??01?????????0?????????0?1011??0???[01]  
]?0?0?1??[12]111211[12]01??2?0?21  
Sulcavis  
[01]010?0?????????????0?????000??0?0?0????1?????11?????11?[12]????24?1010110??  
01?????0?010[12]??0[01]0001?0?1113[12][123]?????????01?????010?????????1??11??[01]???  
0?[02]1??0[01][01]0?00?0120010101120?00?[01]?????????[12]10?????????0?00?0?01??110  
010010??0[123]??0101?0011??11211[12]011110012?  
Bohaiornis ?0[12]01102?0?????????0?????1000??000??0011????1?120?1?110[0  
123]????24000?01101?011110?01020?0[01]0101?0?11122[123]?21311??30?001??100001?10?0  
?011??11?????10?0110000010010120010101230000?????01011[12]??000?0?1?????0?0?0?0?  
10?1100100100?01?[01]0101?0?11??1012102111000121  
Parabohaiornis  
[01]0201102?0?????????????000??000??0??1??01??200??110[12]01?124??0?01101  
101?11102?01?11?010101?0111132[123]?20311?345]30?001??10000101010001110111?????10?0  
1??000010010120010101230000??0?0101011[12]1100000?????0?0?00?00010?100010010??01  
200101?0?11??11121021110022?  
Longusunguis ?0[12]01?02?0?????????????000??000??01?1??[12]?1??20??111  
0[123]????24?00?0110?0111101020??010001?0111?32[123]????1??[23]00001??10000??10?  
00011??11?????10?01??0000100101?00101012200?????01011[12]??000?????1?100?0?00?00  
010?100?1??000?1??010100?1????112102011?100221  
Zhouornis  
[01]0101?01?0?????????????0??1000??000??0??11?[12]?1??20??110?????24??0??1?0??  
011111010101??020101?0111132[123]?2?3110??0?000??10000??10?00011??11?????10?31??00  
0010010120010101220000?????????0[12]??00000??1?1?0?1?00?0?01??110010010??01??0101  
?0?11??11121?201110012?  
Piscivoravis ??????????????????1????111?[01]?????????0?????0??12110110111210[34]  
?????24020??0001101?11?0??0????[23]20????0121002301221??51?0?0????1???0?????1?0?11  
?????0?31??00011000102101010112101010?????0101121003?01121?01?10?22?????1?1120111  
00[01]1?02001100001011001?01??0001000?  
Hongshanornis ?020?10?????????1?????????????00??101?0?????????????1?????????

4??????01?0101110010????[01]211?0?0121?12??2201[12]?210?110?????10?????2????0????11???  
?????31?200?0?00?02100010101?????????0?01[12]????3?????????0?[12]?????1120?0?0  
0?0?0?0200?00111100101011001100001  
**Longicrusavis**  
10[12]01?0?????????????????????00??101??01????11?11?0?20?????????????????10  
11100?????12]21100?01210?23?120110?10?110?01?11012021100010001100??0?31110?200  
010102100010101?????1??[12]?0?????????01?10022[01]121?1112011100??10100100?  
0011?0010101100110000?  
**Archaeornithura** ?????????????????????????????????????????????????????????[23]?0?[12]4??1110001?0101110010110?221100?0?2101230[12]?111?????0??10010??02????0100????  
?????0??[23]1??0[12]?0?000?02100010101?0?????01001[12]??03????2??0??1?0?????2?0?111  
0?1?01??[01]?0100?001111?0101011?01100001  
**Parahongshanornis** ?????????????????????????????????????????????1?1????????????????????  
?????????1????0?10????[01]211??201210123022011??10??10??1?010?0?0????01???11????????  
31?01?0?000102100010101?0?????10??[12]?003?????0????00?????1??11?0?????1?0  
100?0011??001?1011?0110000?  
**Tianyuornis**  
1020??0?????????????????????000??01??01?1?????????????4????????11?10??  
0?10?????2?????1210123?22111??10?1100??010?0?????01?0?11????????[23]1??0?0?00010  
2100010101?????????????????????????1??[12]?12??111011?01??[01]?01?0?0?11?00  
1?011?0110000?  
**STM9\_9** ??????????????????????????????????????????00????????[01]  
]??????00?????0?0????000??2000?????0001?00010?00?0?01?0?10??  
?000?21?00000010001001????[01]30?????????????0?[12]?000?111?0????1?001?00?1100000  
000002?0100?001????00?1?[01]111?10001?

## 8. Supplementary References

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