## 1. Phylogenetic Nomenclature

We adopt the following definitions for the major theropod groups used in this paper:

Coelophysoidea, the most inclusive clade including *Coelophysis bauri* but not Neornithes.

Ceratosauria, the most inclusive clade including *Ceratosaurus nasicornis* but not Neornithes.

Tetanurae, the most inclusive clade including Neornithes but not *Ceratosaurus nasicornis*

Maniraptora, the most inclusive clade including Neornithes but not *Ornithomimus edmontonicus*

Tyrannosauroidea, the most inclusive clade including *Tyrannosaurus rex* but not Neornithes

Compsognathidae, the most inclusive clade including *Compsognathus longipes* but not Neornithes

Ornithomimosauria, the most inclusive clade including *Ornithomimus edmontonicus* but not *Alvarezsaurus calvoi*

Alvarezsauroidea, the most inclusive clade including *Alvarezsaurus calvoi* but not Neornithes and *Ornithomimus edmontonicus*.

Therizinosauroidea, the most inclusive clade including *Therizinosaurus cheloniformis* but not *Oviraptor philoceratops* and *Ornithomimus edmontonicus*.

Oviraptorosauria, the most inclusive clade including *Oviraptor philoceratops* but not Neornithes and *Therizinosaurus cheloniformis*.

Troodontidae, the most inclusive clade including *Troodon formosus* but not *Deinonychus antirrhopus* and Neornithes.

Dromaeosauridae, the most inclusive clade including *Deinonychus antirrhopus* but not *Troodon formosus* and Neornithes.

Scansoriopterygidae, the least inclusive clade including *Epidendrosaurus* and *Epidexipteryx*.

Avialae, the most inclusive clade including Neornithes but not *Deinonychus antirrhopus* and *Troodon formosus*.

Aves, the least inclusive clade including *Archaeopteryx* and Neornithes.

## 2. **Geological setting**

The *Anchiornis huxleyi* holotype is an incomplete skeleton, and was stated in the original report to be from lacustrine deposits of uncertain Jurassic-Cretaceous age at the Yaolugou locality, Jianchang County, western Liaoning Province, China, Liaoning[1]. LPM-B00169 preserves a nearly complete skeleton and extensive plumage (Figs. 1a and S1). It was collected by a local farmer from the Tiaojishan Formation at the Daxishan locality in the same county and was acquried by the expedition team of the Shenyang Normal University when the team was excavating at Yaolugou locality, Jianchang County. Two of us (D. Y. Hu and L. J. Zhang) then visited the quarry that produced LPM0B00169. We compared, in detail, the slabs containing LPM-B00169 and the sediments in the quarry and positively identified the layer that produced the specimen. Later, we excavated in this quarry and collected a number of fossils including two ptycholepid fish specimens and a second *Anchiornis* specimen, which is in preparation now. The geology of Jianchang County is complicated. The Jurassic Tiaojishan Formation is exposed at several different sites, as is the Early Cretaceous Jehol Group, which is now famous for numerous discoveries of feathered dinosaur specimens. Because the *A. huxleyi* holotype was collected by local farmers, its provenance (locality and horizon) remains to be confirmed. It is likely that the-*Anchiornis*-*huxleyi*-holotype-bearing beds are referable to the Tiaojishan Formation, but further work is needed to confirm this. The lacustrine deposits of the Tiaojishan Formation resemble the Jehol Group in being rich in tuff[2], but their fossil fauna is very different from the Jehol fauna.

Besides *A. huxleyi*, the only vertebrate that has been recovered from the lacustrine deposits from Daxishan is fish (Ptycholepidae indet). Ptycholepidae is a group of palaeonisciform fish known mainly from the Triassic. The youngest previously known ptycholepids are from early Middle Jurassic sediments in western China (for example, *Yuchoulepis* from the Middle Jurassic Lower Shaximiao Formation of Sichuan[3] and the Yaojie Formation of Gansu[4]).

Associated invertebrate fossils include the conchostracan *Euestheria* sp., the ostracodans *Darwinula sarytirmenensis*, *D. impudica*, and *D. magna*, the bivalve *Shaanxiconcha cliovata*, and insects (Aeschnoidae indet.). *Euestheria* is widely distributed in the early-middle Middle Jurassic sediments of China[5], and the *Darwinula sarytirmenensis-magna* assemblage is the most widespread Middle Jurassic ostracode assemblage[6]. *Shaanxiconcha* is a common element in the Late Triassic of northern China, although it has also been rocoreded Middle Triassic and Early Jurassic sediments[7]. Aeschnoidae is a primitive taxon restricted to the Jurassic. In agreement with the vertebrates, the invertebrate fossils suggest a Middle Jurassic age for the fossil-bearing beds.

Plant fossils including *Neocalamites nathorsti* and *Coniopteris margaretae* have also been recovered from the Daxishan beds. *Neocalamites* is known from the Triassic through Middle Jurassic and *Coniopteris margaretae* is a Middle Jurassic species known in China and Yorkshire, UK[6, 8]. These elements also support a Middle Jurassic age.

Taken together, the invertebrate and plant fossils associated with *Anchiornis* at the Daxishan locality are closely comparable to fossils recovered from the Middle Jurassic Haifanggou Formation exposed at other localities in western Liaoning and the overlying Tiaojishan Formation[9].

The Haifanggou Formation is a series of sandstones and shales with interbedded tuffs, and the

Tiaojishan Formation is a series of volcanic rocks intercalated with tuffaceous sandstones and ignimbrites. Given that the fossil-bearing beds at Daxishan are intercalated with volcanic rocks, we assign them to the Tiaojishan Formation. Although the Tiaojishan Formation has traditionally been considered to be Middle Jurassic, some recent isotopic dating indicates that it probably dates from 161 to 151 Ma[9]. The fossil-bearing beds are thus inferred to be earliest Late Jurassic (Oxfordian) in age.

Two other Jurassic fossil beds that have produced unquestionable feathered dinosaur specimens are the *Archaeopteryx*-bearing strata near Solnhofen, Germany and the Daohugou Formation of Ningcheng, Inner Mongolia, China[10, 11]. The Solnhofen beds date to less than 150 Ma[12] and are therefore younger than the Tiaojishan Formation. The geological age of the Daohugou Formation is controversial. Some isotopic studies have proposed ages of between 164 and 158 Ma for the formation[13], but other studies have disputed these ages by questioning the relationship between the dated samples and the fossil-bearing beds[14]. *Anchiornis* thus represents the only feathered species unquestionably older than *Archaeopteryx lithographica*[12].

3. **Identification of LPM-B00169**

LPM-B00169 preserves a nearly complete skull, which is absent in the *Anchiornis huxleyi* holotype (Figs. S1 and S2). Postcranial elements present in both LPM-B00169 and the *A. huxleyi* holotype are almost morphologically identical in the two specimens. Diagnostic features of *A. huxleyi* include extreme shortness of the ischium and a sculpturing pattern of numerous small pits on the ventral surface of the coracoid[1]. The coracoid of LPM-B00169 is similar to that of the *A. huxleyi* holotype in general morphology, but its ventral surface is not exposed and cannot be checked for the diagnostic pitting. The ischium of LPM-B00169 is extremely short, only 28% of the femoral length, which is similar to the condition in the *A. huxleyi* holotype. The other possibly diagnostic feature of *A. huxleyi* is the extremely elongated tibiotarsus, which measures about 150% of the femoral length, substantially longer in proportional terms than in any other known non-avian theropod or basal avian[15]. LPM-B00169 apparently possesses this feature.

The vertebrae of LPM-B00169 and the *A. huxleyi* holotype are identical, so far as their morphology can be compared (Figs. S3). Distinctive features seen in both specimens include: middle and posterior dorsal vertebrae elongated (a feature also seen in basal dromaeosaurs and *Archaeopteryx*[16]), anteriormost caudal vertebrae significantly shortened (again, as in basal dromaeosaurs and *Archaeopteryx*[16]), transverse processes of the anteriormost caudals posterolaterally orientated, longer than the corresponding centra, and proportionally slender, zygapophyses of the middle and posterior caudals reduced (a feature also seen in basal birds), and middle chevrons dorsoventrally flattened, ventrally curved, and plate-like, with posterior processes apparently longer than the anterior processes.

Neither specimen preserves an ossified sternum, or uncinate processes. The furcula is identical in LPM-B00169 and the *A. huxleyi* holotype, being similar in both cases to the furcula of *Archaeopteryx* but more slender and characterized by a slightly larger interclavicular angle. Both specimens display a short, slender scapula, though in LPM-B00169 the acromion process of the scapula is more prominent than in the holotype. The forelimbs of both specimens are also identical in morphology. The humerus is long and thick, with a short deltopectoral crest (about one-fourth of the humeral length). The ulna shows little posterior curvature and is only slightly thicker than the radius. These features are also seen in other basal troodontids, but stand in contrast to dromaeosaurs and basal avialans, in which the ulna is considerably bowed posteriorly and is much thicker than the radius[16]. Both specimens exhibit a proportionally large radiale and a significantly elongated manus (Fig. S4a). Metacarpal III is relatively straight in both specimens, another feature also seen in other basal troodontids. In basal dromaeosaurs and avialans, metacarpal III is considerably bowed laterally. Manual phalanx II-1 is much thicker than all of the other manual phalanges, and indeed nearly as thick as the ulna in each of the two specimens. The relative lengths and thicknesses of the manual elements are nearly identical in both specimens. The only major difference is the size and location of the semilunate carpal. In the holotype, the semilunate is small and mainly covers the proximal ends of metacarpals II and III; in LPM-B00169, it covers the proximal ends of all three metacarpals. However, this difference might be a preservational artifact. In LPM-B00169, the main body of the semilunate carpal is centred on metacarpal II, and only a dorsoventrally thin dorsomedial process contacts the dorsal margin of the proximal articular surface of metacarpal I. In the holotype, the dorsomedial process is inferred to be broken, so that the semilunate carpal remains in contact only with the lateral part of the metacarpus.

The two specimens are also identical in pelvic morphology (Figs. S4b, c). Each has a small ilium with a slightly concave anterior margin, an anteroventral process, a distinct supra-acetabular crest, an anteroventrally oriented pubic peduncle, and a postacetabular process that tapers posteriorly and curves ventrally. The ischium has a posteriorly curved, distally tapering shaft with an obturator process located near the midpoint of its length.

LPM-B00169 resembles the *A. huxleyi* holotype in hind limb morphology. Both specimens have an extremely elongate hind limb, and particularly a long lower leg (the tibiotarsus measures about 150% of the femoral length). In both cases the distal half of the femur is much thicker than the proximal half, and pedal digit II shows incipient specializations of the kind seen in some dromaeosaurs (Fig. S4d).

In summary, the overlapping elements of LPM-B00169 and the *A. huxleyi* holotype are nearly identical in their observable morphological features. We scored LPM-B00169 and *A. huxleyi* holotype separately into a dataset from a recently published analysis of coelurosaurian phylogeny[11] (see below for the scorings and complete character list) and the scorings are the same where they are able to be coded in both specimens. Although there are some proportional differences between these two specimens, such differences are expected considering that LPM-B00169 and the *A. huxleyi* holotype are significantly different in size (the femur of the former specimen is about 160% as long as that of the latter). Furthermore, these proportional differences fit the allometric pattern seen in most other small theropod dinosaurs[15, 17-19]. Consequently, LPM-B00169 can be safely referred to *A. huxleyi*.

Scorings for LPM-B00169 and *A. huxleyi* holotype

LPM-B00169
001100?????????????11010??111?00?????0?2?000??1????1?1??????????-000??01??1?????00020
--01??0?101??-00?0??010?01???01101210??011----011031110000??1000000010?21?100110220
0?1?112112???1?1?000??1?01?000121100010?1000?1??00?0???0????030110?1101000100100?0
1?0???0-0?011111101?0001112011010100010101001110010102001011?1011000?20?110000100
0?121000?00000110101?0??0000000
*Anchiornis_huxleyi*_holotype
??????????????????????????????????????????????????????????????????????????????????????
?????0???-00????0?0??????0110?210??01?----011031110000?????0000010?21?1?0???220??1?1?
?????????1?000??1?01?000121100010??00??????0?0?????????????????????????????????????????
?11111101??0011120110101000101010011100101??001?1??101100??20?11000010???121000?0
0?00??0101?????000?0?


Figure S1. Photograph of LPM-B00169 B (counter slab)

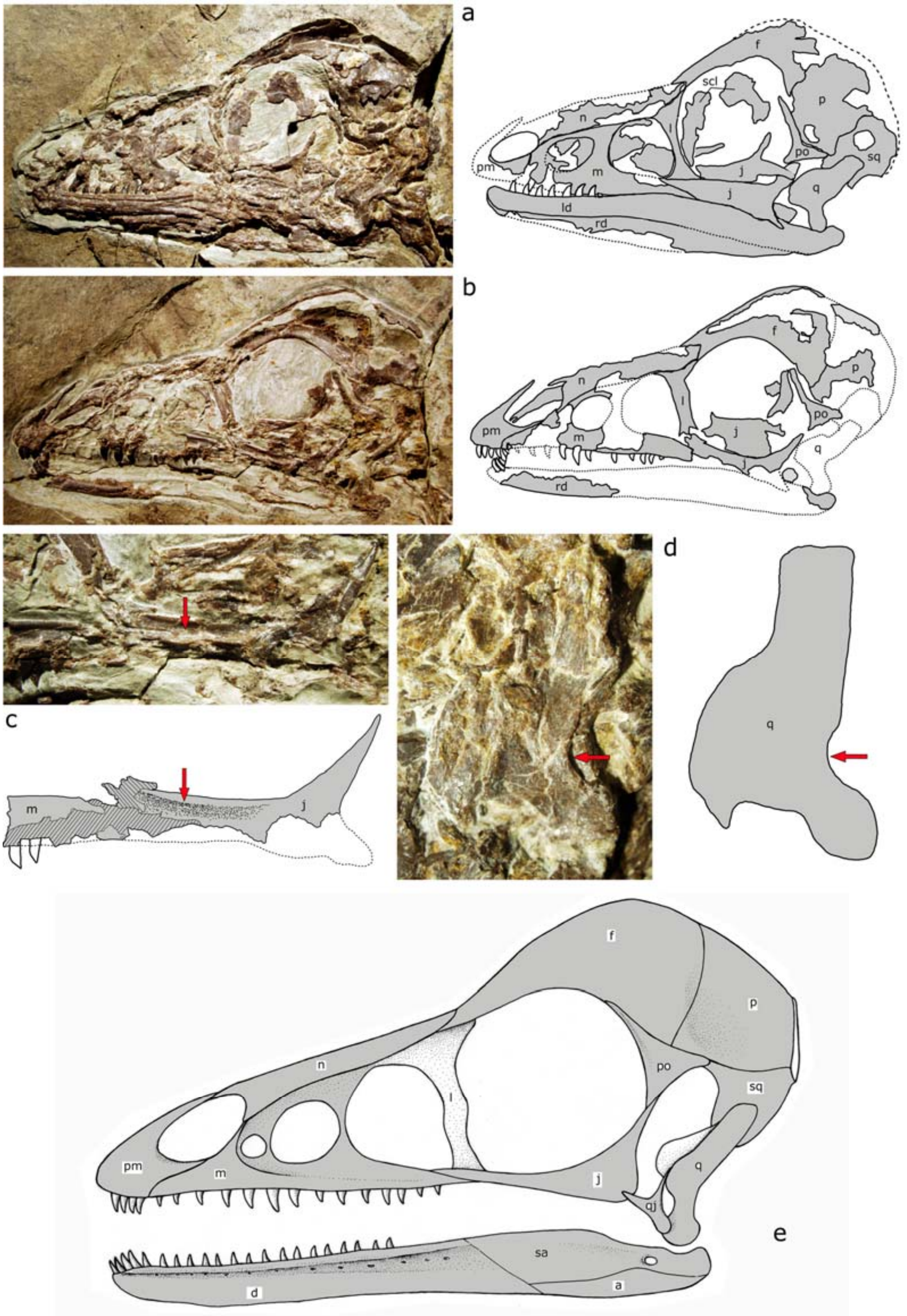


Figure S2. Cranial elements of LPM-B00169. **a**, Skull and mandible in lateral view (slab). **b**, Skull and mandible in lateral view (counter slab). **c**, Left jugal in dorsomedial view. Arrow points to a groove along the dorsomedial margin. **d**, Left quadrate in anterolateral view. Arrow points to the significantly notched lateral margin, which contributes to the formation of the large paraquadrate foramen. **e**, Reconstructed skull and mandible in lateral view.

Figure S3. Selected axial elements of LPM-B00169. **a**, Middle cervical vertebrae in lateral view. **b**, Anterior dorsal vertebrae in dorsal view. **c**, Middle dorsal vertebrae vertebrae in lateral view. **d**, Sacral vertebrae in dorsal view. **e**, Anterior caudal vertebrae in lateral view. **f**, Anteromiddle caudal vertebrae in lateral view. **g**, Middle caudal vertebrae in lateral view.

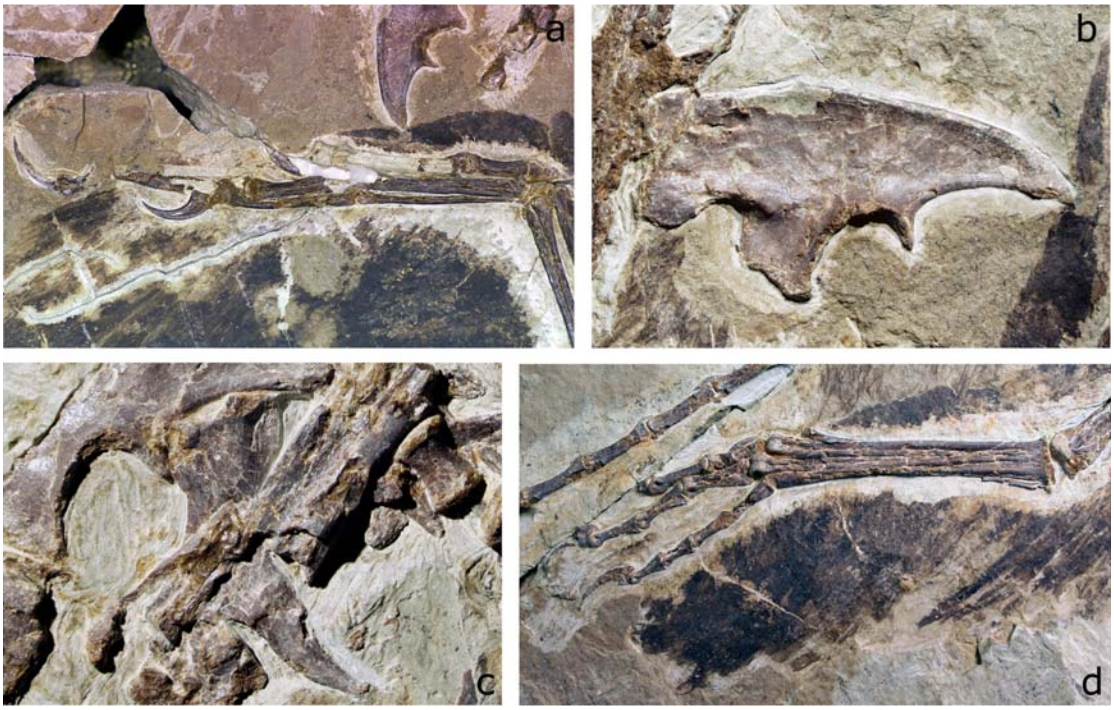


Figure S4. Selected appendicular elements of LPM-B00169. **a**, Left manus in dorsal view. **b**, Right ilium in lateral view. **c**, Left ischium in lateral view. d, Left pes in dorsal view.

## 4. Major morphological features of *Anchiornis huxleyi*

In the original description of *Anchiornis huxleyi*, Xu *et al*. placed this taxon within the Avialae based on postcranial morphology (the holotype preserves no cranial material), but noted many derived features of the postcranial skeleton that appeared to be shared with the Troodontidae[1]. New information from LPM-B00169 reveals additional troodontid synapomorphies that are sufficient to place *A. huxleyi* unequivocally within this clade. Below we summarize various features that are informative as to the systematic position of *A. huxleyi*.

*A. huxleyi* is clearly a maniraptoran theropod based on the presence of many maniraptoran synapomorphies (Figs. S2-4), including anterior process of jugal tapering anteriorly, postaxial cervical centra with weakly convex or flat anterior faces, fewer than 35 caudal vertebrae, posterior chevron blades anteroposteriorly elongated, coracoid longer than high, internal tuberosity of humerus rectangular, olecranon process of ulna weak, semilunate carpal large, manual phalanx III-3 significantly elongated, manual unguals each bearing a dorsal lip on the proximal articular facet, iliac postacetabular process half-crescentic, pubic boot expanded only in the posterior direction, obturator process of ischium located relatively distally, fourth trochanter of femur absent, fibular shaft narrowing abruptly below the iliofibularis tubercle, and metatarsal V strongly reduced and rod-like[16, 20-24].

*A. huxleyi* can be referred to the Paraves based on the following derived features (Figs. S2-4): lacrimal T-shaped, postorbital frontal process anterodorsally orientated, trunk short relative to femur, ten or fewer caudal vertebrae bear transverse processes, ten or fewer caudal vertebrae bear neural spines, anterior caudal vertebrae box-like, middle caudal vertebrae significantly elongated, scapular blade with a relatively narrow distal end, coracoid rectangular in outline, distal medial condyle of metacarpal II larger than distal lateral condyle, flexor tubercle of each manual ungual more than half the articular facet height, ilium with pubic peduncle much larger than ischial peduncle, short ischium, ischial shaft strap-like, ischium with marginal symphyseal region, femur with posterior trochanter, distal end of metatarsal III ginglymoidal, metatarsals III and IV with expanded distal condyles, and pedal digit II with apparently huperextensible claw[16, 21, 22, 24].

Among the paravians, *Anchiornis* resembles other troodontids in possessing the following derived features: large maxillary fenestra separated from antorbital fenestra by a narrow interfenestral bar, internarial bar dorsoventrally flattened, labial surface of dentary bears a distinct, posteriorly widening groove housing neurovascular foramina, closely packed premaxillary and dentary teeth in the symphyseal region (Fig. S2), and dorsal vertebrae and anteriormost caudal vertebrae bear relatively long and slender transverse processes (in dromaeosaurs and basal avialans, the transverse processes of the anteriormost caudal vertebrae are laterally orientated, shorter than the corresponding centra, and proportionally wide; in dromaeosaurs the transverse processes are actually expanded distally in a fan-like configuration)[25-28].

*Anchiornis* also shares many features with the basal troodontid *Mei*, some of which are not seen in other paravians and therefore provide further evidence for the referral of *Anchiornis* to the Troodontidae. These features include large external naris extending posteriorly well beyond anterior border of antorbital fossa[26], longitudinal groove along dorsomedial margin of slender sub-orbital ramus of jugal, un-serrated teeth (also seen in the troodontid *Byronosaurus*[25]), maxillary tooth row approaching preorbital bar posteriorly, and distal articular surface of metatarsal II about as wide as that of metatarsal III (also seen in some dromaeosaurs[29]).

As a Jurassic basal troodontid, *A. huxleyi* differs from other troodontids in many features, most of which are also seen in basal dromaeosaurs and basal avialans. The most salient difference between *A. huxleyi* and other troodontids is the relative length and robustness of the forelimb. All previously known troodontids have relatively short and slender forelimbs, in stark contrast to basal avialans and basal dromaeosaurs. In the latter two groups the forelimbs are significantly elongated and thickened, a feature that might be related to aerodynamic capability. In this respect, *A. huxleyi* is more similar to basal avialans and basal dromaeosaurs than other troodontids. Unlike other troodontids but in agreement with basal birds, the middle and posterior teeth of *Anchiornis* are relatively sparsely distributed. As in *Archaeopteryx*, the middle and posterior caudal vertebrae each bear a distinct groove on the lateral surface near the junction of the neural arch and centrum[12], and the coracoid bears a laterally located coracoid tubercle and a large fossa lateral to the tubercle. *A. huxleyi* also shares several derived similarities with certain dromaeosaurs, including a relatively large paraquadrate foramen and a femur whose distal half is much thicker than the proximal half (as in *Buitreraptor* and *Rahonavis*). *Anchiornis* also resembles dromaeosaurs in some pelvic features.

In summary, *A. huxleyi* can be safely referred to the Paraves based on numerous derived features. Among the paravians, *A. huxleyi* shares with the Troodontidae or with individual troodontid taxa (particularly *Mei*) many derived similarities, including some salient ones such as a distinct groove that widens posteriorly and contains mandibular neurovascular foramina[25, 27]. Although *A. huxleyi* resembles the Avialae and/or Dromaesauridae in several unique features, the derived similarities shared with other troodontids far outnumber those shared with the Avialae or Dromaeosauridae. Further more, *A. huxleyi* differs from the Dromaeosauridae in lacking the following dromaeosaurid synapomorphies: anterior emargination of supratemporal fossa on frontal strongly sinusoidal and reaching onto postorbital process, parapophyses of posterior trunk vertebrae distinctly projected on pedicels, distal caudal chevrons bifurcate at both ends, lateral face of ischial shaft flat with longitudinal ridge dividing lateral surface into anterior and posterior parts, and pedal phalanx II-1 shorter than pedal phalanx IV-1, among others. Also, *A. huxleyi is* different from the Avialae in lacking the following avialan synapomorphies: lateral border of quadrate shaft straight, dentary and maxillary teeth large, proximal end of chevrons of proximal caudals elongate anteroposteriorly, flattened and plate-like, ossified sternal plates fused, preacetabular portion of ilium markedly longe than postacetabular part, metatarsals co-ossified proximally, humeral longer than femur, reversed hallux, hallux large in size, and pedal phalanx II-2 longer than II-1, among others. Consequently, *A. huxleyi* is here referred to the Troodontidae, a systematic hypothesis also supported by our numeric phylogenetic analysis (see below).

The original referral of *A. huxleyi* to the Avialae was published recently (published online in late 2008). The report was already in press when we started the research on LPM-B00169, which led to a different systematic referral for this taxon. However, the present research includes more comprehensive data than the original report, making the systematic hypothesis offered here for *A. huxleyi* more reliable.

## 5. Measurements of LPM-B00169

Selected measurements (in mm) of **LPM-B00169**

| | |
|---|---|
| Skull length | 63.7 |
| Mandible length | 53.8 |
| Snout length | 30.5 |
| Antorbital fossa maximum diameter | 9.9 |
| Maxillary fenestra maximum diameter | 6.6 |
| Cervical series length | 66.8 |
| Dorsal series length | 85.4 |
| Sacral series length | 31.0 |
| Anterior caudal vertebra length (?C1) | 5.2 |
| Middle caudal vertebra length (?C13) | 14.2 |
| Posterior caudal vertebra length (?C18) | 13.5 |
| Scapula length | 45.2 |
| Humerus length | 69.0 |
| Ulna length | 55.1 |
| Radius length | 54.0 |
| Manus length (including carpals and ungual) | 103.0 |
| Metacarpal I length | 12.4 |
| Metacarpal II length | 33.9 |
| Metacarpal III length | 30.5 |
| Manual phalanx I-1 | 26.2 |
| Manual phalanx I-2 | 15.6 |
| Manual phalanx II-1 | 21.0 |
| Manual phalanx II-2 | 27.0 |
| Manual phalanx II-3 | 20.2 |
| Manual phalanx III-1 | 7.2 |
| Manual phalanx III-2 | 8.1 |
| Manual phalanx III-3 | 14.2 |
| Manual phalanx III-4 | 13.8 |
| Ilium length | 37.4 |
| Pubis length | 61.4 |
| Ischium length | 22.4 |
| Hindlimb length | 275.8 |
| Femur length | 66.2 |
| Tibiotarsus length | 106.4 |
| Pes length | 103.2 |
| Metatarsal I length | 11.1 |
| Metatarsal II length | 51.2 |
| Metatarsal III length | 55.2 |
| Metatarsal IV length | 51.9 |
| Metatarsal V length | 19.2 |
| Pedal phalanx I-1 length | ? |
| Pedal phalanx I-2 length | ? |

| | |
|---|---|
| Pedal phalanx II-1 length | 11.5 |
| Pedal phalanx II-2 lengtg | 12.2 |
| Pedal phalanx II-3 length | 14.9 |
| Pedal phalanx III-1 length | 12.9 |
| Pedal phalanx III-2 length | 11.1 |
| Pedal phalanx III-3 length | 10.5 |
| Pedal phalanx III-4 length | 13.7 |
| Pedal phalanx IV-1 length | 10.8 |
| Pedal phalanx IV-2 length | 8.8 |
| Pedal phalanx IV-3 length | 7.0 |
| Pedal phalanx IV-4 length | 7.6 |
| Pedal phalanx IV-5 length | 13.5 |

## 6. First appearances of major theropod groups

The earliest known records of major theropod groups are described briefly below:

Coelophysoidea: The earliest known unquestionable coelophysoid taxon is *Coelophysis bauri*, from late Carnian-late Norian deposits in North America. Some fragmentary specimens from European strata of the same age have also been referred to the group[30].

Ceratosauria: The earliest known unquestionable ceratosaur taxon is the Pliensbachian-Toarcian *Berberosaurus liassicus*[31] from Morocco.

Basal Tetanurae: The earliest uncontroversial tetanuran record comes from the Aalenian-Bajocian of Europe (*Magnosaurus*)[32]. Although the Sinemurian-Pliensbachian *Cryolophosaurus* and the Norian *Zupaysaurus* have been referred to the Tetanurae, both referrals have been questioned by later studies[33, 34]. A partial theropod skeleton recovered from the Sinemurian of northern Italy has also been referred to the Tetanurae, but has not been formally named and described[35].

Tyrannosauroidea: The earliest known unquestionable tyrannosaur is the Oxfordian *Guanlong wucaii*[36] from Xinjiang, China.

Compsognathidae: The earliest known compsognathid is the Kimmeridgian *Compsognathus longipes*, from Europe[37].

Ornithomimosauria: The earliest known unquestionable ornithomimosaur is the Valangian-Barremian *Shenzhousaurus orientalis*[38, 39] from Liaoning, China.

Alvarezsauroidea: The earliest known alvarezsaur taxon is *Patagonykus* from the Late Cretaceous (Turonian) of Argentina, South America[40].

Therizinosauroidea: The earliest known unquestionable therizinosaurs are the Valangian-Barremian *Beipiaosaurus*[39, 41] from Liaoning, China and the Barremian *Falcarius* from North America[42]. Although the Hettangian *Eshanosaurus* has been referred to the Therizinosauroidea, this taxon is based on a very fragmentary specimen and its suggested therizinosauroid affinities require confirmation on the basis of additional material.

Oviraptorosauria: The earliest known unquestionable oviraptorosaur is the Valangian-Barremian *Incisivosaurus*[39, 43] from Liaoning, China.

Dromaeosauridae: The earliest known unquestionable dromaeosaurid is the Valangian-Barremian *Graciliraptor*[29, 39] from Liaoning, China. Some isolated teeth from the Middle Jurassic of Europe have been referred to the group.

Scansoriopterygidae: the Scansoriopterygidae contains only two genera, *Epidendrosaurus*[44] and *Epidexipteryx*[9]. Both are from the Daohugou Formation of Inner Mongolia, China, which also produced the basal avialan *Pedopenna*[45]. Although the Daohugou Formation is likely to be Middle to Late Jurassic (Bathonian-Kimmeridgian) in age[46], this interpretation has been questioned[47].

## 7. Phylogenetic analysis

We coded *Anchiornis huxleyi* into a dataset from a recently published analysis of coelurosaurian phylogeny[11] (see below for complete character list and scorings). The data matrix was analyzed using the NONA (ver 2.0) software package[48], and formatting and character exploration were performed in WinClada[49]. The analysis protocol consisted of 1000 Tree Bisection and Regrafting tree searches followed by branch swapping. Settings included collapsing unsupported branches and counting all states in polymorphic codings. Other settings, including character ordering, follow Zhang et al. 2008. The analysis resulted in 6 equally parsimonious trees, each having a length of 1285 steps. These trees each have a CI of 0.34 and an RI of 0.74. Figure S5 (see next page) shows the strict consensus of the six trees, which places *A. huxleyi* within the Troodontidae.

Unambiguous synapomorphies for major coelurosaurian clades:

Maniraptora: 46.1, 54.1, 57.1, 102.1, 105.1, 158.1, 161.0, 173.1, 175.1, and 263.1.

Paraves: 61.1, 96.1, 137.1, 139.1, 156.1, 176.1, 184.1, 267.1, 277.2, 306.1, and 336.1

Avialae: 54.0, 85.0, 104.0, 122.1, 128.1, 155.1, 159.0, 197.1, 274.2, 317.1, 318.1, and 320.2

Deinonychosauria: 62.0, 64.0, 75.1, 76.1, 183.1, 201.1, 228.0, 302.1, 322.1, 323.1, and 333.1

Troodontidae: 7.0, 9.2, 42.0, 55.1, 89.1, 222.1, 233.1, and 335.2

Dromaeosauridae: 23.0, 43.1, 88.1, 103.1, 106.1, 123.2, 296.1, 319.1, 330.2, and 342.1.

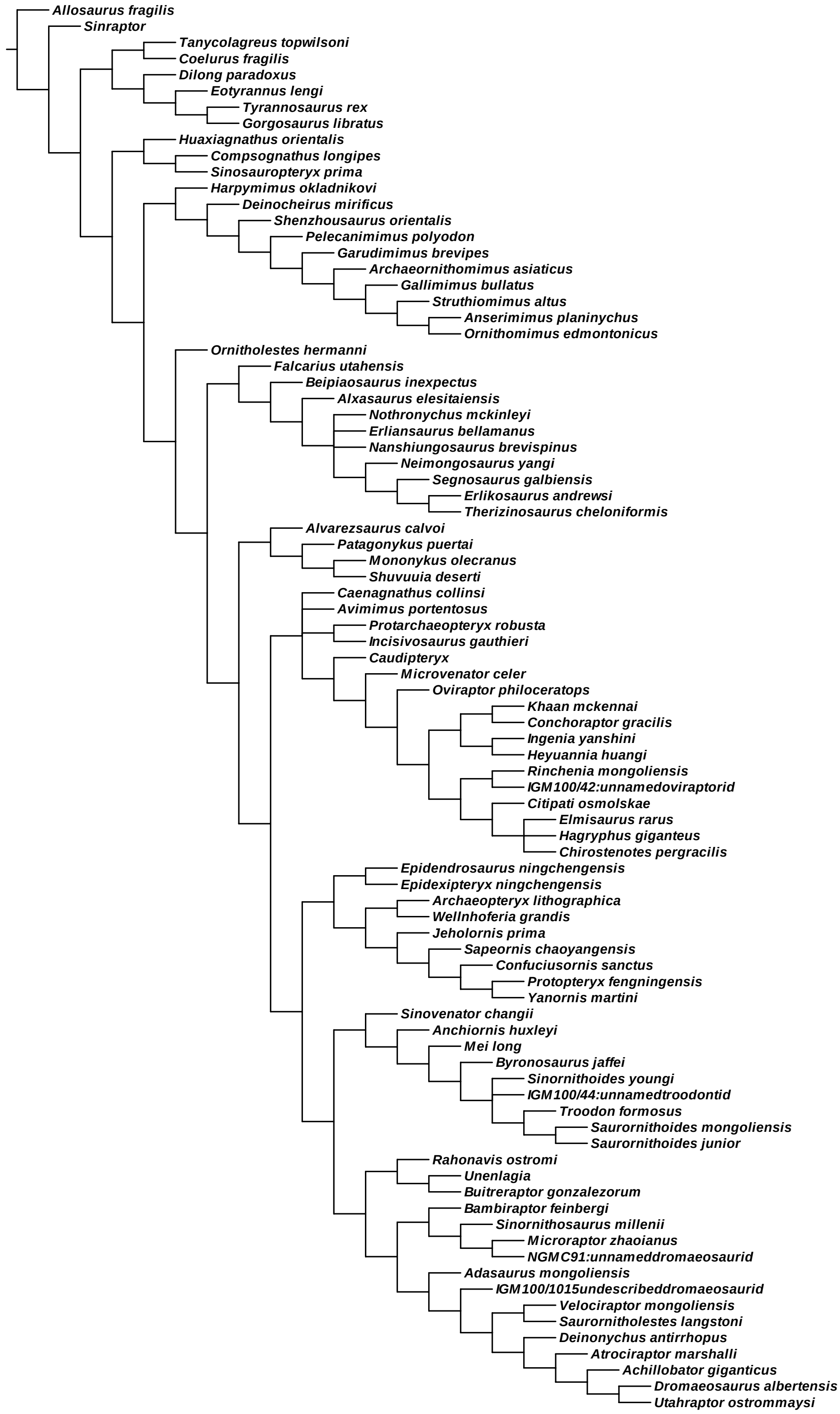


Figure S5. The strict consensus of 6 most parsimonious trees (Tree length, 1285; CI, 0.34, and RI, 0.74)

**Character list (**All characters are from Zhang *et al*. (2008).

1. Vaned feathers on forelimb symmetric (0) or asymmetric (1). The barbs on opposite sides of the rachis differ in length; in extant birds, the barbs on the leading edge of flight feathers are shorter than those on the trailing edge.
2. Orbit round in lateral or dorsolateral view (0) or dorsoventrally elongate (1). It is unclear that the eye occupied the entire orbit of those taxa in which it is keyhole shaped.
3. Anterior process of postorbital projects into orbit (0) or does not project into orbit (1).
4. Postorbital in lateral view with subhorizontal anterior (frontal) process (0) or frontal process diagonal (anterior tip of process higher than base of process) (1). [Formerly: postorbital in lateral view with straight anterior (frontal) process (0) or frontal process curves anterodorsally and dorsal border of temporal bar is dorsally concave (1)]
5. Postorbital bar parallels quadrate, lower temporal fenestra rectangular in shape (0) or jugal and postorbital approach or contact quadratojugal to constrict lower temporal fenestra (1).
6. Otosphenoidal crest vertical on basisphenoid and prootic, and does not border an enlarged pneumatic recess (0) or well developed, crescent shaped, thin crest forms anterior edge of enlarged pneumatic recess (1). This structure forms the anterior, and most distinct, border of the "lateral depression" of the middle ear region (see Currie, 1985; Currie and Zhao, 1992) of troodontids and some extant avians.
7. Crista interfenestralis confluent with lateral surface of prootic and opisthotic (0) or distinctly depressed within middle ear opening (1).
8. Subotic recess (pneumatic fossa ventral to fenestra ovalis) absent (0) or present (1)
9. Basisphenoid recess present between basisphenoid and basioccipital (0) or entirely within basisphenoid (1) or absent (2).
10. Posterior opening of basisphenoid recess single (0) or divided into two small, circular foramina by a thin bar of bone (1).
11. Base of cultriform process not highly pneumatized (0) or base of cultriform process (parasphenoid rostrum) expanded and pneumatic (parasphenoid bulla) (1).
12. Basipterygoid processes ventral or anteroventrally projecting (0) or lateroventrally projecting (1).
13. Basipterygoid processes well developed, extending as a distinct process from the base of the basisphenoid (0) or processes abbreviated or absent (1).
14. Basipterygoid processes solid (0) or processes hollow (1).
15. Basipterygoid recesses on dorsolateral surfaces of basipterygoid processes absent (0) or present (1).
16. Depression for pneumatic recess on prootic absent (0) or present as dorsally open fossa on prootic/opisthotic (1) or present as deep, posterolaterally directed concavity (2). The dorsal tympanic recess referred to here is the depression anterodorsal to the middle ear on the opisthotic, not the recess dorsal to the crista interfenestralis within the middle ear as seen in

Archaeopteryx lithographica, Shuuvuia deserti and Aves.

17. Accessory tympanic recess dorsal to crista interfenestralis absent (0) small pocket present (1) or extensive with indirect pneumatization (2). According to Witmer (1990), this structure may be an extension from the caudal tympanic recess, although it has been interpreted as the main part of the caudal tympanic recess by some authors (e.g., Walker, 1985).

18. Caudal (posterior) tympanic recess absent (0) present as opening on anterior surface of paroccipital process (1) or extends into opisthotic posterodorsal to fenestra ovalis, confluent with this fenestra (2).

19. Exits of C. N. X-XII flush with surface of exoccipital (0) or cranial nerve exits located together in a bowl-like basisphenoid depression (1).

20. Maxillary process of premaxilla contacts nasal to form posterior border of nares (0) or maxillary process reduced so that maxilla participates broadly in external naris (1) or maxillary process of premaxilla extends posteriorly to separate maxilla from nasal posterior to nares (2).

21. Internarial bar rounded (0) or flat (1).

22. Crenulate margin on buccal edge of premaxilla absent (0) or present (1).

23. Caudal margin of naris farther rostral than (0), or nearly reaching or overlapping (1), the rostral border of the antorbital fossa (Chiappe et al. 1998).

24. Premaxillary symphysis acute, V-shaped (0) or rounded, U-shaped (1).

25. Secondary palate short (0) or long, with extensive palatal shelves on maxilla (1). [Reworded according to Makovicky et al. 2005. Formerly: secondary palate formed by premaxilla only (0) or by premaxilla maxilla and vomer (1)]

26. Palatal shelf of maxilla flat (0) or with midline ventral ‘tooth-like’ projection (1)

27. Pronounced, round accessory antorbital fenestra absent (0) or present (1). A small fenestra, variously termed the accessory antorbital fenestra or maxillary fenestra, penetrates the medial wall of the antorbital fossa anterior to the antorbital fenestra in a variety of coelurosaurs and other theropods.

28. Accessory antorbital fossa situated at rostral border of antorbital fossa (0) or situated posterior to rostral border of fossa (1).

29. Tertiary antorbital fenestra (fenestra promaxillaris) absent (0) or present (1).

30. Antorbital fossa without distinct rim ventrally and anteriorly (0) or with distinct rim composed of a thin wall of bone (1). A rim is most strongly developed in the therizinosauroid Erlikosaurus andrewsi (Clark et al., 1994) but is nearly absent in ornithomimosaurs.

31. Narial region apneumatic or poorly pneumatized (0) or with extensive pneumatic fossae, especially along posterodorsal rim of fossa (1).

32. Jugal and postorbital contribute equally to postorbital bar (0) or ascending process of jugal reduced and descending process of postorbital ventrally elongate (1).

33. Jugal quadratojugal process tall beneath lower temporal fenestra, twice or more as tall

dorsoventrally as it is wide transversely (0) or rod-like (1) or concealed by quadratojugal (2). [Formerly: lacked italicised additions.] State 2 added in reference to the condition exhibited by most ornithomimosaurs.

34. Jugal pneumatic recess in posteroventral corner of antorbital fossa present (0) or absent (1).
35. Medial jugal foramen present on medial surface ventral to postorbital bar (0) or absent (1).
36. Quadratojugal without horizontal process posterior to ascending process (reversed "L" shape) (0) or with process (i.e., inverted 'T' or 'Y' shape) (1).
37. Jugal and quadratojugal separate (0) or quadratojugal and jugal fused and not distinguishable from one another (1).
38. Supraorbital crests on lacrimal in adult individuals absent (0) or dorsal crest above orbit (1) or lateral expansion anterior and dorsal to orbit (2).
39. Enlarged foramen or foramina opening laterally at the angle of the lacrimal, absent (0) or present (1).
40. Lacrimal posterodorsal [Formerly: 'anterodorsal', probably a typographical error] process absent (inverted 'L' shaped) (0) or lacrimal 'T' shaped in lateral view (1) or anterodorsal process much longer than posterior process (2) or posterodorsal process subvertical (3). [Formerly without character state 3] State 3 added in reference to the condition in oviraptorids.
41. Prefrontal large, dorsal exposure similar to that of lacrimal (0) or greatly reduced in exposure (1) or without exposure (2). [Formerly: prefrontal large, dorsal exposure similar to that of lacrimal (0) or greatly reduced in size (1) or absent (2).] State 2 reworded to recognize the finding that a prefrontal that appears to be absent is present but unexposed in some taxa.
42. Frontals narrow anteriorly as a wedge between nasals (0) or end abruptly anteriorly, suture with nasal transversely orientated (1) or suture with nasals W-shaped (2). [Formerly without character state 2]
43. Anterior emargination of supratemporal fossa on frontal straight or slightly curved (0) or strongly sinusoidal and reaching onto postorbital process (1)(Currie 1995).
44. Frontal postorbital process (dorsal view): smooth transition from orbital margin (0) or sharply demarcated from orbital margin (1), (Currie 1995).
45. Frontal edge smooth in region of lacrimal suture (0) or edge notched (1) (Currie 1995).
46. Dorsal surface of parietals flat, lateral ridge borders supratemporal fenestra (0) or parietals dorsally convex with very low sagittal crest along midline (1) or dorsally convex with well developed sagittal crest (2).
47. Parietals separate (0) or fused (1).
48. Descending process of squamosal parallels quadrate shaft (0) or nearly perpendicular to quadrate shaft (1).
49. Descending process of squamosal contacts quadratojugal (0) or does not contact quadratojugal (1).

50. Posterolateral shelf on squamosal overhanging quadrate head absent (0) or present (1).
51. Dorsal process of quadrate single headed (0) or with two distinct heads, a lateral one contacting the squamosal and a medial head contacting the braincase (1).
52. Quadrate vertical (0) or strongly inclined anteroventrally so that distal end lies far forward of proximal end (1).
53. Quadrate solid (0) or hollow, with depression on posterior surface (1).
54. Lateral border of quadrate shaft straight (0) or with lateral tab that touches squamosal and quadratojugal above an enlarged quadrate foramen (1)
55. Foramen magnum subcircular, slightly wider than tall (0) or oval, taller than wide (1). See Makovicky and Sues (1998).
56. Occipital condyle without constricted neck (0) or subspherical with constricted neck (1).
57. Paroccipital process elongate and slender, with dorsal and ventral edges nearly parallel (0) or process short, deep with convex distal end (1).
58. Paroccipital process straight, projects laterally or posterolaterally (0) or distal end curves ventrally, pendant (1).
59. Paroccipital process with straight dorsal edge (0) or with dorsal edge twisted rostrolaterally at distal end (1) (Currie 1995).
60. Ectopterygoid with constricted opening into fossa (0) or with open ventral fossa in the main body of the element (1).
61. Dorsal recess on ectopterygoid absent (0) or present (1).
62. Flange of pterygoid well developed (0) or reduced in size or absent (1).
63. Palatine and ectopterygoid separated by pterygoid (0) or contact (1) (Currie 1995).
64. Palatine tetraradiate, with jugal process (0) or palatine triradiate, jugal process absent (1).
65. Suborbital fenestra similar in length to orbit (0) or about half or less than half orbital length (1) or absent (2).[Formerly: reduced in size (less than one quarter orbital length) or absent (1)]
66. Symphyseal region of dentary broad and straight, paralleling lateral margin (0) or medially recurved slightly (1) or strongly recurved medially (2).
67. Dentary symphyseal region in line with main part of buccal edge (0) or abruptly downturned at rostral end (1) or dentary ramus gradually, weakly downturned through its length (2). [Formerly without italicised additions] Reworded to recognise the difference between the abruptly downturned dentary tips of certain oviraptorosaurs and the gradual downturn in the entire dentary ramus of taxa such as Coelurus and therizinosauroids.
68. Mandible without coronoid prominence (0) or with coronoid prominence (1).
69. Posterior end of dentary without posterodorsal process dorsal to mandibular fenestra (0) or with dorsal process above anterior end of mandibular fenestra (1) or with elongate, strongly arched dorsal process extending over most of fenestra (2). [Formerly without italicized

addition]

70. Labial face of dentary flat (0) or with lateral ridge and inset tooth row (1).
71. Dentary subtriangular in lateral view (0) or with subparallel dorsal and ventral edges (1) (Currie 1995).
72. Nutrient foramina on external surface of dentary superficial (0) or lie within deep groove (1).
73. External mandibular fenestra oval (0) or subdivided by a spinous rostral process of the surangular (1).
74. Internal mandibular fenestra small and slit-like (0) or large and rounded (1) (Currie 1995).
75. Foramen in lateral surface of surangular rostral to mandibular articulation, absent (0) or present (1).
76. Splenial not widely exposed on lateral surface of mandible (0) or exposed as a broad triangle between dentary and angular on lateral surface of mandible (1).
77. Coronoid ossification large (0) or only a thin splint (1) or absent (2).
78. Articular without elongate, slender medial, posteromedial, or mediodorsal process from retroarticular process (0) or with process (1).
79. Retroarticular process short, stout (0) or elongate and slender (1).
80. Mandibular articulation surface as long as distal end of quadrate (0) or twice or more as long as quadrate surface, allowing anteroposterior movement of mandible (1).
81. Premaxilla toothed (0) or edentulous (1).
82. Second premaxillary tooth approximately equivalent in size to other premaxillary teeth (0) or second tooth markedly larger than third and fourth premaxillary teeth (1) or first premaxillary tooth huge, other premaxillary teeth tiny (2) or first premaxillary tooth larger than the others but all premaxillary teeth tiny (3).[Formerly without character states 2 and 3] State 2 added in reference to the condition in Protarchaeopteryx and Incisivosaurus (Senter et al. 2004). State 3 added in reference to the condition in Caudipteryx.
83. Maxilla toothed (0) or edentulous (1).
84. Maxillary and dentary teeth serrated (0) or some without serrations anteriorly (except at base in S. mongoliensis) (1) or all without serrations (2).
85. Dentary and maxillary teeth large, less than 25 in dentary (0) or large number of small teeth (25 or more in dentary) (1) or small number of dentary teeth (≤11) (2) or dentary without teeth (3). [Formerly: dentary and maxillary teeth large, less than 25 in dentary (0) or moderate number of small teeth (25–30 in dentary) (1) or teeth relatively small and numerous (more than 30 in dentary) (2).] State 2 added to recognise the extreme reduction in dentary tooth count in some ornithomimosaurs.
86. Serration denticles large (0) or small (1). Farlow et al. (1991) quantify this difference.
87. Serrations simple, denticles convex (0) or distal and often mesial edges of teeth with large, hooked denticles that point toward the tip of the crown (1).

88. Teeth constricted between root and crown (0) or root and crown confluent (1).

89. Dentary teeth evenly spaced (0) or anterior dentary teeth smaller, more numerous, and more closely appressed than those in middle of tooth row (1).

90. Dentaries lack distinct interdental plates (0) or with interdental plates medially between teeth (1). Currie (1995) suggests the interdental plates of dromaeosaurids are present but fused to the medial surface of the dentary, but in the absence of convincing evidence for this fusion we did not recognize this distinction.

91. In cross section, premaxillary tooth crowns sub-oval to sub-circular (0) or asymmetrical (D-shaped in cross section) with flat lingual surface (1) or first premaxillary tooth with flat lingual surface, other premaxillary teeth without flat lingual surfaces (2). [Formerly without state 2] State 2 added in reference to the condition in Protarchaeopteryx and Incisivosaurus.

92. Number of cervical vertebrae: 10 (0) or 12 or more (1).

93. Axial epipophyses absent or poorly developed, not extending past posterior rim of postzygopophyses (0) or large and posteriorly directed, extend beyond postzygapophyses (1).

94. Axial neural spine flared transversely (0) or compressed mediolaterally (1).

95. Epipophyses of cervical vertebrae placed distally on postzygapophyses, above postzygopophyseal facets (0) or placed proximally, proximal to postzygapophyseal facets (1).

96. Anterior cervical centra level with or shorter than posterior extent of neural arch (0) or centra extending beyond posterior limit of neural arch (1).

97. Carotid process on posterior cervical vertebrae absent (0) or present (1).

98. Anterior cervical centra subcircular or square in anterior view (0) or distinctly wider than high, kidney shaped (1).

99. Cervical neural spines anteroposteriorly long and dorsoventrally tall (0) or anteroposteriorly short, dorsoventrally low and centred on neural arch, giving arch an 'X' shape in dorsal view (1) or anteroposteriorly short and dorsoventrally tall (2) or anteroposteriorly long and dorsoventrally short (3). [Formerly without italicised additions] Changes introduced in recognition of a wider variety of cervical neural spine shapes than was recognised by the previous wording.

100. Cervical centra with one pair of pneumatic openings (0) or with two pairs of pneumatic openings (1).

101. Cervical and anterior trunk vertebrae amphiplatyan (0) or opisthocoelous (1).

102. Anterior trunk vertebrae without prominent hypapophyses (0) or with large hypapophyses (1).

103. Parapophyses of posterior trunk vertebrae flush with neural arch (0) or distinctly projected on pedicels (1).

104. Hyposphene -hypantrum articulations in trunk vertebrae absent (0) or present (1).

105. Zygapophyses of trunk vertebrae abutting one another above neural canal, opposite hyposphenes meet to form lamina (0), or zygapohyses placed lateral to neural canal and

separated by groove for interspinuous ligaments, hyposphens separated (1).

106. Middle and posterior dorsal vertebrae not pneumatic (0) or pneumatic (1). [Formerly: cervical vertebrae but not dorsal vertebrae pneumatic (0) or all presacral vertebrae pneumatic (1).] This character was reworded so as to be able to score the conditions of taxa in which dorsal vertebrae are known but cervicals are not.

107. Transverse processes of anterior dorsal vertebrae long and thin (0) or short, wide, and only slightly inclined (1).

108. Neural spines of dorsal vertebrae not expanded distally (0) or expanded to form 'spine table' (1).

109. Scars for interspinous ligaments terminate at apex of neural spine in dorsal vertebrae (0) or terminate below apex of neural spine (1).

110. Number of sacral vertebrae: 5 (0) or 6 (1) or 7 or more (2). [Formerly: character state 2 was '8 or more']

111. Sacral vertebrae with unfused zygapophyses (0) or with fused zygapophyses forming a sinuous ridge in dorsal view (1).

112. Ventral surface of posterior sacral centra gently rounded, convex (0) or ventrally flattened, sometimes with shallow sulcus (1) or centrum strongly constricted transversely, ventral surface keeled (2). Note that in Alvarezsaurus calvoi it is only the fifth sacral that is keeled, unlike other alvarezsaurids (Novas, 1997).

113. Pleurocoels absent on sacral vertebrae (0) or present on anterior sacrals only (1) or present on all sacrals (2). A pleurocoel may be present on the first sacral in Alxasaurus elesitaiensis, although this area is badly crushed (Russell and Dong, 1993b). .

114. Last sacral centrum with flat posterior articulation surface (0) or convex articulation surface (1).

115. Caudal vertebrae with distinct transition point (0) or without transition point (1). [Formerly: caudal vertebrae with distinct transition point, from shorter centra with long transverse processes proximally to longer centra with small or no transverse processes distally (0) or vertebrae homogeneous in shape, without transition point (1)] Vertebrae are not homogeneous in any theropod tails, but there is a distinct difference between the tails of those with the transition point and those without it. Russell (1972) coined the term 'transition point' for the point of abrupt change in vertebral morphology in the coelurosaurian tail, defining it as the point in the tail 'between the last vertebra bearing transverse processes and the first with distinctly elongate prezygapophyses' (p. 376).However, inmany coelurosaurian tails, the abrupt change occurs without prezygapophyseal elongation. Therefore, here, the transition point is considered the point of abrupt change in vertebral morphology in the tail, at which sudden reduction in the lengths of neural spines and transverse processes occurs, with or without concomitant prezygapophyseal elongation and/or change in haemal arch morphology from dorsoventrally long to dorsoventrally short and shaped like an inverted 'T'.

116. Transition point in caudal series begins distal to the 10$^{th}$ caudal (0) or between 7th and 10th caudal vertebra (1) or proximal to the 7th caudal vertebra (2). [reworded according to

Makovicky et al. 2005. Formerly: transition point in caudal series begins distal to the $10^{th}$ caudal (0) or at or proximal to the 10th caudal vertebra (1)]

117. Anterior caudal centra tall, oval in cross section (0) or with box-like centra in caudals I-V (1) or anterior caudal centra laterally compressed with ventral keel (2).

118. Neural spines of caudal vertebrae simple, undivided (0) or separated into anterior and posterior alae throughout much of caudal sequence (1).

119. Neural spines on distal caudals form a low ridge (0) or spine absent (1) or midline sulcus in center of neural arch (2).

120. Prezygapophyses of distal caudal vertebrae between 1/3 and whole centrum length (0) or with extremely long extensions of the prezygapophyses (up to 10 vertebral segments long in some taxa) (1) or strongly reduced as in Archaeopteryx lithographica (2).

121. More than 30 caudal vertebrae (0) or 21–30 caudal vertebrae (1) or < 10 caudal vertebrae, followed by pygostyle (2) or 11–20 vertebrae (3). [Formerly: more than 40 caudal vertebrae (0) or 25–40 caudal vertebrae (1) or no more than 25 caudal vertebrae (2)] State 1 altered due to the difficulty in determining caudal counts greater than 40 in most fossils due to the prevalence of missing tail tips. State 2 added in reference to the condition in ornithothoracine birds. State 3 added in reference to the condition in Wellnhoferia.

122. Proximal end of chevrons of proximal caudals short anteroposteriorly, shaft proximodistally elongate (0) or proximal end elongate anteroposteriorly, flattened and plate-like (1). [Formerly ‘cylindrical’ instead of ‘proximodistally elongate’] Wording changed because chevrons are laterally compressed, rather than cylindrical, in theropods generally.

123. Distal caudal chevrons are simple (0) or anteriorly bifurcate (1) or bifurcate at both ends (2).

124. Shaft of cervical ribs slender and longer than vertebra to which they articulate (0) or broad and shorter than vertebra (1).

125. Ossified uncinate processes absent (0) or present (1).

126. Ossified ventral rib segments absent (0) or present (1).

127. Lateral gastral segment shorter than medial one in each arch (0) or distal segment longer than proximal segment (1).

128. Ossified sternal plates separate in adults (0) or fused (1).

129. Sternum without distinct lateral xiphoid process posterior to costal margin (0) or with lateral xiphoid process (1).

130. Anterior edge of sternum grooved for reception of coracoids (0) or sternum without grooves (1).

131. Articular facet of coracoid on sternum (conditions may be determined by the articular facet on coracoid in taxa without ossified sternum): anterolateral or more lateral than anterior (0); almost anterior (1) (Xu et al. 1999).

132. Hypocleidium on furcula absent (0) or present (1). The hypocleidium is a process extending from the ventral midline of the furcula, and is attached to the sternum by a ligament in extant

birds.

133. Acromion margin of scapula continuous with blade (0) or anterior edge laterally everted (1).

134. Anterior surface of coracoid ventral to glenoid fossa unexpanded (0) or anterior edge of coracoid expanded, forms triangular subglenoid fossa bounded laterally by coracoid tuber (1).

135. Scapula and coracoid separate (0) or fused into scapulacoracoid (1).

136. Coracoid in lateral view subcircular, with shallow ventral blade (0) or subquadrangular with extensive ventral blade (1) or shallow ventral blade with elongate posteroventral process (2) or subtriangular (proximal end constricted, distal end wide) (3). [Formerly without character state 3] State 3 added in reference to the condition in certain birds and dromaeosaurids.

137. Scapula and coracoid form a continuous arc in posterior and anterior views (0) or coracoid inflected medially, scapulocoracoid 'L' shaped in lateral view (1).

138. Glenoid fossa without (0) or with extension of glenoid floor onto external surface of scapula (the surface opposite the costal surface) (1). [Formerly: glenoid fossa faces posteriorly or posterolaterally (0) or laterally (1).] The direction in which the glenoid faces is influenced by both glenoid morphology and scapular position. Here, the wording was changed to remove ambiguity by making it explicit that the character refers to glenoid morphology and not to scapular position.

139. Scapula longer than humerus (0) or humerus longer than scapula (1).

140. Deltopectoral crest large and distinct, proximal end of humerus quadrangular in anterior view (0) or deltopectoral crest less pronounced, forming an arc rather than being quadrangular (1) or deltopectoral crest very weakly developed, proximal end of humerus with rounded edges (2) or deltopectoral crest extremely long (3) or proximal end of humerus extremely broad, triangular in anterior view (4).

141. Anterior surface of deltopectoral crest smooth (0) or with distinct groove or ridge near lateral edge along distal end of crest (1).

142. Olecranon process weakly developed (0) or distinct and large but not hypertrophied (1) or hypertrophied (2). [Formerly without italicised additions] Wording and extra state added in recognition of the difference between a weak olecranon process (as in oviraptorosaurs and dromaeosaurids), a strong but not hypertrophied olecranon process (as in Allosaurus and ornithomimosaurs) and a hypertrophied olecranon process (as in Mononykus).

143. Distal articular surface of ulna flat (0) or convex, semilunate surface (1).

144. Proximal surface of ulna a single continuous articular facet (0) or divided into two distinct fossae separated by a median ridge (1).

145. Lateral proximal carpal (ulnare?) quadrangular (0) or triangular in proximal view (1). The homology of the carpal elements of coelurosaurs is unclear (see, e.g., Padian and Chiappe, 1998) but the large, triangular lateral element of some taxa most likely corresponds to the lateral proximal carpal of basal tetanurans.

146. Two distal carpals in contact with metacarpals, one covering the base of metacarpal I (and

perhaps contacting metacarpal II) the other covering the base of metacarpal II (distal carpals 1 and 2 unfused) (0) or a single distal carpal capping metacarpals I and II (distal carpals 1 and 2 fused) (1). [Formerly without italicized additions]

147. Distal carpals not fused to metacarpals (0) or fused to metacarpals, forming carpometacarpus (1).

148. Distal carpals 1+2 well developed, covering all of proximal ends of metacarpals I and II (0) or small, cover about half of base of metacarpals I and II (1) or cover bases of allmetacarpals (2). [Formerly: 'semilunate carpal' instead of 'distal carpals 1+2'] The conditions in Allosaurus and therizinosauroids make it clear that the 'semilunate carpal' of birds and deinonychosaurs is fused distal carpals 1+2. The wording was changed here so as not to necessarily imply semilunate shape for this pair of carpals.

149. Metacarpal I half or less than half the length of metacarpal II, and longer proximodistally than wide transversely (0) or subequal in length to metacarpal II (1) or very short and wider transversely than long proximodistally (2).

150. Third manual digit present, phalanges present (0) or reduced to no more than metacarpal splint (1).

151. Flexor tubercles of manual unguals proximal (0) or displaced distally from articular end (1) or proximodistally elongated with proximal end close to articular facet (2). [Formerly: manual unguals strongly curved, with large flexor tubercles (0) or weakly curved with weak flexor tubercles displaced distally from articular end (1) or straight with weak flexor tubercles displaced distally from articular end (2)] Wording changed to separate ungual curvature, flexor tubercle size and flexor tubercle position into three different characters (ungual curvature is addressed here by characters 298 and 299, while flexor tubercle size is addressed by character 348).

152. Unguals on all digits generally similar in size (0) or digit I bearing large ungual and unguals of other digits distinctly smaller (1).

153. Proximodorsal 'lip' on first manual ungual – a transverse ridge immediately dorsal to the articulating surface – absent (0) or present (1). [Formerly without 'first'] Wording changed to separate the conditions on different unguals into different characters (characters 153 and 300).

154. Ventral edge of anterior ala of ilium straight or gently curved (0) or ventral edge hooked anteriorly (1) or very strongly hooked (2).

155. Preacetabular part of ilium roughly as long as postacetabular part of ilium (0) or preacetabular portion of ilium markedly longer (more than 2/3 of total ilium length) than postacetabular part (1).

156. Anterior end of ilium gently rounded or straight (0) or anterior end strongly curved (1) or pointed at anterodorsal corner (2).

157. Supraacetabular crest on ilium as a separate process from antitrochanter, forms "hood" over femoral head present (0) reduced, not forming hood (1) or absent (2).

158. Postacetabular ala of ilium in lateral view squared (0) or acuminate (1).

159. Postacetabular blades of ilia in dorsal view parallel (0) or diverge posteriorly (1).

160. Tuber along dorsal edge of ilium, dorsal or slightly posterior to acetabulum absent (0) or present (1).

161. Brevis fossa shelf-like (0) or deeply concave with lateral overhang (1).

162. Antitrochanter posterior to acetabulum absent or poorly developed (0) or prominent (1).

163. Ridge bordering cuppedicus fossa extends far posteriorly and is confluent or almost confluent with acetabular rim (0) or ridge terminates rostral to acetabulum or curves ventrally onto anterior end of pubic peduncle (1). [Reworded according to Makovicky et al. 2005, but with states reversed. Formerly: cuppedicus fossa formed as antiliac shelf anterior to acetabulum, extends posteriorly to above anterior end of acetabulum (0) or posterior end of fossa on anterior end of pubic peduncle, anterior to acetabulum (1)]

164. Cuppedicus fossa deep, ventrally concave (0) or fossa shallow or flat, with no lateral overhang (1) or absent (2).

165. Posterior edge of ischium without (0) or with prominent proximodorsal prong (1). [Formerly: posterior edge of ischium straight (0) or with median posterior process (1)]Wording changed to eliminate potential confusion between the posterodorsal process at the midshaft of Archaeopteryx and some dromaeosaurids with the proximodorsal ischial prong of some birds.

166. Shaft of ischium straight in lateral view (0) or ventrodistal end curved anteriorly (1) or curved dorsally (posterodorsally concave) (2) (Marya´nska et al. 2002). [Formerly: ischium straight (0) or ventrodistally curved anteriorly (1) or twisted at midshaft and with flexure of obturator process toward midline so that distal end is horizontal (2) or with laterally concave curvature in anterior view (3)] State 2 added in reference to the condition in oviraptorosaurs.

167. Obturator process of ischium absent (0) or proximal in position (1) or distally displaced (2). [Formerly: obturator process of ischium absent (0) or proximal in position (1) or located near middle of ischiadic shaft (2) or located at distal end of ischium (3)] Placement of the obturator process at the middle or distal end of the ischium depends on whether or not the process is displaced (character 167) and whether or not the ischium is reduced in length (character 171).

168. Obturator process does not contact pubis (0) or contacts pubis (1).

169. Length of pubic boot≤30% length of pubis (0) or≥40% (1). [Formerly: obturator notch present (0) or notch or foramen absent (1)] The former character was uninformative. If it referred to the pubic obturator notch, only one taxon in this data matrix (Sinraptor) exhibited state 1, because only Sinraptor retains the pubic portion of the puboischiadic plate and therefore lacks an obturator notch. If it referred to the ischial obturator notch (notch between obturator process and pubic peduncle), then all taxa with an obturator process exhibited state 0 and state 1 was redundant with respect to state 0 of character 167 (ischial obturator process absent). Therefore, this character was replaced by an informative pelvic character.

170. Semicircular scar on posterior part of the proximal end of the ischium, absent (0) or present (1).

171. Ischium more than 70% (0) or 70% or less of pubis length (1). [Formerly: ‘two thirds’ instead

of ‘70%’]

172. Distal ends of ischia form symphysis (0) or approach one another but do not form symphysis (1) or widely separated (2). .

173. Ischial boot (expanded distal end) present (0) or absent (1).

174. Tubercle on anterior edge of ischium absent (0) or present (1).

175. Pubis propubic (0) or pubis vertical (1) or pubis moderately posteriorly oriented (2) or pubis fully posteriorly oriented (opisthopubic) (3). The oviraptorid condition, in which the proximal end of the pubis is vertical and the distal end curves anteriorly, is considered to be state 1.

176. Pubic boot projects anteriorly and posteriorly (0) or with little or no anterior process (1) or no anteroposterior projections (2).

177. Shelf on pubic shaft proximal to symphysis (‘pubic apron’) extends medially from middle of cylindrical pubic shaft (0) or shelf extends medially from anterior edge of anteroposteriorly flattened shaft (1).

178. Pubic shaft straight (0) or distal end curves anteriorly, anterior surface of shaft concave in lateral view (1) or anterior surface of shaft convex in lateral view (2). [Formerly without character state 2; similar character state present in character list of Makovicky et al. 2005]

179. Pubic apron about half of pubic shaft length (0) or less than 1/3 of shaft length (1).

180. Femoral head without fovea capitalis (for attachment of capital ligament) (0) or circular fovea present in center of medial surface of head (1).

181. Lesser and greater trochanters unfused (0) or fused (1). [Formerly: lesser trochanter separated from greater trochanter by deep cleft (0) or trochanters separated by small groove (1) or completely fused (or absent) to form crista trochanteris (2)] The former states 1 and 2 both represent fusion of the greater and lesser trochanters. In some cases, fusion is incomplete apically, leaving a ‘small groove’ (former state 1). The degree of apical incompleteness of fusion varies continuously, with no real cut-off between cases in which the groove is distinct, those in which it is present, but just barely, and those in which fusion is complete enough to obliterate most or all of the groove. For this reason, itwas decided to combine former states 1 and 2 into one state, rather than commit to an artificial cut-off between degrees of fusion between greater and lesser trochanters.

182. Lesser trochanter of femur alariform (0) or cylindrical in cross section (1).

183. Posterior trochanter absent or represented only by rugose area (0) or posterior trochanter distinctly raised from shaft, mound-like (1). Cited by Gauthier (1986) as synapomorphy of Coelurosauria (his character 64), but he termed it the greater trochanter, which he equated with the posterior trochanter. Ostrom (1969a, 1990) identifies the posterior and greater trochanter as separate structures, and we follow his terminology.

184. Fourth trochanter on femur present (0) or absent (1).

185. Accessory trochanteric crest distal to lesser trochanter absent (0) or present (1). This character was identified as an autapomorphy of Microvenator celer (Makovicky and Sues,

1998), but it is more widespread.

186. Anterior surface of femur proximal to medial distal condyle without longitudinal crest (0) or crest present extending proximally from medial condyle on anterior surface of shaft (1).

187. Popliteal fossa on distal end of femur open distally (0) or closed off distally by contact betweeen distal condyles (1).

188. Fibula reaches proximal tarsals (0) or short, tapering distally, and not in contact with proximal tarsals (1).

189. Medial surface of proximal end of fibula concave along long axis (0) or flat (1).

190. Deep oval fossa on medial surface of fibula near proximal end absent (0) or present (1).

191. Distal end of tibia and astragalus without distinct condyles (0) or with distinct condyles separated by prominent tendinal groove on anterior surface (1).

192. Medial cnemial crest absent (0) or present on proximal end of tibia (1).

193. Ascending process of the astragalus tall and broad, covering most of anterior surface of distal end of tibia (0) or process short and slender, covering only lateral half of anterior surface of tibia (1) or ascending process tall with medial notch that restricts it to lateral side of anterior face of distal tibia (2).

194. Ascending process of astragalus confluent with condylar portion (0) or separated by transverse groove or fossa across base (1).

195. Astragalus and calcaneum separate from tibia (0) or fused to each other and to the tibia in late ontogeny (1).

196. Distal tarsals separate, not fused to metatarsals (0) or form metatarsal cap with intercondylar prominence that fuses to metatarsal early in postnatal ontogeny (1).

197. Metatarsals not co-ossified (0) or co-ossification of metatarsals begins proximally (1) or distally (2).

198. Distal end of metatarsal II smooth, not ginglymoid (0) or with developed ginglymus (1).

199. Distal end of metatarsal III smooth, not ginglymoid (0) or with developed ginglymus (1).

200. In anterior view, metatarsal III not pinched (0) or pinched proximally (1) or pinched both proximally and through midshaft (2). [Formerly: shaft of metatarsal III prominently visible between metatarsals II and IV in anterior view (0) or metatarsal III pinched between metatarsals II and IV, the latter two contacting one another proximally in front of III (1) or metatarsal III does not reach proximal end of metatarsus (2)] The former ‘character’ is a combination of two characters: pinching of metatarsal III and contact between metatarsals II and IV. Here, the latter character has been separated out as character 358.

201. Ungual of pedal digit II similar in size to that of III (0) or pedal ungual II about 50% larger than pedal ungual III (1). [Formerly: ungual and penultimate phalanx of pedal digit II similar to those of III (0) or penultimate phalanx highly modified for extreme hyper-extension, ungual more strongly curved and about 50% larger than that of III (1)] Character reworded to separate the condition of the ungual from the condition of the penultimate phalanx (character

323).

202. Metatarsal I articulates at middle of metatarsal II (0) or metatarsal I attaches to distal quarter of metatarsal II (1) or metatarsal I articulates with metatarsal II near its proximal end (2) or metatarsal I absent (3). [Formerly: metatarsal I articulates in the middle of the medial surface of metatarsal II (0) or metatarsal I attaches to posterior surface of distal quarter of metatarsal II (1) or metatarsal I articulates to medial surface of metatarsal II near its proximal end (2) or metatarsal I absent (3)]

203. Metatarsal I attenuates proximally (0) or proximal end of metatarsal I similar to that of metatarsals II–IV (1). [Formerly: metatarsal I attenuates proximally, without proximal articulating surface (0) or proximal end of metatarsal I similar to that of metatarsals II–IV (1)] Phrase removed to accommodate the condition in Neimongosaurus, in which metatarsal I attenuates proximally and retains a proximal articulating surface (Zhang et al. 2001).

204. Shaft of MT IV round or thicker dorsoventrally than wide in cross section (0) or shaft of MT IV mediolaterally widened and flat in cross section (1).

205. Foot symmetrical (0) or asymmetrical with slender MTII and very robust MT IV (1).

206. Neural spines on posterior dorsal vertebrae in lateral view rectangular or square (0) or anteroposteriorly expanded distally, fanshaped (1).

207. Shaft diameter of phalanx I-1 less (0) or greater (1) than shaft diameter of radius.

208. Angular exposed almost to end of mandible in lateral view, reaches or almost reaches articular (0) or excluded from posterior end angular suture turns ventrally and meets ventral border of mandible rostral to glenoid (1).

209. Laterally inclined flange along dorsal edge of surangular for articulation with lateral process of lateral quadrate condyle absent (0) or present (1).

210. Distal articular ends of metacarpals I + II ginglymoid (0) or rounded, smooth (1).

211. Radius and ulna well separated (0) or with distinct adherence or syndesmosis distally (1).

212. Kink and downward deflection in dentary buccal margin at rostral end of dentary: absent (0) or present (1). [Formerly: jaws occlude for their full length (0) or diverge rostrally due to kink and downward deflection in dentary buccal margin (1)]

213. Quadrate head covered by squamosal in lateral view (0) or quadrate cotyle of squamosal open laterally exposing quadrate head (1).

214. Brevis fossa poorly developed adjacent to ischial peduncle and without lateral overhang, medial edge of brevis fossa visible in lateral view (0), or fossa well developed along full length of postacetabular blade, lateral overhang extends along full length of fossa, medial edge completely covered in lateral view (1).

215. Vertical ridge on lesser trochanter present (0) or absent (1).

216. Supratemporal fenestra bounded laterally and posteriorly by the squamosal (0) or supratemporal fenestra extended as a fossa on to the dorsal surface of the squamosal (1).

217. Dentary fully toothed (0) or only with teeth rostrally (1) or edentulous (2).

218. Posterior edge of coracoid not or shallowly indented below glenoid (0), or posterior edge of coracoid deely notched just ventral to glenoid, glenoid lip everted (1).

219. Retroarticular process points caudally (0) or curves gently dorsocaudally (1) (Kobayashi, 2001).

220. Flange on supraglenoid buttress on scapula (see Nicholls and Russell, 1985) absent (0) or present (1).

221. Depression (possibly pneumatic) on ventral surface of postorbital process of laterosphenoid absent (0) or present (1).

222. Basal tubera set far apart, level with or beyond lateral edge of occipital condyle and/or foramen magnum (may connected by a web of bone or separated by a large notch) (0) or tubera small, directly below condyle and foramen magnum, and separated by a narrow notch (1).

223. Basioccipital without pneumatization on occipital surface (0) or with subcondylar recess (1).

224. Ventral surface of dentary straight or nearly straight (0) or descends strongly posteriorly (1).

225. Distal humerus with small or no medial epicondyle (0) or with large medial epicondyle, medial condyle centered on distal end (1).

226. Distal humeral condyles on distal end (0) or on anterior surface (1).

227. Ilium and ischium articulation flat or slightly concavo-convex (0) or ilium with process projecting into socket in ischium (1).

228. Roots of dentary and maxillary teeth mediolaterally compressed (0) or circular in cross-section (1).

229. Preacetabular portion of ilium parasagital (0) moderately laterally flaring (1) strongly laterally flaring (2).

230. Maxillary and dentary teeth labiolingually flattened and recurved, with crowns in middle of tooth row more than twice as high as the basal mesiolateral width (0) or lanceolate and subsymmetrical (1) or conical (2) or labiolingually flattened and recurved, with crowns in middle of tooth row less than twice as high as the basal mesiolateral width (fore–aft basal length) (3) [Formerly without italicised additions] State 2 added in reference to the condition in birds and basal ornithomimosaurs. State 3 added in reference to the unique shape of the teeth of some troodontids.

**231.** Dentary teeth do not (0) or do increase in size anteriorly, becoming more conical in shape (1). [Formerly: dentary teeth homodont (0) or increasing in size anteriorly, becoming more conical in shape (1). Character reworded to refer only to tooth size (homodonty refers also to tooth shape).

232. Length of skull more than 90% femoral length (0) or less than 80% (1).

233. Height of skull (minus mandible) at middle of naris more than half the height of skull at middle of orbit (0) or less than half (1).

234. Dorsal margin of naris below level of dorsal margin of orbit (0) or above (1) (modified from

Marya´nska et al. 2002).

235. Snout does not (0) or does taper to an anterior point (1).

236. Area of antorbital fenestra greater than that of orbit (0) or less than that of orbit (1).

237. Body of premaxilla dorsoventrally deep (0) or dorsoventrally shallow (1).

238. Antorbital fossa anteriorly bounded by maxilla (0) or by premaxilla (1) (Marya´nska et al. 2002).

239. Maxillary antorbital fossa: small, from 10% to less than 40% of the rostrocaudal length of the antorbital cavity (0), large, greater than 40% of the rostrocaudal length of the antorbital cavity (1) (Holtz et al. 2004).

240. Maxillary fenestra large and round (0), a large, craniocaudally elongate oblong (1), a small, craniocaudally elongate slit, not dorsally displaced (2), or a small, dorsally displaced opening (3).

241. Nasal fusion: absent, nasals separate (0) or present, nasals fused together (1).

242. Nasal surface: smooth (0) or rugose (1).

243. Suborbital process of jugal short and dorsoventrally stout (0) or elongate and dorsoventrally narrow (1).

244. Nasals at least as long as frontals (0) or shorter than frontals (1).

245. Anterior upturning of nasals absent (0) or present (1).

246. Jugo-maxillary bar at ventral end of antorbital fenestra dorsoventrally deep (0) or dorsoventrally narrow (1).

247. Anteroventral corner of premaxilla does not (0) or does form an acute, ventrally orientated point in lateral view (1).

248. Length of preorbital region of cranium>height at anterior edge of preorbital bar (exclusive of midline sagittal ridge, if any) (0) or≤height at anterior edge of preorbital bar (1).

249. Frontals without supraorbital rim (0) or with supraorbital rim (1).

250. Parietals shorter than frontals (0) or longer (1).

251. Length of ventral border of infratemporal fenestra comparable to that of orbit (0) or much shorter (1).

252. Foramen magnum smaller than or subequal to size of occipital condyle (0) or larger than occipital condyle (1).

253. Dentary not bowed (0) or bowed (concave dorsally) (1).

254. Meckelian groove of dentary deep (0) or shallow (1) (Currie & Varricchio 2004).

255. Dentary without posteroventral process extending to posterior end of external mandibular fenestra (0) or with such a process (1) (Marya´nska et al. 2002).

256. Horizontal shelf on the lateral surface of the surangular, rostral and ventral to the mandibular condyle: absent or faint ridge (0), prominent and extending laterally (1) (Holtz et al. 2004).

257. Premaxillary teeth subequal in size to (0) or much smaller than (1) the maxillary teeth (Holtz et al. 2004).

258. Approximately the same number of denticles per 5 mm on mesial keels of teeth as on distal keels (0) or markedly more denticles per 5 mm on mesial keels (1).

259. Maxillary teeth subperpendicular to ventral margin of maxilla (0) or strongly inclined (1) (Currie&Varricchio 2004).

260. Dentary tooth implantation: in sockets (0), in paradental groove (1) (Holtz et al. 2004).

261. Dentary dentition continues cranially to tip of dentary (0) or terminates before reaching dentary tip (1).

262. Length of mid-cervical centra approximately the same as dorsal centra (0) or markedly longer than dorsal centra (1).

263. Cervical prezygapophyses unflexed (0) or flexed (1) (Holtz et al. 2004).

264. Dorsal centra≥1.2×taller than long (0) or height≤length (1).

265. Posterior dorsal neural spines≥1.5×taller than long (0) or height<1.5×length (1).

266. Postzygapophyses of middle and posterior dorsal vertebrae do not extend posterior to centrum (0) or do (1).

267. Anteriormost haemal arches≥1.5×longer than associated centra (0) or<1.5×as long as centra (1).

268. Angle between furcular arms>80◦ (0) or<60◦ (1).

269. Acromion process contacts coracoid (0), or reduced and does not contact coracoid (1).

270. Acromion process does not match any of the following descriptions: (0) rectangular with its dorsal edge forming a 90◦ angle with the dorsal edge of the scapular blade (1) or a quarter-circle in shape (2) or triangular, with apex pointing away from and subparallel to scapular blade (3).

271. Scapulocoracoid dorsal margin: pronounced notch between the acromion process and the coracoid (0) or margin smooth (1) (Holtz et al. 2004).

272. Wide distal expansion of scapula absent (0) or present (1).

273. Acrocoracoid process absent (0) or present (1).

274. Humeral length is half femoral length or less (0) or shorter than femur but more than half femoral length (1) or longer than femur (2).

275. Length of humeral shaft between deltopectoral crest and distal condyles<4.5×shaft diameter (0) or>4.5×shaft diameter (1).

276. Ulna not bowed away from humerus (0), or bowed away from humerus (1) (Gauthier 1986).

277. Length of radius<1/3 femoral length (0) or between 1/3 and 2/3 femoral length (1) or between 2/3 and 1×femoral length (2) or>femoral length (3).

278. Radial diameter>0.5×ulnar diameter (0) or≤0.5× (1).

279. Distal carpals 1+2 flattish (0) or semilunate in shape (1).

280. Length of manual digit II (including metacarpal) less than 1.25×femoral length (0) or≥1.25×femoral length (1).

281. Distal end of metacarpal I medially (0) or laterally rotated (1) (P´erez-Moreno et al. 1994).

282. Medial side of metacarpal II: expanded proximally (0), not expanded (1) (Holtz et al. 2004).

283. Metacarpal III>0.8×length of metacarpal II (0) or<0.8×(1).

284. Manual phalanx I-1 longer than metacarpal II (0) or shorter (1) (P´erez-Moreno et al. 1994).

285. Length of metacarpal II<length of metacarpal I + phalanx I-1 (0) or≥(1).

286. Metacarpals II and III are not (0) or are appressed for their entire lengths (1).

287. Proximal end of metacarpal III is not (0) or is mainly palmar to that of metacarpal II (1) (Holtz et al. 2004).

288. Length of manual phalanx II-2<1.2×length of phalanx II-1 (0) or>1.2×(1).

289. Medial ligament pits of manual phalanges deep (0) or shallow (1) (Clark et al. 2004).

290. Posterior flange on manual phalanx II-1 absent (0) or present (1).

291. Combined lengths of manual phalanges II-1 and II- 2>length of metacarpal II + carpus (0) or≤length of metacarpal II +carpus (1).

292. Length ofmanual phalanx II-1<2×length of III-1 (0) or≥2×length of III-1 (1).

293. Length of manual phalanx II-2<2×length of II-1 (0) or≥2×(1).

294. Length of manual phalanx III-1<2×length of phalanx III-2 (0) or>2×(1).

295. Manual phalanx I-1 straight (0) or bowed (palmar surface concave) (1).

296. With proximal articular surface of ungual orientated vertically, dorsal surface of manual ungual I does not (0) or does arch higher than level of dorsal extremity of proximal articular surface (1).

297. With proximal articular surface of ungual orientated vertically, dorsal surface of manual ungual II does not (0) or does arch higher than level of dorsal extremity of proximal articular surface.

298. Manual ungual I strongly curved (0), weakly curved (1), or straight (2).

299. Manual unguals II and III strongly curved (0), weakly curved, (1), or straight (2).

300. Proximodorsal ‘lip’ onmanual unguals II and III absent (0) or present (1).

301. Manual digit III with four phalanges (0) or less than four phalanges (1).

302. Manual phalanx III-3 markedly shorter than combined lengths of phalanges III-1 and III-2 (0), subequal in length to their combined lengths (1), or markedly longer (2).

303. Arching of preacetabular iliac blade above height of postacetabular blade absent or small (0) or extreme (1).

304. Shaft of ischium subequal in thickness to the pubis (0), slenderer than the pubic shaft (1), thicker than the pubic shaft (2) (Holtz et al. 2004).

305. Obturator process does not (0) or does form a strongly acute angle in lateral view (1).

306. Obturator process does not (0) or does reach tip of ischium (1).

307. Ventral notch between the distal portion of the obturator process and the shaft of the ischium: present (0), absent (1) (Holtz et al. 2004).

308. Strong kink of pubis at midshaft absent (0) or present, displacing distal half of pubis caudally (1).

309. In adult, femur longer than tibia (0) or shorter (1)

310. Tip of lesser trochanter below level of femoral head (0) or level with femoral head (1) (Holtz et al. 2004).

311. Proximolateral (fibular) condyle of the tibia, development in proximal view: bulge from the main surface of the tibia (0), conspicuous narrowing between the body of the condyle and the main body of the tibia (1) (Holtz et al. 2004).

312. Metatarsus less than half length of femur (0) or more than half femoral length (1).

313. Metatarsal cross-sectional proportions: subequal or wider mediolaterally than craniocaudally at midshaft (0), deeper craniocaudally than mediolaterally at midshaft (1) (Holtz et al. 2004).

314. Shafts of metatarsals not appressed (0) or appressed (1).

315. Length of metatarsal V≥0.5×length of metatarsal IV (0) or<0.5×(1).

316. Marked decrease in transverse width of metatarsus distally, absent (0) or present (1).

317. Plantar surface of hallux faces posteriorly (0) or hallux reorientated so that plantar surface faces medially or anteriorly (1) (Sanz & Buscalioni 1992). This is diagnosable by the degree of torsion in metatarsal I, even in disarticulated specimens (Middleton 2001).

318. Hallucal ungual reduced in size relative to other pedal unguals (0) or not reduced (1).

319. Hallucal ungual weakly curved (0) or strongly curved (1).

320. Length of pedal phalanx II-2 between 0.6×and 1×length of phalanx II-1 (0),≤0.6 ×, or (1)≥1×(2).

321. Total length of pedal phalanx II-2 (not counting posteroventral lip, if any)>2×length of distal condylar eminence (0) or≤2×(1).

322. Pedal phalanx II-2 without posteroventral lip or keel (0) with transversely wide posteroventral lip (1)with transversely narrow posteroventral keel (2) (Makovicky et al. 2005).

323. Pedal phalanx II-1 without dorsal extension of distal condyles (0) or with extension (1).

324. Pedal unguals III and IV straight or weakly curved (0), or strongly curved (1).

325. With fingers extended, tip of ungual III extends no further distally than flexor tubercle of ungual II (0) or extends further (1).

326. Manual ungual III smaller than ungual II (0) or approximately the same size (1).

327. Diameter of non-ungual phalanges of manual digit III>0.5×diameter of non-ungual phalanges of digit II (0) or < 0.5×(1).

328. Manual phalanx II-1 shorter than I-1 (0) or longer (1).

329. Ischial shaft rodlike (0) or flat, platelike (1) (Makovicky et al. 2005).

330. Lateral face of ischial shaft flat (or round in rodlike ischia) (0) or laterally concave (1) or with longitudinal ridge dividing lateral surface into anterior and posterior parts (2) (Makovicky et al. 2005).

331. Contact between pubic apron contributions of both pubes meet extensively (0) or contact interrupted by a slit (1) or no contact (2) (Makovicky et al. 2005).

332. Dorsal margin of postacetabular iliac blade straight or convex (0) or concave (1) (Makovicky et al. 2005).

333. Large, longitudinal flange along caudal or lateral face of metatarsal IV absent (0) or present (1) (Novas & Pol 2005).

334. Distally placed dorsal process along caudal edge of ischial shaft absent (0) or present (1).

335. Length of metatarsus<3.5×transverse midshaft diameter (0) or 3.5–8×midshaft diameter (1) or>8×midshaft diameter (2).

336. Lengths of mid-caudal centra subequal to or less than those of proximal caudal centra (0) or≥twice as long as proximal caudal centra (1).

337. Pubic peduncle of ilium craniocaudally longer (0) or shorter (1) than ischial peduncle of ilium.

338. Phalanges of pedal digit III not blocky (proximal phalanx length≥2×diameter) (0) or blocky (proximal phalanx length<2×diameter) (1).

339. Width of distal humeral expansion<1/3 humeral length (0) or≥1/3 humeral length (1).

340. Lateral epicondyle of humerus not expanded laterally (0) or expanded laterally (1).

341. Distal end of metatarsal I reduced in size relative to distal ends of other metatarsals (0) or comparable in size to distal ends of other metatarsals (1).

342. Pedal phalanx II-1 longer (0) or shorter (1) than pedal phalanx IV-1.

343. Dentary ramus elongate (0) or shortened, not much longer than tall (1).

344. Metacarpal II≥1/3 humeral length (0) or<1/3 humeral length (1).

345. With fingers extended, tip of ungual I does not extend past flexor tubercle of ungual II (0) or extends past flexor tubercle of ungual II but does not extend past tip of ungual II (1) or extends past tip of ungual II (2).

346. Premaxillary teeth serrated (0) or unserrated (1) (Rauhut 2003).

347. Sublacrimal process of jugal dorsoventrally expanded (taller than suborbital bar of jugal) (0) or not dorsoventrally expanded (1) (Rauhut 2003).

doi: 10.1038/nature08322 

348. Flexor tubercles of manual unguals≥1/3×height of articular facet (0) or<1/3 (1).

349. Distal chevrons straight or L-shaped in lateral view (0) or upside-down T-shaped (1).

350. Metacarpal III distally not ginglymoid (0) or ginglymoid (1).

351. Breadth of acromion process perpendicular to long axis of scapular blade: deep (0) or shallow (1).

352. Proximal end of metatarsal IV curls around plantar side of proximal end of metatarsal III (0) or does not (1).

353. Midsagittal ridge formed by dorsal displacement of midline of frontals, nasals and premaxillae, absent (0) or present (1).

354. Ectopterygoid lateral to pterygoid (0) or rostral to pterygoid (1) (Osm´olska et al. 2004).

355. Palatine-pterygoid-ectopterygoid bar does not (0) or does (1) arch below ventral cheek margin (Osm´olska et al. 2004).

356. Co-ossification of angular and surangular absent (0) or present (1) (Osm´olska et al. 2004).

357. Cervical ribs unfused to cervical vertebrae (0) or fused to cervical vertebrae (1) (Osm´olska et al. 2004).

358. Anteroproximal contact between metatarsals II and IV absent (0) or present (1).

359. Anterior caudal vertebrae without pneumatopores (0) or with pneumatopores (1) (Holtz 1998).

360. External mandibular fenestra not rostrally displaced (sits beneath orbit) (0) or rostrally displaced (sits largely anterior to orbit) (1).

361. Ilium, pubic peduncle: substantially larger than (0) or subequal to (1) ischial peduncle

362. Ischium, length relative to pubis: shorter (0) or longer (1)

363. Ischium, shape: distally narrower (0) or distally wider (1) (excluding obturator process)

Matrix

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Pelecanimimus_polyodon ?01???1???1????1?2?21000??10010?????02000?00???
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Archaeornithomimus_asiaticus ????????????????????????????????????????????????????????

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Garudimimus_brevipes ?0110????01101????021001101001000??0020000000
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Anserimimus_planinychus ????????????????????????????????????????????????????
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Struthiomimus_altus ?01110?110??0??10102100 1101?0100211000000000000
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Gallimimus_bullatus ?01110?1101101010102100 1101?0100211000000000000
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Falcarius_utahensis ?01??01000??01?0121??????0???1?????????????00??????
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Alxasaurus_elesitaiensis ??????????????????????????????????????????????????????
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Nanshiungosaurus_brevispinus ?????????????????????????????????????????????????????
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Segnosaurus_galbiensis ?????????????????????????????????????????????????????
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Erlikosaurus_andrewsi ?0110??02?1?1?0???010011100??10001?100000100011
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Elmisaurus_rarus ???????????????????????????????????????????????????
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Ingenia_yanshini ?01?0?????????????????1111110001 0?1?1??132??0?1??
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Khaan_mckennai ?0110???????????????00111?110?01011?1001321000
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Heyuannia_huangi ??11????????????????????????????????0???????????
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Byronosaurus_jaffei ?????101???101?1100110101011?00??????20220??????
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Sinornithoides_youngi ?0??0???????????????1?000??1???0????0020?2???????1
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Sinornithosaurus_millenii ?011??????0???????????00???11100????10001?1100?1???
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Microraptor_zhaoianus
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Deinonychus_antirrhopus ?0110????1???????11?0000?01110000111000 12??????0
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Achillobator_giganticus ??????????????????????????01110??????????????????????
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Dromaeosaurus_albertensis ?0??0010000000000 10??0?0?0???0??01110????1111???
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Atrociraptor_marshalli ??????????????????????????1110??????????????????????
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Epidexipteryx_ningchengensis
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Archaeopteryx_lithographica
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Sapeornis_chaoyangensis ?011????????????????11011?????00001?000002??0011?
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Confuciusornis_sanctus
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Protopteryx_fengningensis
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Yanornis_martini ?01?????????????????111?0??????0??????0??????????
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Hagryphus_giganteus ???????????????????????????????????????????????????
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Alvarezsaurus_calvoi ????????????????????????????????????????????????????
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Microvenator_celer ???????????????????????????????????????????????????
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Caudipteryx
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Oviraptor_philoceratops ?0110???????????1??00?????111?0?011???0132??0?1?0??
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Conchoraptor_gracilis ?0110???????????1???00111?1100?1011?1001321000110
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Chirostenotes_pergracilis ????????01?01101??0???1?11??0???????????????????????
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Incisivosaurus_gauthieri ?0110???1??01?????1000101010001001?0?010??0001100
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Anchiornis_huxleyi
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