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Supplementary Table 1 | Selected measurements of MPC-D102/109

Measurement	mm
Skull dorsoventral depth at postorbital bar	21
Skull length (premaxilla-occiput)	70.5
Snout width at external naris	9.4
Premaxillary body volume (combined left and right elements)	31.69 mm^3
Premaxillary neurovascular chamber volume (combined left and right elements)	9.36 mm^3
Preorbital length (premaxilla-lacrimal)	38.1
Orbit ventral length	18.2
Orbit height	16
Antorbital fenestra length	8.7
Infratemporal fenestra height	9.7
Supratemporal fenestra main axis length	9
Premaxilla dorsoventral depth anterior to naris	5.1
Premaxilla length (tip to subnarial posterior end)	12.6
Maxilla ventral length	35.3
Frontal length	24.8
Left humerus mid-shaft mediolateral width	4.6
Left ulna length	39.3
Left radius length	39
Left manual finger I (including missing mc I)	26 (estimated assuming no dislocation relative to 2nd finger)
Left manual finger II (including missing ungual)	45 (estimated assuming the ungual subequal to ungual I)
Left manual finger III	51
Ilium preacetabulum length	29.2
Ilium total length	65.8
Left ischium length (fragmentary)	22.6
Right femur length	76.2
Right tibia length	105.5
Right femur mid-shaft mediolateral width	7.1
Left femur mid-shaft mediolateral width	7.3
Left femur mid-shaft anteroposterior diameter	5.6
Right metatarsal I length	12.9
Left metatarsal II length	43
Left metatarsal III length	50.2
Left metatarsal IV length	46.7

Left PII-1 pes length	8.6
Left PII-2 pes length	6.6
Left ungual II pes length	15.1
Right pedal ungual II length	15.1
Right metatarsal III length	52.8
Right PIII-1 pes length	20
Right PIII-2 pes length	13.8
Right PIII-3 pes length	12.1
Right PIII-4 pes length	15.8
Left pedal digit III length (only phalanges)	45
Right pedal ungual IV length	12.7
Atlas width	8.6
Cervical 2 centrum length	17.1
Cervical 3 centrum length	22.8
Cervical 4 centrum length	23
Cervical 5 centrum length	22.1
Cervical 6 centrum length	30.6
Cervical 7 centrum length	27.4
Cervical 8 centrum length	23.4
Cervical 9 centrum length	18.9
Cervical 10 centrum length	17
Dorsal 1 centrum length	13.6
Dorsal 2 centrum length	14.9
Dorsal 3 centrum length	9.6
Dorsal 4 centrum length	8.9
Dorsal 5 centrum length	11.4
Dorsal 6 centrum length	10.5
Dorsal 7 centrum length	11.7
Dorsal 8 centrum length	11.7
Dorsal 9 centrum length	11.2
Dorsal 10 centrum length	10.6
Dorsal 11 centrum length	11.8
Dorsal 12 centrum length	10.3
Sacrals 1-6 combined centra length	51.8
Caudal neural arch 2 length	17.3
Caudal neural arch 12 length	11.4
Sternum length	45.6
Right sternal plate maximum width	13.6

Supplementary Table 2 | Synchrotron Scan Parameters of MPC-D102/109

sample	***Halszkaraptor* complete scan**
date	19/10/2016-21/10/2016
voxel size (µm)	53.58
optic	LAFIP2
Average energy (keV)	110
Filters (mm)	Mo 0.4 12 bars of aluminum of 5mm diameter
propagation distance (mm)	4000
sensor	FReLoN 2K14
Scintillator	scintillating fiber
insertion device	BM5
filling mode	200 mA
ID Gap (mm)	N.A.
projection number	5000
scan geometry	360°, half-acquisition 850 pixels, vertical series 3.2 mm, double scan
subframe time (s)	0.04
exposure time (s)	0.2
accumulation level	5
time per scan (min)	18.57
number of scans	148
total time (h)	46
reconstruction	single distance phase retrieval / metallic oxide inclusions correction + texture enhancement algorithm
refs / dark	each scan
sample	***Halszkaraptor* tibia radius mid-diaphysis**
date	21/10/2016
voxel size (µm)	2.25
optic	Hasselblad 100mm / 300mm
Average energy (keV)	100
Filters (mm)	Al 2 10 bars of aluminum of 5mm diameter
propagation distance (mm)	700
sensor	sCMOS PCO edge 5.5
Scintillator	LuAG:Ce 200 µm + meniscus
insertion device	BM5

filling mode	200 mA
ID Gap (mm)	N.A.
projection number	6000
scan geometry	360°, half-acquisition 1000 pixels, vertical series 4 mm crashed scans
subframe time (s)	0.15
exposure time (s)	0.75
accumulation level	5
time per scan (min)	80.42
number of scans	4
total time (h)	5
reconstruction	single distance phase retrieval / metallic oxide inclusions correction
refs / dark	each scan
sample	***Halszkaraptor* tibia radius mid-diaphysis**
date	21/10/2016
voxel size (µm)	2.25
optic	Hasselblad 100mm / 300mm
Average energy (keV)	100
Filters (mm)	Al 2 10 bars of aluminum of 5mm diameter
propagation distance (mm)	700
sensor	sCMOS PCO edge 5.5
Scintillator	LuAG:Ce 200 µm + meniscus
insertion device	BM5
filling mode	200 mA
ID Gap (mm)	N.A.
projection number	6000
scan geometry	360°, half-acquisition 1000 pixels, vertical series 4 mm
subframe time (s)	0.15
exposure time (s)	0.75
accumulation level	5
time per scan (min)	80.42
number of scans	4
total time (h)	5
reconstruction	single distance phase retrieval / metallic oxide inclusions correction
refs / dark	each scan
sample	***Halszkaraptor* skull**
date	23/10/2016
voxel size (µm)	12.97
optic	Hasselblad 210mm / 100mm
Average energy (keV)	210

Filters (mm)	Cu 7 W 1
propagation distance (mm)	11000
sensor	sCMOS PCO edge 5.5
Scintillator	LuAG:Ce 500 µm + meniscus
insertion device	W150 ID19
filling mode	200 mA
ID Gap (mm)	26.5
projection number	6000
scan geometry	360°, half-acquisition 800 pixels, vertical series 5 mm, double scan
subframe time (s)	0.01
exposure time (s)	0.12
accumulation level	12
time per scan (min)	14.27
number of scans	28
total time (h)	7
reconstruction	single distance phase retrieval / metallic oxide inclusions correction / texture enhancement algorithm
refs / dark	each scan
sample	***Halszkaraptor* skull**
date	23/10/2016
voxel size (µm)	12.97
optic	Hasselblad 210mm / 100mm
Average energy (keV)	180
Filters (mm)	Cu 7 W 0.3
propagation distance (mm)	11000
sensor	sCMOS PCO edge 5.5
Scintillator	LuAG:Ce 500 µm + meniscus
insertion device	W150 ID19
filling mode	200 mA
ID Gap (mm)	35
projection number	3499
scan geometry	360°, half-acquisition 200 pixels, vertical series 5 mm, double scan
subframe time (s)	0.01
exposure time (s)	0.05
accumulation level	5
time per scan (min)	4.83
number of scans	10
total time (h)	1
reconstruction	single distance phase retrieval / metallic oxide inclusions correction / texture enhancement algorithm
refs / dark	single

sample	***Halszkaraptor* teeth**
date	25/10/2016
voxel size (µm)	2.25
optic	Hasselblad 210mm / 100mm
Average energy (keV)	90
Filters (mm)	Mo 0.35 4 bars of aluminum of 5mm diameter
propagation distance (mm)	640
sensor	sCMOS PCO edge 5.5
Scintillator	LuAG:Ce 200 µm + meniscus
insertion device	BM5
filling mode	200 mA
ID Gap (mm)	N.A.
projection number	6000
scan geometry	360°, half-acquisition 1000 pixels, vertical series 4 mm
subframe time (s)	0.035
exposure time (s)	0.35
accumulation level	10
time per scan (min)	38.42
number of scans	3
total time (h)	2
reconstruction	single distance phase retrieval
refs / dark	each scan

Institutional abbreviations

ESRF, European Synchrotron Radiation Facility, Grenoble, France. **MPC**, Institute of Paleontology and Geology, Mongolian Academy of Sciences, Ulanbatar, Mongolia. **PMOL**, Palaeontological Museum of Liaoning, Yizhou, China; **RBINS**, Royal Belgian Institute of Natural Sciences, Brussels, Belgium. **YFGP**, Yizhou Fossil and Geology Park, Yizhou, China. **ZPAL**, Institute of Paleobiology, Polish Academy of Sciences, Warsaw.

Processing methods

Accumulation mode

Tomographic data acquisition was conducted by implementation of the recently developed accumulation mode. The accumulation mode for tomographic acquisition used here does not rely on physical modification of the tomographic setup but exploits the high recording frame rate of the latest generations of PCO.edge detectors (PCO AG, Kelheim, Germany) to broaden the dynamic range of the reconstructed tomographic images. During traditional tomographic acquisition, the detector records n projections per complete revolution of the sample in the path of the X-ray beam. With an accumulation count of 10, this is achieved by an initial tenfold increase in the amount of projections ($10n$) recorded within the angular range of which a projection is traditionally recorded only once (n), followed by progressive summing of these projections to generate a single image representing the angular range conventionally captured by a single projection. Since image summing implicitly increases ultimate image dynamic, such images may exceed the dynamic range of the individual ($10n$) projections and of the traditional (n) projections, as delimited by the 16-bit range, and are therefore recorded as 32-bit images. Finally, these 32-bit images are reconstructed following a standard tomographic reconstruction algorithm and remain available for conventional image enhancement solutions during post-processing. The process offers several benefits: in an anisotropic object, X-rays are poorly transmitted through the thickest dimensions and the recorded signal could be very weak and close to the noise of the detector. While increasing exposure time would help collecting more signal, it would also eventually saturate the detector. The accumulation mode and change of dynamic range allow for more signal to be collected while preventing for saturation of the detector, eventually providing a better signal-to-noise ratio. It also offers an alternative to the previously used attenuation protocol[31,32]: this protocol relied on plunging the object in glass or aluminium micro balls, which would prevent saturation of the detector in part where X-ray was barely attenuated (e.g. air surrounding the object). The contact of a delicate fossil with micro-balls was a potential source of damages in many cases. While the attenuation protocol generated data with better contrast, the use of accumulation mode also solves the problem of the weak recorded signal and prevents unnecessary manipulation of fossils.

Voeten et al. (submitted) provided a more extensive discussion of the motivation for and implementation of the accumulation mode.

Normalization of artifactual grey level gradients and metallic inclusions

Low frequency gradients and dense metallic inclusions commonly cause artefacts and other problems in palaeontological tomographic data. While these two problems are not intrinsically linked, they can be negotiated through similar approaches.

The low frequency gradient issue is expressed in tomographic data as a variation in grey values within a domain representing the same medium. The reconstructed volume of a skeletal fossil embedded in a matrix of uniform composition will nevertheless often present variable grey values within the sediment. However, the sediment should be represented uniformly: because X-ray radiation interacts with electrons in the medium, if the chemical composition and density do not change, the tomographic reconstruction should show similar grey values throughout this medium. This artefactual gradient can be elicited by several causes, including, but not limited to, beam hardening, diffusion of light in the scintillator, and local tomography. Regardless of the cause, the resulting variation in grey values can make segmentation and rendering challenging, if not impossible. A selective high-pass filter is an image processing operation optimized for removing structures larger than a given size that is capable of sufficiently correcting for this phenomenon.

Metallic inclusions are commonly present across a large variety of fossils and easily discernible in tomographic data through the relative density of their composing minerals that produces a distinct contrast with the surrounding bones and matrix. Such inclusions can develop in various locations near a fossil and may be scattered throughout the sediment, may coat the fossilized bones, or may fill biological cavities (e.g. cortical canals). The latter example is most problematic for X-ray tomography as adjusting the contrast to resolve the sediment-bone contrast often saturates these inclusions, thereby partially or completely obscuring structures of interest (such as the bone cortex itself). A simple approach to negotiate this issue is decreasing the grey values corresponding to the inclusion itself to values near the range of the bone and sediment, which enables proper contrast adjustment during data assessment. Application of a selective high-pass filter may again offer the desired solution: subtracting almost all low frequencies in the image will only leave the edges of the considered feature. In the specific case of metallic inclusions, their shape and finer details will remain while the grey values representing this structure will be normalized relative to the sediment and fossils.

The processing pipeline presented here offers the possibility to apply two distinct high-pass filters to the image in the spatial domain; one optimized for correcting gradient problems and the second

one for metallic inclusions. Each high-pass filter acts within distinct predetermined thresholds, thereby restricting its impact to specific parts of the image. This can be achieved through the application of two filter types (median or circular average), and/or by acting on features of independent size (size of median window or radius of circular average). The two filters can be applied independently, as in many cases, only one of the two corrections is required.

To correct for the described gradients, the filter must act on a region larger than the largest structure of interest to be visualized, which often exceeds 100 pixels. Conversely, the correction for metallic inclusions is typically applied with a very small radius (or window) of a few pixels (typically 3 to 9 pixels).

As both filters rely on thresholding, they allow for preservation of the structures of interest: since metallic inclusions are defined by grey levels significantly higher than the surrounding material, it is often easy to define a threshold that will only impact these inclusions specifically. For the gradient correction, it is important to avoid the typical grey levels of bones to prevent obscuring of the bone-sediment contrast.

In the specific case of the fossil described here, only metallic inclusions were corrected for (Extended Data Figure 1a-d).

Detail of the process as coded in MATLAB:

Consider an original image im

1. Gradient correction:
    1. The value of lower threshold T_{low} is subtracted from the image. All remaining positive values are set to 0:
    $im_{min}=min(im- T_{low},0)$
    2. Blurring is applied to im_{min}, producing $im_{minblur.}$ The median is calculated using the medfilt2 function of MATLAB; the circular average is obtained through a 2D filter created with the fspecial and imfilter functions of MATLAB. Fspecial is then defined as H=fspecial('disk',radius) and imfilter(im_{min},H,'replicate')
    3. Finally, the $im_{minblur}$ image is subtracted from the original image:
    $im1=im-im_{minblur}$
    4. If gradient correction is not applied, then im1=im

2. Metallic inclusion correction:
    1. The value of the upper threshold, T_{up}, is subtracted from im1 after gradient correction. All resulting negative values are set to 0:
    $im_{max}=max(im1- T_{up},0)$
    2. Blurring (from median or circular average) is applied to im_{max}, producing $im_{maxblur}$
    3. Finally, the $im_{maxblur}$ is subtracted from the original image:
    $im2=im1-im_{maxblur}$
    4. If gradient correction is not applied, then im2=im1

3. If the correction is applied on 16-bit data, the grey level range of im2 may be stretched across 65535 values, as defined by a min and a max input value throughout the image stack.

4. An unsharp mask may be applied to im2 to sharpen structures, the appropriate input parameter being the *alpha* parameter of the MATLAB fspecial function that controls the shape of the Laplace operator.

Tomographic texture enhancement

In order to isolate and enhance the texture present in the tomographic data, a process was developed that relies on image local gradient mapping, not unlike a Sobel operator. MATLAB **(**The MathWorks Inc., Natick, Massachusetts, United States) offers a command (circshift) that shifts all pixel columns (and/or rows) in an image laterally by a given amount of pixels, incrementally returning all pixels shifted outside the image to the opposite side. When an image subjected to a circshift of 1 pixel (im_{circ}) is subtracted from the original image (im), homogeneous areas will produce a corresponding field with value 0. Conversely, areas with a contrast gradient will produce numerical fields in which the field values of the resulting image cumulatively reflect local contrast present in the original image through corresponding grey values (Extended Data Figure 1e-h).

For a given image of the stack (im), this process is operated toward the four edges: first by using a circshift of +1 and -1 in the first dimension for the left edge and right edge, respectively; secondly by repeating the process in the second dimension for the bottom edge and top edge, respectively.

When the four absolute values obtained through these four operations are summed, an image is obtained that visualizes the isotropic 2D gradient distribution in the horizontal plane through grey values (im_{hor}):

im_{hor}= abs(im-circshift(im,1,1))+abs(im-circshift(im,-1,1))+ abs(im-circshift(im,1,2))+abs(im-circshift(im,-1,2))

The same operation is conducted in the vertical plane by adding the overlying image (im_o) and the underlying image (im_u) in the stack: Firstly, two images are created by obtaining the absolute values of im-im_o and im-im_u. These two images are subsequently summed, thereby providing an image that quantifies information on the vertical gradient (im_{vg}). The four sets of circshift are applied to im_{vg} to create information on contrast gradients along the vertical axis (im_{vert}).

By summing these two images, we obtain a quantified representation of local gradients in three dimensions (im_{lg}):

$im_{lg=}$ im_{vert+} im_{hor}

The grey level intensity observed in the resulting image im_{lg} is therefore proportional to the local gradient in the original image.

Because homogeneous materials are not defined by single grey level values, a blurring can be applied to the image using a circular average filter (through the fspecial function in MATLAB using the 'disk' filter) and/or a median filter. Both filters can act on independent window sizes.

Because the strongest contrast gradient in the image does not necessarily represent a boundary of particular interest (e.g. the fossil-air interface), computing the n^{th} root of the image, with n being any positive integer, helps buffering strong signals. When a high value for n is adopted, the intensity of a strong gradient will be significantly attenuated relative to less intense gradients.

A texture-coded 3D volume obtained following this approach can be either evaluated as is, or recombined with the original data set through addition or multiplication to exhibit absorption contrast and texture contrast simultaneously.

Origin of the specimen

Originally poached from the Ukhaa Tolgod locality[33-36] (according to associated documents, deposited at MPC together with the specimen), MPC-D102/109 resided in private collections in Japan and England for an unknown amount of time. In 2015, the specimen was transferred to the Royal Belgian Institute of Natural Sciences through the French company Eldonia. Subsequent negotiations between the RBINS, Eldonia and Mongolian authorities, in the scope of the official cooperation agreement between the Ministry of Education, Culture and Science of Mongolia, the Belgian Science Policy Office and the RBINS, led to the official return of the specimen to the Institute of Paleontology and Geology, Mongolian Academy of Sciences. MPC-D102/109 was incompletely prepared when it arrived at RBINS. Preliminary preparation under the supervision of PG allows us to certify that this specimen is not a composite. Further analyses at the ERSF (below) did reveal limited restoration at the exposed side of the snout and hand: besides those for consolidating the specimen, the restoration had not affected the integrity of the studied fossil. Sediments surrounding the skeleton are composed of fine-grained, poorly sorted, poorly consolidated, and moderate reddish-orange sandstone. Large-scale sedimentary structures could not be identified, but it might be partly explained by the small size of the observable area. The matrix closely resembles Facies S ('Structureless Sandstones Lacking Oriented Concretions or Cross-strata') described at Ukhaa Tolgod[33], and interpreted as fluvio-related eolian deposits[33-36]. This facies is the most fossiliferous at Ukhaa Tolgod and most vertebrate fossils are usually preserved as perfectly articulated skeletons[34,35] like MPC-D102/109. However, similar deposits are more widely distributed within the Bayn Dzak Member of the Djadokhta Formation[36], so it cannot be excluded that the indications on the associated documents are erroneous and that MPC-D102/109 was in fact found in another locality, such as Bayn Dzak, within the Djadokhta Formation of southern Mongolia.

Integrity of the specimen

In order to establish the integrity of the specimen, we assesed at the scan data obtained at the BM05 and ID19 beamlines of the ESRF, both in normal mode and in scattering mode, to determine the relationships between bones, and the natural structures present within the lithic matrix (Extended Data Figures 2-3). The block is crossed by several fractures, including one consolidated with glue: nevertheless, the sediment shows good structural continuity and all the fractures in the matrix continue within the bones (Extended Data Figures 2a-d). This indicates that the specimen is not an

assemblage of bones from distinct individuals glued together on the matrix block: all restoration done on the specimen before our analyses was thus aimed at consolidating and stabilising the block including the skeleton. Minor portions of few exposed bones had been restored in plaster. In the skull, only the anterior half of both nasals and the anterior end of the exposed (right) maxilla, anterior to the antorbital fenestra, have been reconstructed in plaster. The rest of the exposed skull shows no signs of being restored, as also confirmed by the overall correspondence and symmetry with the cranial elements still inside the block matrix. In the postcranial skeleton, only some elements of the exposed hand were restored in plaster: restoration affected particularly the badly preserved epiphyses (proximal and distal extremities) of many elements and metacarpal I entirely (Extended Data Figure 3). Given that epiphyseal dissolution affected also the right forelimb that is still inside the block, the absence of epiphyseal bone in the exposed hand is not caused by restoration, and is interpreted as a pre-burial phenomenon (e.g., soft tissue decay and invertebrate scavenging that targeted the least ossified elements of the skeleton). It is noteworthy that a comparable preservation pattern is also present in the only known specimen of *Mahakala omnogovae*, where extensive epiphysial dissolution is widespread among most forelimb bones, but in the hindlimb remains limited to the knee joint[16].

The skeleton, with the exception of the exposed scapula, is articulated and in anatomical continuity. The skull is still articulated with the first cervical vertebra, and the entire pre-caudal series of vertebrae is complete and in anatomical connection. Along the majority of the vertebral series, the zygapophyses of each vertebra still contact the corresponding zygapophyses in the adjacent vertebrae. In the neck, a partial torsion of the series is present between the 4th and 5th vertebra (i.e., the anterior part of the neck is rotated clockwise relative to the posterior part): nevertheless, the presence in both 4th and 5th vertebra of the unique cervical morphology that diagnoses *Halszkaraptor* (i.e., marked elongation of the centrum, absence of epipophyses, absence of pneumatic foramina, presence of a narrow and crest-like neural spine restricted to the anterior part of the neural arch, presence of a single postzygapophyseal process that is posteriorly convex, fusion of the ribs to the centrum) confirms that these elements belong to the same individual. The first caudal vertebra is slightly dislocated relative to the sacrum, but still in continuity with the pelvis. The caudal series is almost complete and articulated. The exposed scapula is clearly dislocated anteriorly to its natural position, having been displaced in a position ventral to the middle of the neck. Scan analysis shows that the sediment associated with the scapula is clearly in discontinuity with the sediment below. We provisionally consider the scapula as part of this individual because its

shape and proportions recall those in other paravians: note that the exclusion of this poorly preserved bone from the comparative and phylogenetic analyses does not affect the interpretation of *Halszkaraptor*.

The left hand appears to have suffered epiphyseal dissolution, and on first glance this part may have been retrofitted (Extended Data Figure 3). The zeugo- and stylopodial long bones, and the epiphyseal portions of the preserved manual elements are largely lacking, as are some diaphyseal aspects. This is probably caused by a differential dissolution of the fossil bones where the thicker and more robust diaphyses have generally been preferentially preserved, a taphonomic phenomenon already documented among Mongolian theropods housed in the MPC collection.

The left metacarpal I appears to be reconstructed completely. In general, the left manual domain largely rests on what appears to represent reconstructed matrix. This is evident by the aberrant structure of the deeper matrix. Although the surface as a whole appears to be moderately retrofitted, it has been applied at an angle, as can be seen by the local “wedge-shape” of the inserted filling (Extended Data Figure 3b). This is also evident from the distance between the main elements and some small, isolated splints that still reside in their original configuration in the main slab (Extended Data Figure 3c-e). It is noteworthy that the presence of these deeper lying splints is consistent with an original association between the main slab of matrix and the hand itself. Those splints actually originated from the third metacarpal and the first phalanx of the third finger, respectively. As can be seen in the cross-sections (Extended Data Figure 3b, e), the main (visible) portions of the manual elements are actually embedded in thin "slabs" of matrix that are placed on a support of introduced material. The space between the referred fragments (still present in the original position in the matrix) and the corresponding elements is filled with such material. The small fragments originally continued seamlessly into their adjacent elements, but were then separated by a crack/fracture. That crack was later filled in with additional material. If this filler would not have been present, these fragments would have a near-perfect fit to their corresponding elements. The fact that we can still see this relation across the introduced filler confirms that these manual elements were originally also part of the specimen.

Additional lines of evidence, based on comparative analysis, support the integrity of MPC-D102/109:

Serial homology between cervical and caudal vertebrae. The unusual planar surfaces of the anterior cervical zygapophyses (i.e., the interzygapophyseal articular facets are oriented dorsoventrally,

instead of partially mediolaterally) are unique among theropod dinosaurs. This unique articular pattern is shared with the anterior caudal vertebrae, suggesting serial homology and functional unity between the anterior end posterior parts of the vertebral column.

Presence of muscoloskeletal adaptations in the pelvis and hindlimb related to the anterior shift of the center of mass due to neck hyperelongation. The extreme elongation of the neck in MPC-D102/109 implies an anterior shift of the center of mass in this animal relative to the pelvic region. *Halszkaraptor* and *Mahakala* show a hypertrophied, "shelf-like" supratrochanteric process in the ilium and the development of an elongate fossa bordered by a lateral crest on the posterolateral margin of the femur[16] (equivalent to the *ansa iliofibularis* of birds[26]), a combination of features absent in other non-avialan tetanurans, but shared with short-tailed birds[26]. In modern birds, these features are osteological correlates indicating an increased hip extension moment arm of the *iliofibularis* muscle, and are interpreted as muscoloskeletal adaptations for counterbalancing the anterior shift of the center of mass, that in birds is mainly due to tail reduction coupled with the great expansion of the pectoral musculature[26]. This peculiar combination of features in the pelvis and femur is thus functionally linked to neck elongation, and supports the integrity of MPC-D102/109.

Distribution of halszkaraptorine synapomorphies along the entire skeleton. The skeleton of MPC-D102/109 shares a unique combination of derived features exclusively with *Mahakala omnogovae*. These features, interpreted as synapomorphies of Halszkaraptorinae, are present in the skull, vertebrae and appendicular skeleton, and confirm the integrity of MPC-D102/109 as a single (not composite) individual (see diagnosis of Halszkaraptorinae).

Although not listed among the halszkaraptorine synapomorphies, the combination of features in the frontal in MPC-D102/109 is also uniquely shared with *Mahakala* among theropods[16]. This morphology supports the referral of the skull to a *Mahakala*-like taxon, is consistent with the shared features in the postcranial skeleton (see diagnosis of Halszkaraptorinae), and thus further corroborates the integrity of the specimen: the frontal is dorsally convex and moderately vaulted; the interorbital region is narrower than the frontoparietal suture; the postorbital process is positioned at the same level as the frontoparietal suture (not displaced anteriorly as in other dromaeosaurids[17,42]); the shallow supratemporal fossa is limited to the dorsal surface of the postorbital process; the orbital roof bears a distinctly rimmed margin.

Histological analysis

Synchrotron scanning revealed some details of the histology of the skull, mandible and appendicular skeleton of MPC-D102/109 (Extended Data Figure 4). These were compared with histological preparations of the exposed left hindlimb of MPC-D102/109. The left tibia and fibula were sampled at the mid-shaft region (Extended Data Figure 5). A thin section was prepared using standard petrographic methods, and studied with an Orthoplan (Leitz, Wetzlar, Germany) polarized light microscope and photographed and analyzed with a Firecam with Leica Application Suite software (Leica Microsystems, Wetzlar, Germany).

In general, the bony tissues are poorly preserved, but in some areas significant features can be seen nonetheless. The overall morphology is consistent with those of other small-bodied maniraptorans, including the other halszkaraptorine *Mahakala*[37]. The innermost cortex of the tibia is nearly completely remodeled, and is sharply truncated from the primary outer cortex (dotted fill) by a resorption line (solid line). A single line of arrested growth (LAG) can be seen in the innermost region of the primary cortex: the same pattern is consistently observed in all virtual slices from the skull and the appendicular skeleton (Extended Data Figures 4, 5). The fibula consists of poor to moderately vascularized primary bone, but shows some resorption features on the external surface. The periosteal surface is poorly preserved, which could be the result of resorption processes, but it may also be the result of diagenesis or preparation. The cortex of the tibia consists of two main layers of bone: an innermost layer of remodeled bone and outermost layer of primary bone. The innermost layer is extensively remodeled and shows an abrupt erosional border with the medullary cavity. Remodeling features in the innermost cortex and border with the medullary cavity are clear. Remnants of inner circumferential lamellae (ICL) are sparsely distributed on the contact between cortex and medullary cavity. No continuous inner circumferential lamellae could be observed, but local patches of this layer can be seen forming the boundary between remodeled innermost cortex and medullary cavity. The interstitial tissue between the numerous secondary osteons in the innermost cortical layer show large, randomly oriented and occasionally confluent osteocyte lacunae, typical for woven bone[38]. The tissue is well vascularised with secondary osteons, and abruptly transitions into the outermost cortex with a cementing line which crosscuts the secondary osteons. The layer of primary bone is composed of parallel-fibered tissue and contains at least one observable line of arrested growth. The primary bone of the cortex is moderately vascularized with mostly longitudinal canals, but sparse circumferential anastomoses can also be observed near the border with the remodeled innermost cortex. No clear decrease in vascular density towards the peripheral cortex could be observed, nor were outer circumferential lamellae identified. The

specimen shows a mature histology with several remodeling features. However, because a number of vascular canals is open to the periosteal surface, and no decrease in vascular density in the peripheral cortex is obvious, we argue that the specimen was a subadult rather than fully adult. The high density of longitudinal canals and the relatively low porosity is found in other paravians of comparable body size (e.g., *Archaeopteryx*, *Jeholornis*, *Mahakala*)[37]. The presence of at least one LAG also suggests it was at least one year old, which indicates high growth rates, comparable to other small-bodied stem-avians[37], but not as high as modern birds of similar size.

Phylogenetic taxonomy

Maniraptoriformes: The least inclusive clade containing *Ornithomimus velox* and *Vultur gryphus*.
Maniraptora: The most inclusive clade containing *Vultur gryphus* but not *Ornithomimus velox*.
Paraves: The most inclusive clade containing *Vultur gryphus* but not *Oviraptor phyloceratops*.
Scansoriopterygidae: The least inclusive clade containing *Epidendrosaurus ninchengensis* and *Epidexipteryx hui*.
Eumaniraptora: The least inclusive clade containing *Deinonychus antirrhopus* and *Vultur gryphus*.
Anchiornithidae: The most inclusive clade containing *Anchiornis huxlei* but not *Archaeopteryx lithographica*, *Vultur gryphus*, *Epidendrosaurus ninchengensis*, *Saurornithoides mongoliensis*, *Dromaeosaurus albertensis* or *Unenlagia comahuensis*.
Avialae: The most inclusive clade containing *Vultur gryphus* but not *Dromaeosaurus albertensis* or *Saurornithoides mongoliensis*.
Dromaeosauridae: The most inclusive clade containing *Dromaeosaurus albertensis* but not *Saurornithoides mongoliensis* or *Vultur gryphus*.
Halszkaraptorinae clade nov.: The most inclusive clade containing *Halszkaraptor escuilliei* but not *Dromaeosaurus albertensis*, *Unenlagia comahuensis*, *Saurornithoides mongoliensis* or *Vultur gryphus*.
Unenlagiinae: The most inclusive clade containing *Unenlagia comahuensis* but not *Dromaeosaurus albertensis*, *Microraptor zhaoianus* or *Vultur gryphus*.
Microraptorinae: The most inclusive clade containing *Microraptor zhaoianus* but not *Dromaeosaurus albertensis*.
Eudromaeosauria: The least inclusive clade containing *Dromaeosaurus albertensis*, *Deinonychus antirrhopus*, *Saurornitholestes langstoni* and *Velociraptor mongoliensis*.
Dromaeosaurinae: The most inclusive clade containing *Dromaeosaurus albertensis* but not

Velociraptor mongoliensis.

Velociraptorinae: The most inclusive clade containing *Velociraptor mongoliensis* but not *Dromaeosaurus albertensis*.

Systematic Palaeontology

Theropoda Marsh, 1881

Maniraptora Gauthier, 1986

Dromaeosauridae Matthew and Brown, 1922

Halszkaraptorinae subfam. nov.

Halszkaraptor escuilliei gen. et sp. nov.

Diagnosis (Autapomorphies marked by *): platyrostral premaxilla forming 32% of snout* and bearing 11 teeth*; external naris posterior to premaxillary oral margin; rod-like jugal with ascending process excluded from orbital margin and forming only 10% of postorbital bar*; ventral ramus of postorbital rod-like; 22 presacral vertebrae; neck forms 50% of snout-sacrum length*; absence of epipophyses*; ridge-like cervical neural spines restricted to 2nd-5th vertebrae*; postzygapophyses on cervicals 2-5 fused medially and forming single lobate processes*; pleurocoels restricted to cervicals 7-9; tuber-like neural spines in tail restricted to 1st-3rd vertebrae*; proximalmost chevrons large and pentagonal*; transition point in 7th-8th caudals; 3rd finger longer than 2nd; elongate pedal phalanx III-1 is 47% of metatarsal III*.

Differential diagnosis. Among Halszkaraptorinae, *Ha. escuilliei* differs from other taxa in showing horizontally oriented paroccipital processes (processes pendant in *M. omnogovae*, unknown in *Hu. perlei*); axial centrum apneumatic (a pleurocoel is present in *M. omnogovae*; unknown in *Hu. perlei*); absence of epipophyses (present along whole neck in *M. omnogovae*; unknown in *Hu. perlei*); postzygapophyses on cervicals 2-5 fused medially and forming single lobate processes (distinct postzygapophyses in *M. omnogovae*; unknown in *Hu. perlei*); neural spines in tail restricted to 1st-3rd vertebrae as low tuber-like processes and absent in other caudal vertebrae (neural spines extended more distally along the tail in *M. omnogovae*; unknown in *Hu. perlei*); transition point in 7th-8th caudals (in *M. omnogovae*, the transition point is placed more distally, in 11th-12th caudals; unknown in *Hu. perlei*); posterolaterally-directed anterior caudal ribs (the condition in

Halszkaraptor is probably plesiomorphic, being it shared with non-halszkaraptorine dromaeosaurids; laterally-oriented in *Mahakala*; unknown in *Hu. perlei*); humerus longer than 60% of femur (in *M. omnogovae*, the humerus is about half the femur length; unknown in *Hu. perlei*); fourth trochanter of femur developed as a robust tuber (not developed in *M. omnogovae*; unknown in *Hu. perlei*); length of metatarsal III <80% of femur (in *M. omnogovae*, the length of metatarsal III is 107% of femur length; since the types of *Ha. escuilliei* and *M. omnogovae* show comparable femur lengths, the difference in metatarsal elongation is unlikely to be a size-related feature; unknown in *Hu. perlei*); trochleae of metatarsals I and II do not curve medially (in *M. omnogovae*, both trochleae of metatarsals I and II diverge medially, metatarsal I is unknown in *Hu. perlei*); distal shaft of metatarsal III does not overlap metatarsal II (in both *Hu. perlei* and *M. omnogovae*, the medial margin of metatarsal III describes a convex border that dorsally overlaps metatarsal II, the latter appearing as transversely constricted in extensor view); metatarsal IV appressed to metatarsal III for whole length (in *Hu. perlei*, the distal end of metatarsal IV diverges laterally from the rest of metatarsus); metatarsal IV subequal to metatarsal II in length (in *Mahakala* and probably also *Hulsanpes*, metatarsal IV is longer than metatarsal II); pedal phalanx III-1 is 47% length of metatarsal III (in *M. omnogovae*, pedal phalanx III-1 is about 36% of metatarsal III, unknown in *Hu. perlei*).

Emended diagnosis of *Mahakala omnogovae*. Halszkaraptorine dromaeosaurid with unique combination of: a ledgelike depression at the confluence of metotic strut and posterior tympanic recess on the anterior face of the paroccipital process (provisional autapomorphy, unknown in other Halszkaraptorinae); pendant paroccipital processes (unknown in *Hu. perlei*); laterally oriented anteriormost caudal ribs (see *Halszkaraptor* diagnosis); a short forelimb (humerus not longer than 50% femur, relatively longer in *Ha. escuilliei*, unknown in *Hu. perlei*); the absence of a cuppedicus fossa (present in *Ha. escuilliei*, unknown in *Hu. perlei*); distal ends of both metatarsal I and II diverge medially (unknown in *Hu. perlei*); metatarsal III longer than femur (unknown in *Hu. perlei*); distal end of metatarsal III with symmetrical constriction proximal to trochlea (constriction absent in *Ha. escuilliei*; constriction asymmetrical, more developed medially in *Hu. perlei*).

Emended diagnosis of *Hulsanpes perlei.* Halszkaraptorine dromaeosaurid with unique combination of: dorsal overlap of metatarsal III on distal third of metatarsal II more extensive than in *M. omnogovae*; in extensor view, medial margin of metatarsal III with constriction between distal shaft and trochlea; distal end of shaft of metatarsal IV diverges from metatarsal III proximal to metatarsal III distal constriction (divergence absent in *Ha. escuilliei*; in *M. omnogovae*, the

divergence starts at level of the distal constriction of metatarsal III shaft).

Extended morphological description of MPC-D102/109

The *Halszkaraptor escuilliei* holotype, not counting the missing distal end of tail, is 75 cm long. The smooth external texture of the bones, extensive obliteration of neurocentral sutures, and histological analysis (above) indicate that it represents a subadult individual.

Skull and mandible

The skull is lightly built, and the preorbital region forms 60% of basicranial length. The combined premaxillae form a platyrostral snout tip, about 180% wider than dorsoventrally tall in front of the narial margin, differing from most theropods that show oreinirostral premaxillae. Each premaxilla is elongate (forming 32% of snout length) and low, bearing eleven teeth, the highest number among dinosaurs. Among other theropods, only *Pelecanimimus* and spinosaurids have more than five premaxillary teeth. The relative elongation of the premaxilla recalls the condition in many avialans[39,40]. The external naris is dorsolaterally oriented and placed posterior to the premaxillary body as in spinosaurids, most avialans (e.g., *Archaeopteryx*[39], *Confuciusornis*[40]), *Anchiornis* and *Mei*[41]. Each premaxillary body houses an enlarged chamber that branches rostrally, anterior to the narial border, leading to the numerous neurovascular foramina that open on both dorsolateral and palatal surfaces of the premaxilla (Extended Data Figure 8). This feature is shared with aquatic/semiaquatic reptiles, e.g., crocodiles (Extended Data Figure 8) and pliosauroids[12], and has been described in two theropods: *Spinosaurus* and *Neovenator*[13]. This enlarged chamber is interpreted as the rostral termination of the neurovascular system including blood vessels and the maxillary branch of the trigeminal nerve[12,13]. Compared to other reptiles, the extent and development of the neurovascular chambers in the premaxilla of *Halszkaraptor* recalls crocodiles (Extended Data Figure 8) in being extensively developed medially and dorsally. In the terrestrial *Neovenator*, instead, the neurovascular system does not extend along the medial and dorsal parts of the premaxillae, being mostly developed along the lateral part of the bone[13]. As in other dromaeosaurids (e.g., *Shanag*, *Tsagaan*, *Velociraptor*[17,44]) and differing from the majority of pennaraptorans[19,20, 40,41], the preantorbital part of the maxilla is shallow and elongate. Although the antorbital region is relatively elongate as in most dromaeosaurids, the antorbital fenestra recalls other pennaraptorans with a relatively shortened snout (e.g., *Yi*[20], *Confuciusornis*[40], *Khaan*[19]) in being taller than long. The posterior end of both nasals is preserved. The nasals are triangular,

tapering posteriorly and diverging along their medial margins. As in most pennaraptorans (e.g., *Velociraptor*[42], *Khaan*[19]) and differing from the alvarezsauroids like *Shuvuuia*[43-45], the preorbital bar lacks a distinct prefrontal bone, and the large posterodorsal process of the lacrimal contacts the frontal overhanging the orbit. The anterodorsal process of the lacrimal differs from *Shuvuuia* and *Velociraptor* in being much shorter, as in oviraptorosaurs[19] and basal paravians (e.g., *Anchiornis*)[41]. The ventral process of the lacrimal is relatively stout and inclined anterodorsally, as in *Mei*. The frontals are similar to *Mahakala*[16]: they are trapezoidal in dorsal view (not triangular as in anchiornithids and troodontids[41]), with large orbital contributions, a narrow interorbital space and bear triangular postorbital processes placed at the level of the parietal suture (in other dromaeosaurids, the posterior margin of the postorbital process is placed anterior to the parietal suture, producing a "T"-shaped frontal[17,42]). The frontal participation in the supratemporal fossa is limited to a shallow triangular depression placed on the postorbital process. The posterior margin of the frontals is oriented transversely, differing from the notched margin present in *Shuvuuia*[43]. The parietals are fused and lack a sagittal crest. The intertemporal region of the skull roof is wider than the interorbital region (as in most paravians[41,42], and opposite to the condition in *Shuvuuia*[43]). The postorbital is slender, with an upturned anterodorsal process and a rod-like ventral process that forms the whole posterior margin of the orbit. In other dromaeosaurids, the postorbital bar is significantly more robust and plate-like[17,42]. In *Shuvuuia*[43,44], the ventral process of postorbital is anteriorly curved and does not contact the jugal. The jugal is rod-like and bears a small ascending process that forms 1/10 of the posterior margin of the postorbital bar, differing from most birds (e.g., *Confuciusornis*[40]) and *Shuvuuia*[43,44] that completely lack the postorbital process. The jugal also differs from other dromaeosaurids (e.g., *Tsagaan*, *Velociraptor*[17,42]) where the suborbital ramus is deeper and has a well-developed postorbital process that contributes to the orbital margin. The quadratojugal is not fused to the jugal (the jugal-quadratojugal fusion occurs in *Shuvuuia*[44]) and fits into the posterior cleft of the jugal. The quadrate is gently bent posteriorly in lateral view, and forms the medial margin of a large paraquadrate fenestra (depth ~1/3 of postorbital skull depth), a feature shared with other dromaeosaurids (e.g., *Velociraptor*)[42]. The laterosphenoid is exposed above the intratemporal bar due to the marked doming of the frontoparietal. The dorsomedial margin of the supratemporal fenestra is horizontal. The squamosal is large and triangular. As in other dromaeosaurids (e.g., *Velociraptor*)[42], the height of the infratemporal fenestra is about half of skull height at the orbit, and the dorsal border of the fenestra is longer than the ventral border. This condition differs from *Shuvuuia*, where the infratemporal fenestra is proportionally taller (~3/4 of

skull height) and the dorsal margin is constricted by the quadrate-postorbital contact[43]. The supraoccipital is low and excavated posteriorly by a couple of shallow fossae. The paroccipital process is short and stout, oriented horizontally (not pendant as in *Mahakala*)[16] and has a distal apex that is twisted to face posterodorsally, as in other dromaeosaurids[17]. As in other small-bodied maniraptorans[16,44], the foramen magnum is larger than the occipital condyle, and is distinctly wider than tall. This condition differs from those in the troodontids *Byronosaurus*, *Sinovenator* and *Zanabazar*[46] , that bear a foramen magnum taller than wide, or that in specimens referred to *Troodon*[46] and in *Velociraptor*[42], with a relatively smaller and subcircular foramen. Synchrotron scanning revealed the palatal elements. The parabasisphenoid rostrum is slender and subtriangular in ventral view, not inflated as in ornithomimids[18] and some troodontids[46]. Some elements of the pterygopalatine complex are preserved, slightly displaced dorsally, inside the orbital chambers. As in other dromaeosaurids[17], the ventral and the alveolar margins of the dentary are subparallel. The lateral surface of the dentary houses a shallow groove that widens posteriorly. The external mandibular fenestra is low and elongate. The splenial is not exposed laterally, differing from troodontids and most dromaeosaurids[42,46]. The retroarticular process is blunt, as in *Xiaotingia* and *Confuciusornis*[40]. The maxilla accomodates about 20-25 alveoli, with 16 of them placed anteriorly to the antorbital fenestra. The tooth row reaches posteriorly to the base of the preorbital bar, as in some basal paravians[44] (e.g., *Anchiornis* and *Mei*), differing from the more anteriorly restricted dentition of *Shuvuuia* and *Pelecanimimus*[45]. About 20-25 alveoli are estimated to have been present in the less preserved dentary tooth row. Unlike in alvarezsaurids and troodontids (e.g., *Shuvuuia*, *Zanabazar*)[43,46], the dentary alveoli are distinct and do not form a continuous groove. Among theropods, the maxillary and dentary dental formula of *Halszkaraptor* is comparable to those in some coelophysoids, in baryonychine spinosaurids[8], and in unenlagiine dromaeosaurids[23], and is intermediate between those of the majority of theropods, including toothed avialans, basal oviraptorosaurs, microraptorines and eudromaeosaurs - that bear less numerous but relatively larger teeth - and those in other maniraptoriforms (i.e., *Pelecanimimus*, alvarezsauroids, therizinosauroids and derived troodontids) that bear more numerous but relatively smaller teeth[5,17,43,46]. As in other dromaeosaurids, the dentition is heterodont with variable crown height, differing from the tiny and uniform dentition in *Pelecanimimus*, alvarezsaurids[43,45] and some troodontids[46]: the premaxillary teeth bear a deep root and an incisiviform crown; whereas the posterior dentition is formed by more fang-like teeth with a relatively shorter root and a concave distal margin of the crown. There is no evidence of serrations on the teeth, as in other basal dromaeosaurids[23], in basal paravians[44] –

including toothed birds – and in parvicursorines[43]. The cross section of the maxillary and dentary tooth crowns is labiolingually compressed and elliptical. Synchrotron scanning also revealed disparity in the pattern of tooth replacement between the rostral and the posterior teeth: only four premaxillary teeth show a replacement germ, whereas the majority of the maxillary teeth are associated with a replacement tooth.

Vertebral column

The presacral vertebrae include 10 cervicals and 12 dorsals. The neck is markedly elongate, being about 290% the length of the skull and 150% the length of the trunk. As a consequence, the neck forms 50% of the snout-sacrum length, the highest ratio among Mesozoic paravians. In other long-necked maniraptoriforms, such as ornithomimids, the neck forms about 40% of the snout-sacrum length[18], and only some oviraptorosaurs show a neck elongation comparable to *Halszkaraptor*[19]. As in ornithomimosaurs[18], neck elongation is mainly due to elongation of each vertebra, and not by increase in vertebral count, as in oviraptorosaurs[19]. The longest cervical vertebra (6th) is four times as long as deep. Each cervical centrum recalls parvicursorines[43] in being transversally compressed ventrally, but differs from Mongolian alvarezsaurids in being amphicoelous[47]. Furthermore, the ventral surface of the cervical centra differs from alvarezsaurids and unenlagiines (e.g., *Austroraptor*, *Unenlagia paynemili*) in lacking a ventral sulcus bound by lateral ridges[17,47]. The neural arches do not extend beyond the level of the centra, as in other dromaeosaurids[16,17] and differing from most maniraptoriforms that have more elongate centra relative to the neural arches[18,19,47,48]. The cervical neural spines are very low, ridge-like and limited to the first five vertebrae. In other dromaeosaurids (e.g., *Deinonychus*[21]), the neural spines are more developed along the whole neck, and plate-like in lateral view. The first five neural arches are unique among theropods in lacking interpostzygapophyseal spaces: instead, each pair of postzygapophyses forms a single lobate process with a convex posterior margin. Although an interpostzygapophyseal lamina is widespread among the anterior cervicals of many maniraptoriforms (e.g., *Gallimimus*[18], *Shuvuuia*[47], *Falcarius*[48]), it is usually cleft in the middle by the postspinal fossa, forming a gently concave posterior margin of the neural arch: in *Halszkaraptor*, the postspinal fossa is absent, and the posterior border of the neural arch is convex in dorsal view. No epipophyses are present, and shallow pneumatic foramina are present only in the 7th to 9th cervical centrum. The diapophyses are positioned at the anterolateral corners of the vertebrae, at the bases of the prezygapophyses. The cervical ribs are not longer than the centra and fused to both parapophyses and diapophyses, as in

Mahakala[16]. The cervicodorsal vertebrae have narrow keels but lack hypapophyses. The dorsal vertebrae lack pneumatic foramina. One cervicodorsal parapophysis is preserved and is clearly stalked; a feature shared by alvarezsaurids[47] and paravians[17,40]. The neural spines are low and moderately fan-shaped, as in basal coelurosaurs and small-bodied paravians. A few fragments of the dorsal ribs are exposed, and an almost complete dorsal rib, still inside the matrix, is revealed by synchrotron scanning. The sacrum includes six vertebrae. The ventral surface of the sacrum bears a longitudinal sulcus that is shorter and deeper than in *Mahakala*[16]. The proximal 20 caudal vertebrae are well-preserved. The transition point is between caudals 7 and 8 - more proximal than in *Mahakala*[16] - and is less abrupt than in most paravians[17,21,41] (i.e., the transition from proximal caudal vertebral morphology to the distal tail vertebrae is gradual). As in *Mahakala* and Unenlagiinae[16,17], the caudal vertebrae lack the extreme elongation of both prezygapophyses and chevrons shared by microraptorines and eudromaeosaurs[21]. The proximal caudal ribs are moderately elongate, posterolaterally directed (not laterally as in *Mahakaka*[16]) and quadrangular in dorsal view (not triangular as in *Anchiornis*[41]). The proximal tail vertebrae share with *Mahakala* the unique combination of moderately elongate centra (not "box-like" as in most paravians), wide and horizontal zygapophyses, and prominent zygodiapophyseal laminae that form lateral shelves[16]. The neural spines are reduced, tuber-like, and restricted to the first three vertebrae. The middle caudal vertebrae differ from those in many basal paravians[17,41] in that they are not significantly elongate, being not longer than the anterior caudal vertebrae; they have relatively robust, upturned prezygapophyses, as in *Mahakala* and most non-paravian theropods, differing from the slender zygapophyses present in the mid-caudals of other dromaeosaurids[21]. The anterior chevrons are large, pentagonal and platelike. Most of the pectoral girdle is not preserved. The sternal plates are exposed dorsally. They are large, D-shaped and not fused medially.

Appendicular skeleton

The preserved part of the scapular blade is slender. As in *Austroraptor* and *Mahakala*, the forelimb is relatively shorter than in most dromaeosaurids[16,17]. The proximal end is not preserved in both humeri. Nevertheless, the preserved part (55-60% of femur length) indicates that the bone was relatively longer than in *Mahakala*, but relatively shorter and stouter than those of most paravians. Distally, the humerus is relatively flattened anteroposteriorly. The radius is only slightly more slender than the ulna. The ulna shares with *Mahakala* an ovoid cross section and a transversely narrow posterior margin, an unusual condition absent in other paravians[16], but differs from the other

halszkaraptorine in being straight posteriorly. There is no evidence of quill knobs. As in the humerus, the distal end of the ulna is flattened. No carpal bones are present. The hand has a morphology that is unique among theropods. Metacarpal I is missing, and its original length is estimated at about 40% of metacarpal II by the *in situ* position of phalanx I-1, a value comparable to most dromaeosaurids[21,49]. Manual phalanx I-1 is relatively shorter and stouter than in other paravians, being about half of metacarpal II. As in *Microraptor*[49], the distal end of this phalanx does not reach the end of metacarpal II. The first ungual is moderately curved. Although the distal end of metacarpal II is missing, its length can be estimated by the *in situ* position of manus phalanx II-1. Phalanx II-2 is longer than phalanx II-1 but not markedly elongate to the degree seen in other paravians[41,49]. The second manual ungual is poorly preserved and appears subequal in size to the first. As in *Mahakala*, metacarpal III is not gracile, being it slightly more robust than metacarpal II, whereas in the majority of other paravians it is usually the most gracile metacarpal[41,49]. As in scansoriopterygids[20], and differing from the majority of theropods, the third finger is the most robust and much longer than the second. The non-ungual phalanges of the third finger are subequal in length: the proportions among these phalanges differ from the majority of theropods, that usually bear the third phalanx significantly longer than the sum of the preceding two, but also differ from the unusual proportions of scansoriopterygids, where the first phalanx is longer than metacarpal III. The iliac preacetabular blade is slightly longer than the postacetabular ala, and has a shallow cuppedicus fossa that is not found in *Mahakala*[16]. As in *Mahakala*[16], the supratrochanteric process is hypertrophied and projects laterally, forming a distinct shelf. A similar condition is present in *Buitreraptor*, where most of the dorsal margin of the postacetabular blade is flexed laterally[17]. In other paravians where it is present, the supratrochanteric process is variably developed as a tuber (e.g., *Rahonavis*)[17]. The pubis is missing and the plate-like ischium is poorly preserved. The 76 mm long femur has a robust greater trochanter, a flange-like anterior trochanter not reaching the proximal end of the femur and separated from the greater trochanter by a cleft, and a low tuber-like 4th trochanter. In *Mahakala*, there is no evidence of a distinct 4th trochanter. The proximal end of the femur, including the location of the posterior trochanter, is poorly preserved. In the posterior surface of the distal end of the femur, an elongate posterolateral ridge is confluent with the ectocondylar tuber, and laterally bounds a distinct fossa elongate proximodistally; a combination of features shared exclusively with *Mahakala*[16]. The tibia measures 131% of femoral length. The slender fibula reaches the proximal tarsals. The feet are complete and articulated, although some elements are poorly visible, being overlapped by adjacent bones. The metatarsus is relatively shorter than in

Mahakala, and is only 80% of femur length (in *Mahakala* it is longer than the femur[16]): because the two taxa have comparable femoral sizes, this difference is not size-related. The splint-like first metatarsal articulates with the distal end of the medial surface of metatarsal II. The distal ends of both metatarsals II and III are ginglymoidal as in some dromaeosaurids[17] (e.g., *Deinonychus*[21]). As in other halszkaraptorines[15,16] and many basal avialans[22], the proximal half of metatarsal III is not constricted and is dorsally convex, differing from the "subarctometatarsalian" condition in unenlagiines and microraptorines. The distal shaft of metatarsal III differs from those of *Hulsanpes* and *Mahakala* in that it does not overlap metatarsal II and lacks a distinct transversal constriction proximal to the trochlea: the condition in *Hulsanpes* and *Mahakala* is also present in the unenlagiine *Neuquenraptor*[17]. Metatarsal V is not preserved. The first ungual reaches distally the level of the articular facet of the second ungual. The phalanges in the second to fourth toe decrease in length distally. The second toe is short (about half the length of the third), with an abbreviated phalanx II-2 and a large falciform ungual, as in other eumaniraptorans[17,22]. Phalanx III-1 is elongate, and is about half the length of metatarsal III. The fourth pedal ungual reaches distally the level of the articular facet of the third ungual. Both third and fourth pedal unguals are low, slightly curved ventrally, and lack distinct flexor tubercles.

Phylogenetic analyses

We included *Halszkaraptor* in two widely sampled data sets focusing on coelurosaurian theropods. The first data set is the largest data matrix for Mesozoic theropod relationships and is an updated version of an analysis used to investigate body size and divergence rates among theropods[50], here modified to focus on maniraptorans. The second data set[51], focusing on coelurosaurian theropods, was recently updated for testing the phylogenetic affinities of the enigmatic paravian *Balaur*[22]. Both data sets were analysed using TNT[30]. In both analyses, we performed a first round of 100 replications of the “New Technology” search analysis, with default parameters, and then explored the shortest tree islands found performing “Traditional Search” analyses using default parameters, saving all shortest trees found. Nodal support was calculated in TNT saving all trees up to 10 steps longer than the most parsimonious results.

First data set. The first analysis includes 199 taxonomic units and 1773 morphological characters. The analysis found >99,999 shortest trees of 6456 steps each (Consistency Index excluding uninformative characters = 0.2092; Retention Index = 0.6054; Extended Data Figure 9). Halszkaraptorinae is supported by 13 synapomorphies (decay index pruning *Hulsanpes* =3, see

Diagnosis of Halszkaraptorinae).

Second data set. The second analysis includes 154 taxonomic units and 860 morphological characters. The character list has not been modified from the previous versions[22,51] (e.g., by including those characters or character states identified as synapomorphies of Halszkaraptorinae): accordingly, the second phylogenetic analysis represents an independent and unbiased test for the affinities of *Halszkaraptor* among Coelurosauria. The third halszkaraptorine taxon discussed here, *Hulsanpes*, was not included in the second analysis because all codable scores of *Hulsanpes* in the second character list are identical to those of *Mahakala*: the former was thus excluded from the data matrix, using the principles of safe taxonomic reduction[52]. The analysis found >99,999 shortest trees of 3431 steps each (Consistency Index excluding uninformative characters = 0.3156; Retention Index = 0.6844; Extended Data Figure 10). The reduced strict consensus of the shortest trees found by the analysis after the *a posteriori* pruning of six "wildcard" taxa (*Epidendrosaurus*, *Graciliraptor*, *Hesperonychus*, *Kinnareemimus*, *Pyroraptor* and *Shanag*) places *Halszkaraptor* among the basalmost dromaeosaurid branch, as sister taxon of *Mahakala*. Halszkaraptorinae (the "*Halszkaraptor* + *Mahakala*" node) is supported by two unambiguous synapomorphies (decay index =1). The relatively weaker support for Halszkaraptorinae in the second analysis is probably biased by the absence in this data set of most of the halszkaraptorine synapomorphies discussed here, and included in the first analysis (i.e., most of these characters were considered as autapomorphies of *Mahakala* prior to the discovery of *Halszkaraptor* and thus were not included in the original data set[51], since they were considered phylogenetically uninformative).

In overall topologies, the results of the two analyses broadly overlap. In general, it is noteworthy that both analyses, developed independently, confirm the following pectinate series of successively closer sister taxa of avialans (birds): Ornithomimosauria, Alvarezsauroidea, Therizinosauria, Oviraptorosauria, Dromaeosauridae and Troodontidae. In particular, both analyses recover *Halszkaraptor* as closely related to *Mahakala* among the basalmost dromaeosaurid lineage. The only notable differences in the topologies recovered by the two analyses are the positions of Anchiornithidae and Scansoriopterygidae among Pennaraptora. In the first analysis, anchiornithids are recovered closer to avialans than troodontids, whereas in the second analysis they are recovered closer to troodontids than avialans. In the first analysis, scansoriopterygids are found among basal avialans, whereas they are recovered as basal oviraptorosaurs in the second analysis.

Dromaeosaurid synapomorphies present in *Halszkaraptor* (Fig. 3a-f) include the elongation of the

anterior (pre-antorbital) ramus of maxilla, the dorsal displacement of the maxillary fenestra in the antorbital fossa, the presence of an enlarged paraquadrate fenestra bordered dorsally by a prominent lateral process of the quadrate, the presence of subparallel dorsal and ventral margins in the dentary, the presence of a distinctly concave distal margin of the cheek teeth, the absence of basal constriction in the tooth crowns, the posterior extension of the neural arch to the level of the intercentral articulation in the cervical vertebrae, the presence of at least six sacral vertebrae, the presence of a ginglymoidal distal end of metatarsal II, and the presence of stout phalanges with abbreviated diaphyses in the second toe.

Morphometric analyses of the forelimb of *Halszkaraptor*

We compared the among-digits proportions in the hand of *Halszkaraptor* with those of 83 extant and fossil reptiles. Manual proportions in articulated specimens were taken from skeletal drawings and photographs of hand skeletons with all elements lying in the same plane and shown in extensor/flexor view. Digit length was defined as the distance between the proximal end of the metacarpus and the distal tip of the terminal phalanx. The sample was divided into six groups: I, quadrupedal terrestrial reptiles; II, non-tetanuran bipedal dinosaurs (basal dinosaurs with more than three functional metacarpals); III, non-avialan tetanurans (three-fingered, non-flying theropods); IV, Mesozoic avialans (flying birds); V, short-necked aquatic reptiles, and VI, long-necked acquatic reptiles. Here, a long-necked form is defined by the neck that is more than twice longer than the skull.

Once plotted according to the proportions among the first three fingers (i.e., the second-to-first fingers ratio vs the third-to-second fingers ratio), the quadrupedal and short-necked aquatic reptiles broadly overlap. Also, a subset of the long-necked aquatic reptiles plots with the quadrupedal and short-necked forms. This suggests that these aquatic reptiles did not evolve manual proportions distinct from their terrestrial ancestors. On the contrary, the tetanuran theropods, the flying birds and part of the long-necked aquatic reptiles are plotted in distinct clusters and do not overlap with other groups. The basal (non-tetanuran) dinosaurs are placed between the quadrupedal and tetanuran ranges, a result consistent with their phylogenetic positions along the evolutionary grade between quadrupedal archosaurs and three-fingered theropods. The enigmatic maniraptoran *Scansoriopteryx* is plotted well above the ranges of all groups, due to its aberrant third finger: this position, also distinct from non-avialan tetanurans and flying birds, is consistent with the hypothesis that scansoriopterygids evolved unique gliding adaptations not related to the origin of the feathered

wings of birds[20].

The unique proportions of *Halszkaraptor*'s hand also deviate from all other theropods. These unusual proportions are not biased by the preservation of the forelimb bones. The *in situ* positions of the preserved bones indicate that the hand is not disarticulated. As described above, the left hand of MPC-D102/109 lacks the first metacarpal, most of the second ungual and the majority of the epiphyses in metacarpal II, metacarpal III and non-ungual phalanges. The complete absence of the first metacarpal may be explained assuming that the bone was very short, with the epiphysial extremities (still unossified at the time of death) forming the great majority of the entire bone. This is consistent with the phylogenetic position of *Halszkaraptor* among paravian tetanurans: as is usual among non-ornithomimid tetanuran theropods[18,19,21,22,40,45,48], the first metacarpal is much shorter than the other metacarpals, and in many paravians it is represented by an extremely shortened diaphysis[21,22]. Among theropods, the first metacarpal is always shorter than the first phalanx of the first finger: we thus consider it likely that the missing metacarpal was not longer than the preserved manual phalanx P1-I.

Based on comparisons with the hands of other paravian theropods[21,40,41,49], we assume that the preserved elements in the fingers of MPC-D102/109 represent no less than 75% of the original lengths of the bones. Following this hypothesis, we inferred 1000 alternative values of the original lengths for the manual digits of MPC-D102/109, increasing the lengths of the preserved fingers to randomly-sampled values ranging between 100% and 125% of the actual values, and used these 1000 pseudo-replicates to estimate a conservative distribution of among-digits proportions in *Halszkaraptor*. The entire distribution of pseudo-replicates of *Halszkaraptor* plots into the distribution of the long-necked aquatic reptiles, and does not overlap other groups (in particular, the other maniraptorans): it ranges between 1.74 to 1.96 for digit II to I ratio, and between 1.08 to 1.19 for digit III to II ratio. The value of *Halszkaraptor* plotted in Fig. 4a, (1.84, 1.13), is based on the mean values of the 95% concentration ellipses of the pseudo-replicate sample.

We used a broadly-sampled morphometric data set of modern and fossil birds (ref. 53) to contextualise the aquatic adaptations in the forelimb of *Halszkaraptor*. The original data set includes 245 ornithurine birds, with the extant taxa grouped into six categories according to their habitual locomotory affinity: non-swimmer (including both flying and flightless forms), foot-propelled underwater swimmer, wing-propelled underwater swimmer, surface swimmer, plunger, and foot-and-wing-propelled underwater swimmer (see ref. 53 for details). We restricted the analysis to the ten pectoral and forelimb measurements directly available from *Halszkaraptor* (sternum length,

sternum width, humerus length, humerus mid-shaft anteroposterior diameter, humerus mid-shaft mediolateral diameter, ulna length, ulna mid-shaft anteroposterior diameter, ulna mid-shaft mediolateral diameter, metacarpus length and metacarpus mid-shaft mediolateral diameter). All measurements were log-transformed. *Halszkaraptor* shows a mediolateral diameter of the long bones proportionally wider than most birds, and clusters among the wing-propelled swimmer taxa in both humeral and ulnar proportions. Following ref. 53, we performed a Principal Component Analysis (PCA) of the correlation matrix of the data set to identify which locomotory group(s) best fit *Halszkaraptor*. The first three Principal Components describe >95% of the variance in the sample. The PCA loadings indicate that PC1 describes size variation, and thus cannot be used to discriminate between locomotory modes. The loadings of the PC2 relate to the mediolateral expansion (flattening) and the proximodistal contraction (shortening) of the forelimb bones. PC3 is mostly loaded by sternum mediolateral expansion, and thus might be related to the pectoral musculature development. In a plot of PC 2 and 3, the foot-propelled underwater swimmer group, the surface swimmer group, the plunger group, and foot-and-wing-propelled underwater swimmer group all share an important overlap with the non-swimmer group (Fig. 4b). The morphofunctional domain of the wing-propelled underwater swimmer group represented by penguins markedly deviates from the whole sample. The other wing-propelled underwater swimming birds partially overlap the surface swimmer and the non-swimming group. *Halszkaraptor* plots into the wing-propelled underwater distribution, in a position intermediate between penguins and the other members of that group, but distinctly separated from the other groups. As in wing-propelled birds, the forelimb bones of *Halszkaraptor* are relatively shorter than in most birds, and distinctly flattened craniocaudally (wider mediolaterally).

It is noteworthy that *Halszkaraptor* does not cluster among non-swimming birds, in particular, it does not plot within the group including flightless or ground-dwelling avians; instead it is plotted within aquatic, wing-propelled birds (i.e., intermediate between alcids and penguins). This result is in agreement with the unusual finger proportions discussed above: both analyses predict that the forelimb of *Halszkaraptor* was functionally adapted to a forelimb-assisted mode of swimming.

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Phylogenetic data sets

First data set (updated from ref. 22, 29)

OTU	Sources for coding
Achillesaurus manazzonei	Martinelli and Vera 2007
Achillobator giganticus	Perle et al. 1999; Turner et al. 2012
Adasaurus mongoliensis	Turner et al. 2012
Albertonykus borealis	Longrich and Currie 2009b
Albinykus baatar	Nesbitt et al. 2011
Allosaurus fragilis	Gilmore 1920; Chure 2000; Madsen 1976
Alnashetri cerropolicensis	Makovicky et al. 2012
Alvarezsaurus calvoi	Bonaparte 1991; Novas 1997
Alxasaurus elesitaiensis	Russell and Dong 1994
Ambiortus dementjevi	Kurochkin 1999; O'Connor and Zelenkov 2013
*Anchiornis huxleyi*_type	Xu et al. 2009; Hu et al. 2009a
*Anchiornis huxleyi*_referred_specimen	Hu et al. 2009a
Anserimimus planinychus	Barsbold 1988; Kobayashi and Barsbold 2006; Bronovicz 2011
Anzu wyliei	Lamanna et al. 2014
Apatoraptor	Funston and Currie 2016
Apsaravis ukhaana	Clarke and Norell 2002
Archaeopteryx spp.	Witmer 1990; Elżanowski and Wellnhofer 1996; Elżanowski 2001; Elżanowski 2002; Mayr et al. 2007; Rauhut 2013
Archaeorhynchus spathula	Zhou and Zhang 2006; Zhou et al. 2013
Archaeornithura	Wang et al. 2016
Aurornis xui	YFGP-T5198, Godefroit et al. 2013b
Austroraptor cabazai	Novas et al. 2008; Currie and Paulina Carabajal 2012
Avimimus portentosus	Kurzanov 1987; Vicker Rich et al. 2002
Balaur bondoc	Csiki et al. 2010; Brusatte et al. 2013
Bambiraptor feinbergorum	Burnham et al. 2000; Burnham 2004; Senter 2006
Banji long	Xu and Han 2010
Beipiaosaurus inexpectus	Xu et al. 1999; Xu et al. 2009b
Beishanlong grandis	Makovicky et al. 2010
Bohaiornis guoi	Hu et al. 2011; Li et al. 2014
Boluochia zhengi	O'Connor et al. 2011b
Bonapartenykus ultimus	Agnolin et al. 2012

Borogovia gracilicrus	Osmolska 1987
Buitreraptor gonzalezorum	Makovicky et al. 2005
Byronosaurus jaffei	Makovicky et al. 2003
Caenagnathasia martinsoni	Currie et al. 1994
Caenagnathus sp.	Currie et al. 1994
Cathayornis yandica	O'Connor 2009; O'Connor and Dyke 2010
Caudipteryx spp.	Ji et al. 1998; Zhou and Wang 2000; Zhou et al. 2000
Ceratonykus oculatus	Alifanov and Barsbold 2009
Changchengornis hengdaoziensis	Ji et al. 1999
Changmaornis houi	Wang et al. 2013
Changyuraptor yangi	Han et al. 2014
Chirostenotes pergracilis	Gilmore 1924, Currie and Russell 1988
Citipati osmolskae	Clark et al. 1999, 2001, 2002
Coelophysis rhodesiensis	Raath 1969, 1977; Bristowe and Raath 2004
Coelurus fragilis	Carpenter et al. 2005b
Concornis lacustris	Sanz et al. 1995
Confuciusornis spp.	Chiappe et al. 1999
Deinocheirus mirificus	Osmolska and Roniewicz 1970; Kobayashi and Barsbold 2006; Lee et al. 2014
Deinonychus antirrhopus	Ostrom 1969, 1974, 1976; Brinkman et al. 1998; Gishlick 2002; Grellet–Tinner and Makovicky 2006; Senter 2006; Turner et al. 2012; Parsons and Parsons 2015
Dromaeosaurus albertensis	Colbert and Russell 1969; Currie 1995
Elmisaurus spp.	Osmólska, 1981, Currie 1989
Elsornis keni	Chiappe et al. 2007
Enigmosaurus mongoliensis	Barsbold 1983; Zanno 2010b
Eocathayornis walkeri	Zhou 2002; O'Connor 2009
Eoenantiornis buhleri	Zhou et al. 2005
Eopengornis martini	Wang et al. 2014
Eosinopteryx brevipenna	YFGP-T5197, Godefroit et al. 2013a
Epichirostenotes curriei	Sues 1997
Epidendrosaurus ningchengensis	Zhang et al. 2002; Czerkas and Yuan 2002
Epidexipteryx hui	Zhang et al. 2008
Erliansaurus bellamanus	Xu et al. 2002c; Zanno 2010b
Erlikosaurus andrewsi	Barsbold and Perle 1980; Clark et al. 1994; Zanno 2010b
Euparkeria capensis	Ewer 1965
Falcarius utahensis	Zanno 2010a
Feitianius paradisi	O'Connor et al. 2015
Fukuivenator paradoxus	Azuma et al. 2016
Gallimimus bullatus	Osmólska et al. 1972; Kobayashi and Barsbold 2006

Gansus yumenensis	You et al. 2006
Ganzhousaurus nankangensis	Wang et al. 2013
Garudimimus brevipes	Kobayashi 2004; Kobayashi and Barsbold 2005a
Gigantoraptor erlianensis	Xu et al. 2007
Gobipteryx minuta	Elżanowski 1974, 1977; Kurochkin 1996; Chiappe et al. 2001
Gobivenator mongoliensis	Tsuihiji et al. 2014
Graciliraptor lujitanensis	Xu and Wang 2004a
Hagryphus giganteus	Zanno and Sampson 2005
Halszkaraptor escuilliei	This study
Haplocheirus sollers	Choiniere et al. 2010b; Choiniere et al. 2014
Harpymimus oklandikovi	Kobayashi 2004; Kobayashi and Barsbold 2005b
Hebeiornis fengningensis	Zhang et al. 2004
Hesperonychus elizabethae	Longrich and Currie 2009a
Hesperornis regalis	Marsh 1880; Witmer 1990
Heyuannia (Ingenia) yanshini	Barsbold 1981
Heyuannia huangi	Lü 2002; Lü et al. 2005
Hollanda luceria	Bell et al. 2010
Houornis caudatus	Wang and Liu 2015
Hongshanornis longicresta	Zhou and Zhang 2005; Chiappe et al. 2014
Hulsanpes perlei	High resolution photographs of type specimen
Huoshanornis huji	Wang et al. 2010
Iaceornis marshi	Clarke 2004
Iberomesornis romerali	Sereno 2000; Sanz et al. 2002
Ichthyornis spp.	Clarke 2004
Incisivosaurus gauthieri	Xu et al. 2002a; Balanoff et al. 2009
Iteravis huchzermeyeri	Zhou et al. 2014
Jianchangornis microdonta	Zhou et al. 2009
Jianchangosaurus yixianensis	Pu et al. 2013
Jinfengopteryx elegans	Ji et al. 2005; Ji and Ji 2007
Jixiangornis orientalis	Ji et al. 2002b; Nesbitt et al. 2009c
Khaan mckennai	Clark et al. 2001; Balanoff and Norell 2012
Kol ghuva	Turner et al. 2009a
Limenavis patagonica	Clarke and Chiappe 2001
Linhenykus monodactylus	Xu et al. 2011a; Xu et al. 2013
Linheraptor exquisitus	Xu et al. 2010; Xu et al. 2015
Linhevenator hani	Xu et al. 2011b
Longicrusavis houi	O'Connor et al. 2010
Longipteryx chaoyangensis	Zhang et al. 2001; O'Connor 2009

Longirostravis hani	Hou et al. 2004; O'Connor 2009
Longusunguis kurochkini	Wang et al. 2014
Machairasaurus leptonychus	Longrich et al. 2010
Mahakala omnogovae	Turner et al. 2011
Mei long	Xu and Norell 2004; Gao et al. 2012
Meleagris spp.	Harvey et al. 1968; Witmer 1990; Bochensky and Campbell 2006
Microraptor spp.	Xu et al. 2000; Hwang et al. 2002; Xu et al. 2003
Microvenator celer	Makovicky and Sues 1998
Mononykus olecranus	Perle et al. 1994
MPC D 100/140	Tsuihiji et al. 2016
MPCD 100/42	Barsbold 1981; Barsbold et al. 1990; Senter 2007
MPCD 100/44	Barsbold et al. 1987
Nankangia jiangxiensis	Lü et al. 2013
Nanshiungosaurus brevispinus	Zanno 2010
Neimongosaurus yangi	Zhang et al. 2001; Zanno 2010
Nemegtomaia barsboldi	Lü et al. 2004; Fanti et al. 2012
Neuquenornis volans	Chiappe and Calvo 1994
Neuquenraptor argentinus	Novas and Pol 2005
NGMC 91	Ji et al. 2001
Nomingia gobiensis	Barsbold et al. 2000
Nothronychus graffami	Zanno et al. 2009; Zanno 2010
Nothronychus mckinleyi	Kirkland and Wolfe 2001; Kirkland et al. 2005; Zanno 2010; Smith 2014
Nqwebasaurus thwazi	de Klerk et al. 2000; Choiniere et al. 2012
Ornitholestes hermanni	Osborn 1917; Carpenter et al. 2005
Ornithomimus spp.	Russell 1972; Makovicky et al. 2004
Oviraptor phyloceratops	Osborn 1924; Clark et al. 2002
Parabohaiornis martini	Wang et al. 2014
Parahongshanornis chaoyangensis	Li et al. 2011
Parvicursor remotus	Karhu and Rautian 1996; Chiappe et al. 2002b
Patagonykus puertai	Novas 1997
Patagopteryx deferrariisi	Chiappe 2002
Pelecanimimus polyodon	Perez–Moreno et al. 1994
Pengornis houi	Zhou et al. 2008; O'Connor and Chiappe 2011
Philovenator curriei	Xu et al. 2012b
Piscivoravis lii	Zhou et al. 2013
Protarchaeopteryx robusta	Ji and Ji 1997; Ji et al. 1998
Protopteryx fengningensis	Zhang and Zhou 2000

Pterygornis dapingfangensis	Wang et al. 2015
Qiupalong henanensis	Xu et al. 2011
Rahonavis ostromi	Forster et al. 1998
Rapaxavis pani	Morschhauser et al. 2009
Rinchenia mongoliensis	Barsbold 1986
Sapeornis chaoyangensis	Czerkas and Ji 2002; Zhou and Zhang 2003; Hu et al. 2010; Gao et al. 2012
Saurornithoides mongoliensis	Norell et al. 2009
Saurornitholestes langstoni	Sues 1978
Schizooura lii	Zhou et al. 2012
Segnosaurus galbinensis	Perle 1979; Zanno 2010
Serikornis sungei	PMOL-AB00200
Shanag ashile	Turner et al. 2007
Shenzhouraptor spp.	Ji et al. 2002a; Zhou and Zhang 2002, 2003; Ji et al. 2003a; O'Connor et al. 2012
Shenzhousaurus orientalis	Ji et al. 2003b
Shixinggia oblita	Chang and Kun 2005
Shuvuuia deserti	Chiappe et al. 2008; Sereno 2001
Similicaudipteryx yixianensis	He et al. 2008; Xu et al. 2010b
Sinornis santensis	Sereno et al. 2002
Sinornithoides youngi	Russell and Dong 1993; Currie and Dong 2001
Sinornithosaurus millennii	Xu et al. 1999; Xu and Wang 2000; Xu and Wu 2001
Sinovenator changii	Xu et al. 2002
Sinraptor dongi	Currie and Zhao 1993; Paulina Carabajal and Currie 2012
Sinusonasus magnodens	Xu and Wang 2004b
Sulcavis geeorum	O'Connor et al. 2013
Suzhousaurus megatherioides	Li et al. 2007, 2008
Talos sampsoni	Zanno et al. 2011
Tanycolagreus topwilsoni	Carpenter et al. 2005a, b
Teviornis gobiensis	Kurochkin et al. 2002
Therizinosaurus cheloniformis	Barsbold 1976; Perle 1982; Zanno 2010
Tianyuraptor ostromi	Zheng et al. 2010
Troodon spp.	Russell 1969; Currie 1987; Currie and Zhao 1994b
Tsaagan mangas	Norell et al. 2006
Tugriken Shireh Parvicursorine (MPCD 100/99, 100/120)	Suzuki et al. 2002
Unenlagia comahuensis	Novas and Puerta 1997; Norell and Makovicky 1999; Novas 2000
Unenlagia paynemili	Calvo et al. 2004a
Utahraptor ostrommaysorum	Kirkland et al. 1993; Britt et al. 2001
Vegavis iaai	Clarke et al. 2005

Velociraptor mongoliensis	Osborn 1924; Norell and Makovicky 1997, 1999; Barsbold and Osmolska 1999
Vorona berivotrensis	Forster et al. 2002
Wulatelong gobiensi	Xu et al. 2013
Xiaotingia zhengi	Xu et al. 2011c
Xixianykus zhangi	Xu et al. 2010a
Xixiasaurus henanensis	Lü et al. 2010
Yanornis martini	Zhou and Zhang 2001; Zhou et al. 2002, 2004
Yi qi	Xu et al. 2015
Yixianornis grabaui	Zhou and Zhang 2001; Clarke et al. 2006
Yixianosaurus longimanus	Xu and Wang 2003
Yumenornis huangi	Wang et al. 2013
Zanabazar junior	Norell et al. 2009
Zhenyuanlong suni	Lü and Brusatte 2015
Zhongjianornis yangi	Zhou et al. 2010
Zhongornis haoae	Gao et al. 2008
Zhouornis hani	Zhang et al. 2013
Zuolong sellei	Choiniere et al. 2010a

Data matrix in tnt format

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Eoenantiornis 1?01?0?100?0?01?0?10?1???011????10010????0?00000110?1??????????????????0?00??1?1??
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Eopengornis 1?1??0?1?000?0?????????????1??????0??0??????0?????
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Epichirostenotes ?????0??1???????????1010????11001?00000001?0??01???
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Gobivenator 10???0?????????????????1?000??100111000?000000001000?1010010101101O?1100100?1?011000100001000010001?0?????11?100??
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Longicrusavis 1011????0010????0?????0??01??????001?????0?00????1?????????????????????????
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Meleagris 1111?1??01100???00?????0?1101011?001011010000001001?????0????????0????0100011011 00???00?000?10?1?1?0110??1? 10011???01??1101100????????01100?11????00?1??11???????????100???1?0?0??1100?00??100?01110 1010?1?11?0110??1? 1000100000110101110110111101?0?????110101?1?0101110111001010?0101011100011100010110?0101?011?1111010 0?01?1110010?1???1?0??????1???1111011111?01?011?11????001??010?0?011????1111000?10101??00????00111100?1010?010?1? 1110001000010111010001 11?1100000010?0??1?110?0??11????1??0111000011??11011?0?101?11110?001101111100 1???1?0?01??1?1?0??0??? 0????1101??0000?110?10??10?01???11??101?????10??01?0?0101001 0??1111??0??0?0?0?

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Nashiungosaurus_brevispinus ???
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Nemegtomaia 01110010111107??10??1?111110110110?0000000100101117??0110110011111100?0000000011110001000000?001?1???000?00?
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Neuquenornis ??0??0??0?0??????????????????????????????0001???
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101????00?0?1000?????11???0?????????????????????????0??1??????1?1??????110?010010??1?????????????????00?1???11??00???????
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Nqwebasaurus ??????????????????????01?1???010001?000?100??0??????????0?????1??????????01?01?001?00???????0?????????
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Ornithomimus 000010?001000???00??1100100010011?0000100000000001?0000100001011110?1110000110000001000000?0100100????
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Oviraptor ?1??????1???????????1?0????011011?0????00??01?1???????01?0000111????00????????11???????0??????
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Parabohaiornis 1110?0?1?0?0?01?0?1000???111??1110010????10000??11?0?100?00010?1???????0??01?000??
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Parahongshanornis ??
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Parvicursor ??
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Patagonykus ??
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Patagopteryx ??0?????????????1?00???0???1??????1??1?1???
11?????????????????????????0???0????????1?????0???0?0?????0?????????????0?0?1000???????0?
01?????000??0010?0?0??1???011111011100001001??000?000?1101010?10?00????1??????0??0?????1??000?1???0?0??????????111?????
1?000???????????01???1000?0??0???1111000000010?00001????00???10?0010?010?1?101101100??10?100100010??11???00?1?1???0?
110????1?????????1110001l0??0?011?0?10??0?1??010?10?????????????1?????????0?????????1?????0??1?????????????1??0???0??????10???
1?????????101?111????0?10???0?????????????110?????????????0????????????????????1?1?????????1?0???000????????11??0000?
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Pelecanimimus ?0?0?0?000???1110?0001?11010??0?110000?00000000????00001001010l???1????01??1?0?????????0?00??
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1011?????????1?????????????????????????????0??1???01??????00?????????????0????0????1??0?????????????0???0???????????
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Pengornis 1010?0?10000??100?0???0??011??10101000???00000?1?0?0?101?0?01???1??????????????????????????0?0???
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Philovenator ??
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Piscivoravis ??
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111????01??1???1?????????????11?????1???????0??????0?????0?????????10?0??10?1?00101?0?01?1????????1???????0????1???1?
11?????????????????1110?01????11011?0?001???1??0?011??1?11????0?????????????0?????????????0?0?11?0????????1????0??0???????????
01??????????0????10?????????0?????????????1100?0?????????????????????????????1??111??01????0?1???????0?????????1??????0?????????
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Protarchaeopteryx 0????0??0000?0?10?11?????????????10?????????00???0???
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01?????????0???0??????00?0?????01??01110?0?0010??010????10?10??????11?0??000?????00??0????1??1?????????????????????11?0???
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10??00???0???0????????
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Protopteryx 101??0??0010?0??0????1???01?????1??????????00?????????????0?????????????????????????????????00?01??0?0?
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101?????????0??0??0?0????1?0??1011101??0?1?1?01?0001100l?0100???0?0?0101?011?11110????1101011011l??11?01?????
1001111100111?????1??11??10????????????11?????11??????000??????????1?????0???11?0??10????01?????01?0???1010?????1???
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Pterygornis ??????????????????????????????????0011??????0?0????0????0??0?01???1?????????????????????????????????010????
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Qiliania ??
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101?01?1?1?????????????1?????????????????????????0??1???????0???????1??????????00???11?????????????????0?????????????????????
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Rahonavis ??

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00?0????000?????010?0??0??11?001?0??0?00?0???0?????1000?0??1?0???????????0???????1??0?10?01?0??0?1??1???00????0????0?
0010????0???0?????01?????????0???0??????01?0??000?01????1???????00?1?????0???1????0????1?????1?0??00??????0????11010??1??
11????0?????0??1?????1??101?0??????????????0??1??????0?????????????????11???0?????????????01001000??00?????0???0???????
00???????0???????????10?0??0??0??0?????????0?0??????0?????1?????000????1????????0?000?0???0????10??1???0??????????0?01?
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0?????????????????????????0?????????????????????1????????????0???????1??0?????0???0?????????0??0?0????1???
1?????????????????????????????????00??10?01?0?1001?0?0?0?0????1?0?00???0????????00???0?0?????????????????????01?????????????
01??1???00???1?000?????1??00?0??1??????????0???00??????10?01010?01??1?????001?0?01???0???????0?01?????????????????0?0??????
0??????0??0?01??10?0?0???10??0???????0??0?????10???????1?????1?????1?????0?0??????????1??00?01?????????????0????????0??????
00??????0????????0??0?????????000?0???????0?????????????????0???????????0?1????101111101???1?111100001?001?00101??00??1?????
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Saurornithoides ?00010?10000?0??0???010?1001100?110100?000000001?100??010??01??1?????????????1?????????????????????????????????????
00???1??1??11?????1110???1?0??10????00???0000?010?1?0??010???????1?0???1?????????????????????????1?????????????????????
00????0???1?0?
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01???10?1?????????0???0???????11??00?????????0???????1?0???0?1?1?????????????????????1?0???0?????0????????????0????
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Character List of First data set

1): Skull, anteroposterior length in adult: less than (0); more than (1) 4/5 of femoral length. The length of the skull is here defined as the distance from the anteroventral margin of premaxilla to the posteroventral margin of the mandibular condyles of the quadrate.
2): Skull, preorbital region, length in adult: more than half of skull length (0); less than half of skull length (1). (Modified from Rauhut 2003).
3): Premaxilla, body in front of the external naris, angle between the anterior margin and the alveolar margin: more than 75º (0); less than 75º (1). (Modified from Rauhut 2003).
4): Premaxilla, subnarial body, length compared to length of preantorbital part of maxilla: not longer (0); longer (1).
5): Premaxilla, shape of internarial process: transversely flattened (0); dorsoventrally flattened (1). (Sereno 1999).
6): Premaxilla, nasal process, posterior end, position relative to the preorbital bar: anterior (0) at the same level (1). (Modified from O'Connor 2009).
7): Premaxillary body, pneumatisation: absent (0); present (1).
8): Premaxilla, subnarial process, posteriormost extent relative to posteroventral corner of external naris: posterior or coincident (0); anterior (1). (Modified from Rauhut 2003).
9): Premaxilla, oral margin: smooth (0), crenulate (1). (Modified from Senter 2010).
10): Premaxilla, anterior half of oral margin, teeth: present (0); absent (1).
11): Premaxillae in adult: unfused (0); fused (1). (Sereno 1999).
12): Premaxilla, subnarial body, proportions in lateral view: not taller than long (0); taller than long (1). (Modified from Holtz 2000).
13): Premaxilla-maxilla articulation, lateral surface, exposed subnarial foramen: absent (0); present (1). (Gauthier 1986; Langer and Benton 2006).
14): Premaxilla, fifth alveolus: absent (0); present (1).
15): Premaxillary teeth, serration: present at least in posterior teeth (0); absent in all teeth (1). (Modified from Sereno 1999).
16): Premaxillary teeth, crown cross-section shape: round-elliptical (0), asymmetrical (more convex labially, more flattened lingually) (1). (Modified from Holtz et al. 2004).
17): Premaxilla, buccal margin in lateral view: in the same plane as maxilla (0), set below the anterior buccal margin of the maxilla (1).
18): Premaxilla, medial palatal alae, development: widely contacting in front of vomers (0), reduced and separated (1). (Modified from Carrano and Sampson 2008; Holtz 2000).
19): Premaxillary teeth, size: subequal or smaller than maxillary teeth (0); larger than maxillary teeth size (1). (Modified from Sereno 1999)
20): Premaxillary teeth, first tooth size: comparable to (0); larger than (1) the remaining premaxillary teeth. (Modified from Senter 2010).
21): Maxilla, promaxillary recess/fenestra: absent (0); present (1). (Holtz 2000).
22): Maxilla, maxillary recess/fenestra: absent (0); present (1). (Gauthier 1986).
23): Premaxilla, participation to antorbital fossa: absent (0); present (1). (Senter 2010).
24): Maxilla, ventral process, lateral horizontal ridge bounding the antorbital fossa: absent (0), present (1). (Carrano and Sampson 2008).
25): Nasal, narial fossa: absent (0); present (1). (Rauhut 2003; Wilson et al. 2003; Eddy 2008).
26): Nasal, narial margin, distance from narial border of premaxilla: no more than 1/3 (0); more than 1/3 (1) of preorbital skull length. (Modified from Holtz et al., 2004).

27): Premaxilla, narial margin, anteroventral corner, position relative to the mid point of premaxillary oral border: anterior (0); posterior (1). (Modified from Rauhut 2003).
28): Maxilla, participation to the ventral margin of the external naris: absent (0); present (1).
29): Maxilla, palatal process, mediolateral development: narrow ridges (0); broad shelves (1).
30): Maxilla, palatal shelf, ventral surface: flat (0), with midline ventral toothlike projection (1). (Senter 2010).
31): Maxilla, antorbital fossa, anterior margin, anteroposterior extent: more than 1/5 (0); less than 1/5 (1) of antorbital fossa length. (Modified from Holtz 2000; Carrano and Sampson 2008; Wilson et al. 2003).
32): Maxilla, antorbital fossa, ventral margin, anteroposterior extent: more than (0); less than (1) 1/3 of the length of the antorbital fenestra. (Modified from Yates 2006).
33): Maxillary teeth ventral to orbit and ascending ramus of lacrimal: present (0); absent (1). (Modified from Gauthier 1986; Holtz 2000).
34): Cheek teeth (estimated sum of dentary and maxillary teeth), number: no more than 75, relatively large alveoli (0); more than 75, relatively small alveoli (1).
35): Maxilla, preantorbital process (anterior to antorbital fossa), length: subequal or less (0); more than (1) 2/5 of the length of the maxilla. (Modified from Sereno 1999).
36): Maxilla, anterodorsal margin, shape in lateral view: straight to convex (0); concave (1). (Modified from Rauhut 2003; Holtz et al. 2004).
37): Maxilla, dorsal process, posterodorsal extent dorsal to antorbital fossa: elongate and posteriorly directed (0); strongly reduced (1). (Modified from Carrano and Sampson 2008).
38): Maxilla, ventral process, jugal overlap: less than (0); more than (1) 1/3 of maxillary length. (Modified from Wilson et al. 2003).
39): Maxilla, antorbital fossa, anteroventral margin: with (0); without (1) a raised rim. (Senter 2010).
40): Maxilla, antorbital fossa: distinct from subcutaneous surface (0); indistinct (1).
41): Maxilla, lateral lamina obscuring the anteriormost portion of the antorbital fossa in lateral view: absent (0), present (1). (Holtz et al. 2004).
42): Nasal, narial margin, position: anterior (0), posterior (1) to the anterior margin of the maxillary antorbital fossa.
43): Nasal, participation to the antorbital fossa: absent (0); present (1). (Rauhut 2003).
44): Premaxilla/maxilla/dentary, lateral surface, extensive pattern of grooves: absent (0); present (1). (Modified from Wilson et al. 2003).
45): Nasal, median crest/eminence: absent (0); present (1). (Modified from Holtz 2000; Rauhut 2003).
46): Nasal, dorsal surface: smooth (0); rugose (1). (Holtz et al. 2004).
47): Nasals: apneumatic (0); pneumatized (1). (Rauhut 2003).
48): Nasals, dorsal view: expanded posteriorly, so that the lateral margins diverge (0), width subequal throughout their length (1). (Holtz 2000).
49): Nasal, anteroposterior length along the medial suture: longer (0); shorter (1) than the frontal. (Maryańska et al. 2002).
50): Nasal, subnarial process: present (0); absent (1). (Sereno 1999).
51): Nasal, dorsal surface, row of foramina: absent (0); present (1). (Carrano and Sampson 2008).
52): Nasals: contact (0); do not contact (separated by the premaxillary posterodorsal processes) (1). (Modified from O'Connor 2009).
53): Prefrontal, participation to the anterior margin of orbit: present (0); absent (1). (Modified from Rauhut 2003).
54): Frontal-lacrimal contact: absent (0); present (1). (Modified from Gauthier 1986; Rauhut 2003).
55): Lacrimal, orbital margin, suborbital process: absent (0); present (1). (Currie and Carpenter 2000).
56): Lacrimal, ventral process, main axis in lateral view: anterodorsal (0); subvertical or slightly posterodorsal (1).
57): Lacrimal, posterodorsal corner, pneumatic recesses: absent (0); present (1). (Holtz 2000).
58): Jugal, anterior process, shape: unexpanded anteriorly (0); dorsoventrally expanded anteriorly (1). (Rauhut 2003).
59): Lacrimal, laterodorsal shelf bordering the antorbital fossa: absent (0); present (1). (Holtz 2000).
60): Lacrimal, anterodorsal process, length: more than 2/5 (0); less than 2/5 (1) of the lacrimal height. (Modified from Holtz 2000; Carrano and Sampson 2008).
61): Lacrimal, posterodorsal process: absent (0); present (1). (Senter 2010).
62): Lacrimal, anteroposterior length of the ventral process (at base) in lateral view: less than 1/3 (0); more than 1/3 (1) of the lacrimal height.
63): Jugal, participation to the antorbital fossa: absent (0); present (1). (Holtz 2000).
64): Lacrimal, ventral process, position of anterior half of the margin: above the ventral margin of the orbit (0); at the level of ventral margin of the orbit (1). (Modified from Rauhut 2003).
65): Jugal, postorbital process, height: more (0); less (1) than half orbit height. (Modified from O'Connor 2009).
66): Jugal, posterior (quadratojugal) process: unforked (0); posteriorly forked (1). (Modified from Holtz 2000; Rauhut 2003).

67): Jugal, anterior pneumatic recess: absent (0); present (1). (Holtz 2000; Rauhut 2003).
68): Lacrimal, laterodorsal recess, position: exposed laterally (0); in an anteriorly facing recess (1).
69): Infratemporal fenestra, ventral margin length: more than (0); less than (1) half orbit height.
70): Infratemporal fenestra, dorsoventral diameter: more than (0); less than (1); 3/4 of the orbital height.
71): Squamosal, distal margin of the quadratojugal process: closer to the posterior margin of the infratemporal fenestra (0); closer to the anterior margin of the infratemporal fenestra (1).
72): Frontal, shape of the lateral margin in dorsal view: describes a smooth transition between the anterior half and the postorbital process (0); describes an abrupt transition between the anterior half and the postorbital process (1). (Senter 2010).
73): Frontal, dorsal surface, supratemporal fossa: absent (0); present (1). (Modified from Sereno 1999; Norell et al. 2001).
74): Fronto-parietal, lateral longitudinal shelves medially directed: absent (0); present (1). (Coria and Currie 2002).
75): Frontal, interorbital region, degree of thickening: reduced, bone laminar in cross section (0); marked, bone dorsoventrally expanded (1). (Modified from Wilson et al. 2003).
76): Frontal, shape of the anterior half in dorsal view: trapezoidal (0); triangular (1). (Modified from Holtz 2000; Wilson et al. 2003).
77): Frontal, ventral surface, medial delimitation of the orbit: not expanded ventrally (0); expanded ventrally, forming a pronounced rim (1). (Modified from Rauhut 2003).
78): Parietal, length: less than 3/4 of the frontal (0), subequal or more than 3/4 of the frontal (1).
79): Parietal, dorsal surface, sagittal crest: absent (0), present (1). (Rauhut, 2003).
80): Parietals: unfused (0); fused (1).
81): Fronto-parietal fusion: absent (0); present (1). (Coria and Currie 2002).
82): Frontals, mediolateral width of the paired bones: less than (0); more than (1) 4/3 of frontal length.
83): Parietal, posterodorsal projection (nuchal plate): absent (0); present (1). (Wilson et al. 2003).
84): Squamosal, participation to the supratemporal fossa: absent (0); present (1). (Hwang et al. 2004; Benson et al., 2010).
85): Squamosal, participation to the dorsal margin of the infratemporal fenestra: subequal to the postorbital participation (0); wide, postorbital process of the squamosal anteriorly expanded, reduced postorbital participation to the dorsal margin of the infratemporal fenestra (1).
86): Squamosal, lateroventral (quadratojugal) process, ratio of proximodistal length to mid-length anteroposterior diameter: less than (0); more than (1) 3 times.
87): Squamosal, posterolateral shelf: absent (0); present and overhanging the quadrate head (1). (Senter 2010).
88): Postorbital, anterodorsal process, contact with the preorbital bar: absent (0); present (1). (Brusatte and Sereno 2008).
89): Postorbital, posterodorsal process: subequal or less than the anterodorsal process of the postorbital (0); longer than the anterodorsal process of the postorbital (1).
90): Postorbital, frontal (anterodorsal) process, ornamentation: absent, smooth lateral surface (0); rugose lateral surface (1). (Modified from Wilson et al. 2003; Currie and Carpenter 2000).
91): Postorbital, suborbital process bordering ventrally the eyeball: absent (0); present (1). (Modified from Wilson et al. 2003; Currie and Carpenter 2000).
92): Postorbital, ventral (jugal) process, cross section: subtriangular, longer than deep (0); “U”-shaped and transversely expanded (1). (Sereno 1999).
93): Postorbital, ventral (jugal) process, contribution to the posterior margin of the orbit: more than 1/2 (0); less than 1/2 (1) of the orbital margin.
94): Quadrato-articular articulation, anteriormost extent relative to the dorsoventral plane of the occipital condyle: ventral to posterior (0); anterior (1). (Modified from Holtz 2000; Rauhut 2003).
95): Quadrato-articular articulation, ventralmost extent: lies at the same level of the dorsal margin of the dentary (0), lies well below the dorsal margin of the dentary, at or close to the level of the ventral margin of the dentary (1). (Modified from Gauthier 1986).
96): Quadrate, posterior margin in lateral view: exposed (0), hidden by quadratojugal (1).
97): Quadrate shaft, posterior surface, pneumatic recess: absent (0); present (1). (Senter 2010).
98): Quadratojugal, participation to the paraquadrate foramen: extensive, comparable to the quadrate (0); reduced (foramen enclosed almost entirely within the dorsal process of the quadrate) (1). (Modified from Rauhut 2003).
99): Quadrate, dorsal condyles, number: one (0); two (1). (Senter 2010).
100): Quadrate, paraquadrate foramen margin, placement: a mid-height or dorsal (0); ventral, close to mandibular condyles (1). (Loewen et al. 2013).
101): Quadrate, distal end, lateral condyle, width: subequal in size or larger (0); narrower (1) than the mediodistal condyle. (Coria and Salgado 2000).

102): Quadrate, pterygoid process, dorsoventral expansion: reduced, reaches its greatest anteroposterior width dorsally to the mid-point of the dorsoventral axis of the quadrate (0); expanded, reachs its greatest anteroposterior width at the same level or ventrally to the mid-point of the dorsoventral axis of the quadrate (1).
103): Quadratojugal, ventromedial process for quadrate articulation: absent (0); present (1). (Modified from O'Connor 2009; Wilson et al. 2003; Carrano and Sampson 2008).
104): Quadratojugal, articulation with the squamosal: present (0); absent (1). (Modified from O'Connor 2009).
105): Quadratojugal, anteroventral (jugal) process, anteriormost extent in lateral view: does not (0); does (1) reach the level of the postorbital bar. (Modified from Holtz et al. 2004).
106): Quadratojugal, dorsal (squamosal) process in lateral view: slender (anteroposterior length at mid-height less than 1/3 of the length of the jugal process of the quadratojugal) (0); broad (anteroposterior length at mid-height longer than 1/3 of the length of the jugal process of the quadratojugal) (1). (Modified from Holtz et al. 2004).
107): Quadratojugal, dorsoventral diameter of the ascending process: more than 2/5 of the height of the orbit (0); less than 2/5 of the height of the orbit (1).
108): Quadratojugal, posteroventral process: absent (0); present (1). (Modified from Holtz et al. 2004).
109): Jugal-quadratojugal fusion: absent (0); present (1).
110): Supraoccipital, dorsoventral diameter in occipital view: less than twice the dorsoventral diameter of the foramen magnum (0); more than twice the dorsoventral diameter of the foramen magnum (1). (Wilson et al. 2003).
111): Parietal, tongue-like process overlapping the supraoccipital: absent (0); present (1). (Coria and Currie 2002).
112): Foramen magnum, shape: subcircular (0); elliptical, taller than wide (1).
113): Foramen magnum, mediolateral width: subequal or less than (0); more than (1), the width of the occipital condyle.
114): Occipital condyle, ventrolateral surface, pair of pneumatic cavities that join medially: absent (0); present (1). (Coria and Currie 2002).
115): Occipital condyle, angle formed with the basituberal process in lateral view: perpendicular or almost perpendicular (0); acute (1). (Coria and Currie 2002).
116): Basioccipital, participation to the basal tubera: present (0); absent (1). (Holtz 2000).
117): Basal tubera, mediolateral width between the paired processes: more than the mediolateral width of the occipital condyle (0); less than the mediolateral width of the occipital condyle (1). (Modified from Holtz 2000; Senter 2010).
118): Paroccipital processes, ventral rim of the base, position: above or level with the dorsal border of the occipital condyles (1); situated at or below mid-height of the occipital condyles (1). (Rauhut 2003).
119): Parabasisphenoid, anterior tympanic recess: absent (0); present (1). (Rauhut 2003).
120): Posterior tympanic recess: absent (0); present (1).
121): Paroccipital processes, distal end, placement relative to forame magnum: at the same level or dorsally (0); ventrally (1). (Modified from Holtz 2000; Currie and Carpenter 2000).
122): Forebrain: cilindrical and unexpanded (0); expanded and trapezoidal in dorsal view, leaves marked impressions on the inner surface of the neuroanterior bones (1). (Modified from Rauhut 2003).
123): Bulbous parasphenoid capsulae: absent (0); present (1). (Holtz 2000).
124): Pneumatic recess ventral to fenestra ovalis (subotic recess): absent (0); present (1).
125): Basisphenoid, basipterygoid processes, development: distinct pedicels (0); indistinct (1).
126): Basisphenoid, ventral recess: absent (0); present (1). (Holtz 2001; Rauhut 2003).
127): Basisphenoid: antero-posteriorly elongate (0); dorso-ventrally expanded (1). (Modified from Sereno 1999).
128): Basal tubera, notch separing from the exoccipital-opisthotic and the basisphenoid: absent (0); present (1). (Holtz et al. 2004).
129): Basipterygoid process, shape: anteroposteriorly short and fingerlike (approximately as long as wide) (0); elongate anteroposteriorly (longer than wide) (1). (Modified from Holtz et al. 2004; Senter 2010).
130): Basipterygoid processes, medio-lateral width: more than the mediolateral width across the basal tubera (0); less than the mediolateral width across the basal tubera (1). (Holtz 2000).
131): Basipterygoid process: solid (0); hollow (1). (Senter 2010).
132): Otosphenoid crest: vertical on the basisphenoid and prootic and does not border an enlarged pneumatic recess (0), well developed, crescentic, and thin, forming the anterior edge of the enlarged pneumatic recess (1). (Senter 2010).
133): Prootic, depression for pneumatic recess: absent (0); present as dorsally open (1). (Modified from Senter 2010).
134): Cranial nerve V, number: single (0); two (1). (Modified from Currie and Carpenter 2000).
135): Pituiary fossa, branches of the internal carotid artery, number: more than one, enter separately (0); a single common foramen (1). (Currie and Carpenter 2000).
136): Exit of the cranial nerves X and XI, position on braincase: laterally (0); posteriorly through a foramen lateral to the exit of cranial nerve XII and the occipital condyle (1). (Modified from Rauhut 2003; Senter 2010).
137): Vomers, posteriormost extent: anterior to the mid-point of the anteroposterior axis of the palatine (0); posterior to the mid-point of the anteroposterior axis of the palatine (1).
138): Vomera: anteriorly unfused (0); anteriorly fused (1). (Modified from Sereno 1999).

139): Pterygoid in ventral view; shape of the lateroposterior border, at the confluence of the quadrate process and the mandibular process: narrow incisure facing posteriorly (0); wide concavity facing laterally (1).
140): Palatines, contact medially: absent (0); present (1). (Currie and Carpenter 2000).
141): Palatine, pneumatic recess at the confluence of the maxillary process and of the vomeropterygoideus process: absent (0); present (1). (Currie and Carpenter 2000).
142): Pterygoid, accessory fenestra with the palatine: absent (0); present (1). (Gauthier 1986; Rauht 2003).
143): Palatal teeth: present (0); absent (1). (Rauhut 2003).
144): Palatine, jugal process: present (0); absent (1). (Senter 2010).
145): Ectopterygoid, ventral recess: absent (0); present (1). (Modified from Rauhut 2003).
146): Ectopterygoid and palatine, contact: absent (0); present (1). (Modified from Holtz 2000).
147): Suborbital fenestra: present (0); absent (1).
148): Intramandibular joint between the dentary-splenial-supradentary complex and the surangular-angular-coronoid-prearticular-articular complex: absent (0); present (1). (Langer and Benton 2006).
149): Dentary, anteroposterior length in front of the external mandibular fenestra: longer (0); less (1) than the dorsoventral diameter of the dentary at the level of the anterior margin of the external mandibular fenestra .
150): Dentary, symphysis, shape in lateral view: subtriangular (0); quadrangular, with a ventrodistally expanded tip (1). (Modified from Currie and Carpenter 2000; Brusatte and Sereno 2008).
151): Dentary, second alveolus, size compared to alveoli fourth to sixth: comparable (0); much smaller (1).
152): Dentary, ventral margin, shape in lateral view: straight to convex (0); concave (1). (Modified from Senter 2010; Sereno 1999).
153): Paradental laminae, plates: distinct (0); indistinct (1). (Modified from Senter 2010).
154): Maxillary and dentary teeth, distal margin, apicobasal curvature in labial/lingual view: marked (the apex of the tooth is placed distally to the distal margin of the crown base, the distal margin is concave) (0); reduced (the apex of the tooth is placed above the crown base, the distal margin is straight or convex) (1). (Modified from Sereno 1999).
155): Dentary, anterior fourth: toothed (0); lacking teeth (1).
156): Dentary, post-symphyseal region (excluded the part included in the character 155): toothed (0); lacking teeth (1).
157): Dentary, interdental septa, mesiodistal diameter relative to adjacent alveoli: smaller to subequal (0); much larger, teeth widely spaced (1). (Modified from Sereno 1999; Holtz 2000; Senter 2010).
158): Maxillary teeth, apicobasal length of the longest crown: less than (0); more than (1) 6/5 to the depth of the ventral ramus of maxilla. (Modified from Rauhut 2004).
159): Maxillary/dentary teeth, carinae, serration: present at least along distal carina (0); absent, carinae unserrated (1). Unapplicable in taxa lacking carinae. (Modified from Senter 2010, O'Connor 2009).
160): Maxillary and dentary teeth, basal constriction between the root and the crown: absent (0); present (1). (Holtz 2000).
161): Maxillary/dentary teeth, mesial/distal carinae: present (0); absent (1). (Modified from Senter 2010; O'Connor 2009).
162): Dentary, symphysis, dorsal surface, vascular foramina and grooves: absent (0); present (1).
163): Teeth, mesial/distal denticulation, development: small denticles (0); coarse serration (1). (Modified from Senter 2010).
164): Dentary, third alveolus, size compared to alveoli fourth to sixth: subequal (0); clearly larger (1). (Modified from Gauthier 1986).
165): Teeth, surfaces adjacent to carinae: smooth (0), having series of marked wrinkles, inclined basally (1). (Currie and Carpenter 2000).
166): Dentary, posteroventral process, participation to the ventral border of the external mandibular fenestra: less than (0); more than (1) the angular participation.
167): Dentary, posterodorsal process: absent (0); present (1). (Modified from Holtz 2000).
168): Dentary, anterior symphysis: loose (0); tightly sutured/fused (1).
169): Dentary, anterior symphysis, shape in dorsal/ventral view: “V”-shaped (0); “U”-shaped (1). (Senter 2010).
170): Dentary, dorsolateral surface, longitudinal posterior ridge/shelf: absent (0); present (1). (Modified from Senter 2010; Barrett 2009).
171): External mandibular fenestra, anteroposterior diameter: less than 1/4 of the length of the mandible (0); subequal or longer than 1/4 of the length of the mandible (1).
172): External mandibular fenestra, dorsoventral diameter: more (0); less (1) than 1/3 of the maximus dorsoventral diameter of the mandible.
173): Surangular, contact with the angular separated for most of its length by the external mandibular fenestra: absent (0); present (1).
174): Retroarticular process, width in dorsal view: less (0); more (1) than the width of the pre-glenoideal region of the mandible. (Modified from Rauhut 2003).

175): Retroarticular process, attachment of the M. depressor mandibulae, inclination: facing posterodorsally (0); facing almost completely posteriorly (1). (Sereno 1999; Rauhut 2003).
176): Retroarticular process, anteroposterior length: longer than the dorsoventral depth of the mandible at the level of the mandibular glenoid (0); less than the dorsoventral depth of the mandible at the level of the mandibular glenoid (1). (Modified from Senter 2010).
177): Dentary-surangular articulation in lateral view: surangular overlaps dentary (0); dentary overlaps surangular (1).
178): Dentary, lateral surface, posterior groove: shallow (0); deep with distinct margins (1). (Modified from Senter 2010).
179): Splenial, lateroventral exposition in lateral view: absent, covered by deep posteroventral process of dentary (0); present, posteroventral process of dentary shallow (1). (Senter 2010).
180): Splenial, posterior margin in lateral/medial view: straight or slightly concave posteriorly (0); deeply concave posteriorly (1). (Rauhut 2003).
181): Coronoid ossification: large to moderately developed (0); reduced as a split of bone (1). (Modified from Senter 2010).
182): Articular, pneumatic recess: absent (0); present (1). (Modified from O'Connor 2009).
183): Antarticular: absent (0); present (1). (Madsen 1974).
184): Splenial, mylohyoid anteroventral foramen/notch: absent (0); present (1). (Rauhut 2003; Sereno 1999).
185): Surangular, position of the anteriormost extent: anterior to or at the level of the external mandibular fenestra (0); posterodorsal to the anterior margin of the external mandibular fenestra (1). (Carrano and Sampson 2008).
186): Mandibular glenoid surface: as long as the anteroposterior length of the distal end of quadrate (0) or twice or more as long as the length of the distal quadrate surface, allowing anteroposterior movement of the mandible (1). (Senter 2010).
187): Surangular, coronoid process: absent (0); present (1). (Modified from Norell et al. 2001). (Char. # 187).
188): Surangular, posterolateral foramen/fenestra: small, maximum diameter less than (0); expanded, maximum diameter more than (1) 1/3 of the anteroposterior length of the mandibular glenoid (1). (Modified from Holtz et al. 2004).
189): Surangular, maximus dorsoventral depth of the anterior process: less than twice maximus depth of the angular (0); more than twice maximus depth of the angular (1). (Holtz 2000).
190): Articular-surangular complex: unfused (0); fused (1). (Maryańska et al. 2002).
191): Surangular, participation to the mandibular glenoid: present (0); absent (1). (Modified from Maryańska et al. 2002).
192): Surangular, laterodorsal shelf: absent (0); present (1). (Modified from Holtz 2000).
193): Angular, anterior prong, contact with the dentary-splenial cavity: absent (0); present (1). (Holtz 2000).
194): Presacral vertebrae, cervical and anterior dorsal centra, anterior surface, shape: flat to concave (0); convex (1). (Modified from Rauhut 2003; Holtz 2000; Carrano and Sampson 2008).
195): Cervical ribs, pneumatic recess: absent (0); present (1). (Wilson et al. 2003).
196): Cervical ribs, articulation to vertebrae in adults: loose (0); firmly attached/fused (1). (Holtz 2000).
197): Atlas, neurapophyses, shape in lateral view: subrectangular and posterodorsally directed (0); subtriangular (1). (Currie and Carpenter 2000).
198): Axis, neural spine in lateral view: low and antero-posteriorly expanded (0); mediolaterally compressed and dorso-ventrally elongate (1). (Currie and Carpenter 2000).
199): Axis, neural spine base, large groove/excavation: present (0); absent (1). (Rauhut 2003).
200): Axis, diapophyses, development: poorly developed (0); prominent (1). (Modified from Tykoski 2005; Holtz 2000).
201): Axis, pleurocoel: absent (0); present (1). (Rauhut 2003; modified from Tykoski 2005).
202): Axis, ventral keel: present (0); absent (1). (Currie and Carpenter 2000).
203): Axis, epipophyses: absent (0); present (1). (Rauhut 2003).
204): Axis, intercentrum, position of the ventral margin: at the same level of the ventral margin of the axial centrum (0); strongly tilted dorsally (1). (Currie and Carpenter 2000).
205): Axis, neural spine, dorsal surface, shape: mediolaterally narrow (0); mediolaterally expanded (1). (Currie and Carpenter 2000; Holtz 2000; Brusatte et al. 2010).
206): Cervical vertebrae, anterior post-axial centra, shape in anterior view: as wide as tall (0); dorsoventrally compressed (1). (Modified from Holtz 2000).
207): Cervical vertebrae, anterior post-axial centra, ventral keel, development: absent (0); present (1). (Ezcurra and Novas 2007).
208): Postaxial cervical vertebrae epipophyses: absent (0); present (1). (Rauhut 2003).
209): Postaxial cervical prezygoepipophyseal lamina: absent (0); present (1). (Modified from Carrano et al. 2002).
210): Cervical vertebrae, post-axial centra, ventral sulcus delimited by ventrolaterally directed ridges: absent (0);

present (1). (Makovichy et al. 2005).
211): Cervical vertebrae, anterior post-axial neural arches, neural spines, length: longer than 1/2 of the length of the neural arch (0); subequal or less than 1/2 of the length of the neural arch (1).
212): Cervical vertebrae, anterior post-axial neural spines in lateral view: longer than tall (0); taller than long (1).
213): Cervical vertebrae, post-axial neural arches, position of the neural spine: placed at mid-length or in its posterior half (0); placed in the anterior half (1). (Carrano and Sampson 2008).
214): Cervical vertebrae, post-axial neural spines, shape in anterior/posterior view: dorsoventrally taller than mediolaterally wide (0); wider than tall (1). (Coria and Salgado 2000).
215): Presacral vertebrae, neural arches, postzygodiapophyseal lamina, development: poorly developed (0); pronounced (1). (Coria and Salgado 2000).
216): Cervical vertebrae, anterior post-axial prezygapophyses, mediolateral placement in anterior view: dorsally to the centrum (0); laterally to the lateral border of the centrum (1). (Modified from Senter 2010).
217): Cervical vertebrae, articular surface, anterior post-axial prezygapophyses, shape: straight (0); anteroposteriorly convex, distal half flexed ventrally (1). (Holtz 2000; Rauhut 2003).
218): Presacral vertebrae, neural arches, prespinal fossa, development: shallow depression (0); dorsoventrally elongate and deep (1). (Modified from Wilson et al. 2003).
219): Cervical vertebrae, posterior centra, anterior surface, elevation relative to the posterior surface: reduced (0); marked (1). (Gauthier 1986).
220): Presacral vertebrae, anterior ribs, alariform process: absent (0); present (1). (Wilson et al. 2003).
221): Cervical ribs, length: longer than their corrisponding centra (0); subequal or less than their corresponding centra (1).
222): Cervical vertebrae, middle and posterior centra, length: less than two times (0); more than two times (1) the dorsoventral height of the anterior surface. (Modified from Holtz 2000; Wilson et al. 2003).
223): Cervical vertebrae, post-axial centra, position of the longest centrum: proximal to the VI position (0); distal to the VI position (1). (Gauthier 1986).
224): Presacral vertebrae, neural arches, pneumatic recesses on the lateroventral surface, development: poorly developed (0); pronounced (1). (Modified from Carrano and Sampson 2008; Wilson et al. 2003).
225): Dorsal vertebrae, anterior centra, ventral processes anterior to the keel (hypapophysis): poorly developed (0); strongly developed (1). (Modified from Rauhut 2003; O'Connor 2009).
226): Dorsal vertebrae, anterior centra, ventral keel, development: poorly developed (0); pronounced (1). (Rauhut; 2003).
227): Anterior presacral centra, posterior half of centrum, pneumatic recess: absent (0); present (1). (Modified from Holtz 2000). (Char. # 227).
228): Dorsal vertebrae, anterior centra, pleurocoels: absent (0); present (1). (Holtz 2000; Currie and Carpenter 2000; Senter 2010).
229): Presacral vertebrae, pleurocoel, structure: camerate (few diverticula separated by robust septa) (0); camellate (many diverticula separated by thin lamellae) (1). (Modified from Holtz 2000; O'Connor 2006).
230): Dorsal vertebrae, centra, anterior surface, proportions: as tall as wide (0); mediolaterally wider than dorso-ventrally tall (1).
231): Dorsal vertebrae with ribs articulating with the sternum, prominent hypapophyses: absent (0); present (1).
232): Dorsal vertebrae, posteriormost centra, anteroposterior length: subequal or more (0); less (1) than anterior centrum height. (Modified from Rauhut 2003).
233): Dorsal vertebrae, middle to posterior centra, articulation: concavo-convex (0); saddle-shaped (1). (Modified from Holtz 2000).
234): Dorsal vertebrae, neural arches, parapophysis, position: on anteroventral lamina from transverse process (0); dorsal to lamina, on prezygapophyseal base (1). (Holtz 2000).
235): Dorsal vertebrae, transverse processes, anterior margin, orientation: laterally directed (0); strongly backturned posterolaterally (1). (Modified from Tykoski 2005; Holtz 2000).
236): Dorsal vertebrae, posterior neural spines, dorsal margin, anteroposterior expansion relative to spine length at mid-height: moderate (0); marked (1). (Modified from Senter 2010).
237): Dorsal vertebrae, posterior neural spines, dorsoventral axis, inclination in lateral view: perpendicular to the anteroposterior axis of the centrum or posterodorsally inclined (0); anterodorsally directed (1). (Currie and Carpenter 2000).
238): Dorsal vertebrae, parapophyses, shape: low processes (0); elongate, often stalked on pedicels (1). (Carrano and Sampson 2008; Senter 2010).
239): Dorsal vertebrae, parapophyses, position: anteroventral to diapophysis (0); directly ventral to transverse processes, close to midpoint of vertebrae (1). (O'Connor 2009).
240): Dorsal vertebrae, posteriormost parapophyses, position: anteroventral or anterior to transverse processes

(tuberculum and capitulum of the ribs offset horizontally) (0); distinctly ventral to transverse process (tuberculum and capitulum of the ribs offset vertically) (1). (Rauhut 2003).
241): Dorsal ribs, uncinate processes: unossified or absent (0); ossified (1).
242): Dorsal ribs, ventral process: unossified (0); ossified (1).
243): Dorsal vertebrae, posterior neural arches, hyposphene (wall of bone developed ventromedially to the base of the postzygapophyses): absent (0); present (1). (Gauthier 1986).
244): Dorsal vertebrae, zygapophyses, position: abutting one another dorsal to the neural canal (0); placed laterodorsal to neural canal (1). (Senter 2010).
245): Tibia and/or femur, length compared to posterior dorsal centra length: more (0); less (1) than five times.
246): Dorsal vertebrae, number: more (0); no more (1) than 11. (Modified from O'Connor 2009).
247): Dorsal vertebrae, hyposphene, development: hyposphene developed as a single sheet of bone (0); hyposphene wide, formed by the ventrally bowed medial parts of the postzygapophyses, and only connected by a thin horizontal lamina of bone (1). (Rauhut 2003).
248): Gastralia: ossified (0); absent or unossified (1).
249): Dorsal vertebrae, neural spine, mediolateral expansion of the dorsal surface: absent (0); present (1). (Makovicky and Sues 1998).
250): Vertebrae, posterior dorsal, sacral and anterior caudal neural spines, ratio between the dorsoventral height and the basal anteroposterior length: less (0); more (1) than 5/2. (Modified from Rauhut 2003).
251): Scapula, ratio between the proximo-distal length and the minimal dorsoventral depth: less than (0); more than (1) six times. (Modified from Rauhut 2003).
252): Scapula, proximodistal length: less than 9/10 of humerus (0); subequal or longer than 9/10 of humerus (1).
253): Scapula, dorsal and ventral margins in lateral/costal view: markedly diverge posteriorly (0); not diverging posteriorly (1).
254): Scapula, angle between the proximodistal (anteroposterior) axis and the scapulosternal axis of the coracoid: wider than 110° (0); narrower than 110° (1). (Modified from O'Connor 2009).
255): Scapulo-coracoid articulation in adult: sutured (0); mobile (1). (O'Connor 2009).
256): Scapula, acromion, dorsoventral diameter relative to the minimal dorsoventral diameter of the scapular shaft: less (0); more (1) than 4/5.
257): Scapula, acromion, anteriormost extent (placing the anteroposterior axis of the scapula subhorizontal): placed dorsally (0); anteriorly (1) to the scapular glenoid.
258): Scapula, acromion, contact between its dorsal half and the coracoid: present (0); absent (1). (Modified from Currie and Carpenter 2000).
259): Scapula, participation to the glenoid: subequal to the coracoid participation (0); wider than the coracoid participation (1). (Sereno 1999).
260): Coracoid, depth (as scapular facet dorsoventral depth) to length (as anteroposterior length of bone at glenoid taken perpendicular to scapular facet): longer than deep (0); deeper than long (1).
261): Coracoid, ventrolateral surface, fenestra: absent (0); present (1). (O'Connor 2009).
262): Coracoid, procoracoid process: absent (0); present (1). (O'Connor 2009; Zhang and Zhou 2000).
263): Coracoid, longitudinal bar of bone placed close to the medial margin: absent (0); present (1). (Modified from O'Conor 2009).
264): Coracoid, lateral tubercle: absent (0); present (1). (Modified from Holtz 2000).
265): Coracoid, sulcus housing the supracoracoid nerve foramen: absent (0); present (1). (Modified from O'Connor 2009).
266): Coracoid, articular facet for the scapula: flat or slightly concave (0); convex (1). (O'Connor 2009).
267): Coracoid, posteroventral process: indistinct (0); distinct (1). (Modified from Holtz 2000; Senter 2010).
268): Coracoid, lateral tubercle, longitudinal extent: short (boss/tubercle) (0); anterodistally elongate (ridge) (1). (Modified from Novas 1997; Benson et al. 2010).
269): Coracoid, scapulo-sternal axis, length: less than (0); more than (1) three times the sternal width.
270): Coracoid, laterodistal border, shape: straight or slightly convex (0); broadly convex (1). (Modified from O'Connor 2009).
271): Humerus, head, shape in proximal view: ellipsoidal (0); rounded (1). (Modified from Rauhut 2003; O'Connor 2009).
272): Humerus, mid-shaft, mediolateral diameter: less (0); subequal or more (1) than mid-shaft diameter of the femur (Senter 2010).
273): Humerus, proximoventral tuberosity, shape: proximodistally short (0); proximodistally elongate (1). (Modified from Rauhut 2003).
274): Humerus, proximoventral tuberosity, position: placed distally (0); proximally (1) to the humeral head (1). (Holtz 2000).

275): Humerus, deltopectoral crest, proximodistal length: less than (0); more than (1) 2/5 of the length of the humerus. (Modified from Gauthier 1986).
276): Humerus, bicipital crest, ventral projection: absent (0); prominent and anteriorly projected in ventral view (1). (Modified from O'Connor 2009).
277): Humerus, posterior surface, pneumotricipital fossa in proximal end: poorly developed (0); well developed (1). (O'Connor 2009).
278): Humerus, deltopectoral crest, maximus anteroposterior diameter: subequal or more (0); less (1) than mid-shaft anteroposterior diameter of the humerus. (Modified from Rauhut 2003; Wilson et al. 2003).
279): Humerus, distal condyles, position: distally placed (0); anteriorly placed (1). (O'Connor 2009).
280): Humerus, distal condyles, number: two distinct (0); one single (1). (Holtz 2000).
281): Humerus, proximodistal length: subequal or more (0); less (1) than 3/5 of the length of the femur.
282): Humerus, distal condyles, shape: broadly convex or hemispherical (0); proximodistally depressed, flattened (1). (Modified from Wilson et al. 2003).
283): Humerus, distal epiphysis, mediolateral width: less than (0); more than (1); 3/2 of mid-shaft humeral width.
284): Humerus, medial epicondyle, development: not wider than the humeral distal condyles (0); hypertrophied, proximodistally expanded (1). (Modified from Zanno 2010).
285): Humerus, anterior surface, "transverse groove" placed proximally to the humeral bicipital tubercle, develepoment: absent (0); present (1). (Modified from O'Connor 2009).
286): Ulna, bicipital insertion: slightly developed scar (0); marked tubercle (1). (Modified from O'Connor 2009).
287): Ulna, olecranon process, proximodistal length: less (0); more (1) than 1/4 of the length of the ulnar shaft.
288): Ulna, radial facet, development: rounded facet (0); triangular suture (1).
289): Radio-ulnar distal syndesmosys: absent (0); present (1). (Holtz 2000).
290): Radius, mid-shaft width: more than 3/5 (0); less than 3/5 (1) of the mid-shaft diameter of the ulna. (Modified from Senter 2010).
291): Radius, proximodistal length: more than (0); less than (1) 3/5 of the proximodistal length of the humerus.
292): Manual phalanx P1-III, length: more than (0) less than (1) 3/5 of the proximodistal length of manual phalanx P1-II.
293): Pisiform, shape in dorsal view: small and discoidal (0); large and subtriangular (1). (Modified from O'Connor 2009).
294): Distal carpals: proximodistally uncompressed bones with distinct articular surfaces (0); discoidals (proximodistally compressed) without distinct articular surfaces (1). (Modified from Holtz 2000).
295): Distal carpals 1 and 2: distinct (0); fused into a single wide laterodistal carpal capping both mcs I and II (1). (Modified from Rauhut 2003).
296): Mc II, proximodistal length: less (0); more (1) than 2 times the mediolateral width of its distal articular surface. Ordered. (Modified from Rauhut 2003).
297): Mc I, shape in proximal view: broad trapezoid with rounded medial side (0); narrow triangular, with sharp dorsomedial edge (1). (Modified from Rauhut and Xu 2005).
298): Distal carpal 5: present (0); absent or unossified (1).
299): Mc I, proximal surface, medial half contacting the distal carpals: present (0); absent (1). (O'Connor 2009).
300): Mc I, lateral surface, extent of the articulation for Mc II: proximally reduced to the proximal third of the bone (0); distally expanded over the proximal third of the bone (1). (Modified from Rauhut 2003).
301): Mc I, proximodistal length: more (0); less (1) than 3/5 of the length of Mc II.
302): Mc I, minimal mediolateral diameter: more than (0); less than (1) ¼ of the proximodistal diameter of the same mc. (Modified from Rauhut 2003).
303): Mc I, laterodistal condyle: subequal in proximodistal extension (0); proximodistally more elongate (1) than the lateromedial condyle. (Rauhut 2003).
304): Mcs, distal end, extensor pits: poorly developed (0); deep and well developed (1). (Rauhut 2003).
305): Manual phalanx P1-I, lateral surface, proximodorsal process, development: poorly developed (0); pronounced (1). (Modified from Sereno 1999).
306): Manual phalanx P1-I, ventrodistal (flexor) fossa: absent or shallow (0); present and deep (1). (Sereno 1999).
307): Manual phalanx P1-I, mediolateral diameter of mid-shaft relative to mid-shaft diameter of the radius: more than (0); less than (1) 1/2. (Modified from Senter 2010).
308): Manual phalanx P1-I, proximodistal length: no more than 3/2 (0); more than 3/2 (1) of Mc I length.
309): Manual ungual I, proximodistal length: less than (0); more than (1) manual phalanx P1-I length. The proximodistal length of the unguals is defined as the length of the segment connecting the proximodorsal border and the distal tip, in lateral view.
310): Mc II, medial side in dorsal/ventral view: mediolaterally expanded proximally (0); mediolaterally unexpanded proximally (1). (Rauhut 2003).

311): Mc II and distal carpals, relationships in adult: unfused (0); fused, suture obliterated (1).
312): Manual digit I (P1-I + P2-I), proximodistal length relative to manual digit II (P1-II + P2-II + P3-II): longer (0); shorter (1).
313): Manual phalanx P1-I, proximodistal length: less than 5 times (0); more than 5 times (1) the mediolateral width at midshaft of the same phalanx. (Senter 2010).
314): Manual digit II (P1-II + P2-II + P3-II), proximodistal length: less than (0); more than (1) 4/5 of proximodistal length of the humerus.
315): Manual phalanx P1-II, lateral shelf: absent (0); present (1). (Modified from Senter 2010; O'Connor 2009).
316): Manual phalanx P2-II, proximodistally length: subequal or shorter than (0); longer than (1) manual phalanx P1-II.
317): Manual ungual II, proximodistal length: less (0); longer (1) than 3/5 of manual phalanx P2-II.
318): Mc II-III, proximal end, Intermetacarpal suture: open (0); fused (1).
319): Mc IV, shape in dorsal/ventral view: mediolaterally expanded proximally (0); mediolaterally unexpanded proximally (1).
320): Mc III, shape in proximal view: quadrangular (0); subtriangular, wider ventrally than dorsally (1). (Modified from Rauhut 2003).
321): Mc III, proximal end, mediolateral diameter compared to mid-shaft diameter: wider (0); subequal (1). (Modified from Holtz et al. 2004).
322): Mc III, mediolateral width of mid-shaft: more than (0); less than (1) 3/5 of mc II mid-shaft width . (Modified from Holtz 2000).
323): Mc IV, mediolateral width of mid-shaft of Mc: more than 1/2 (0); subequal or less than 1/2 (1) of mid-shaft diameter of Mc II. (Modified from Holtz et al. 2004).
324): Mc III, proximodistal length: more than (0); less than (1) 3/4 of Mc II.
325): Manual phalanx P2-III, proximodistal length: more (0); less (1) than 1/2 of manual phalanx P1-III.
326): Manual ungual III, proximodistal length: longer than 3/4 (0); less than 3/4 (1) of manual ungual II.
327): Manual phalanx P2-III, proximoventral heel: absent (0); present (1).
328): Manual phalanx P3-III, proximodistal length: subequal to or less than (0); longer than (1) the sum of the preceding phalanges. (Modified from Holtz 2000).
329): Mc IV, proximodistal length: more than (0); less than (1) ½ of Mc II length. (Modified from Holtz et al. 2004).
330): Manual digit IV, phalanges: present (0); absent (1). Inapplicable in taxa lacking Mc IV.
331): Mc V: present (0); absent or unossified (1).
332): Manual unguals II and III, transversely expanded proximodorsal lip distinct from rest of dorsal margin: absent (0); present (1). (Modified from Senter 2010).
333): Manual unguals, flexor tubercles, dorsoventral diameter: less (0); more (1) than 1/3 the depth of the proximal articular surface. (Rauhut 2003).
334): Manual unguals II-III, shape in lateral view: straight or slightly curved ventrally (0); distinctly curved ventrally (1).
335): Sternal plates: unfused (0); fused (1).
336): Sternum, anterior margin of the paired sterna, shape in ventral/dorsal view: concave to straight (0); distinctly convex (1). (Modified from O'Connor 2009).
337): Sternum, articular facet for coracoid (conditions may be determined by the articular facet on coracoid in taxa without ossified sternum), position: anterolateral or more lateral than anterior (0); almost anterior (1). (Senter 2010).
338): Sternum, posterolateral processes: absent (0); present (1).
339): Sternum, paired posteromedial processes, development: indistinct (0); distinctly elongate (1). The lateral margin of the posterior sternal fenestrae – when present (Char. # 903) – is considered formed by the posteromedial process.
340): Sternum, posteromedian process in taxa with posteriorly acuminate sternum, proximodistal length: no more than (0); more than (1) 3/2 of its proximal mediolateral width (0).
341): Clavicles, interclavicular angle: more than (0); less than (1) 70°. (Modified from O'Connor 2009).
342): Clavicles, fusion (furcula): absent (0); present (1).
343): Third sacral vertebra: absent (0); present (1).
344): Sacrum, ribs, central articulation, anteroposterior extent: on a single centrum (0); on two centra (1). (Nesbitt 2011; modified from Brusatte et al. 2010).
345): Sacral vertebrae, posterior central keel: absent (0); present (1). (Modified from Holtz 2000; Senter 2010).
346): Sacral centra, mediolateral width of the middle (primordial) sacral vertebrae relative to the width of the remaining sacral centra: not wider (0); wider (1). (Modified from Holtz 2000; Wilson et al. 2003).
347): Sacral vertebrae, pleurocoels: absent (0); present (1).
348): Sacral ribs, lateral surface: slender (0); dorsoventrally hypertrophied, covering almost the entire medial surface of the iliac blades (1). (Modified from Rauhut 2003).
349): Sacral vertebrae, posteriormost transverse processes, shape and inclination: short and laterally directed (0);

elongate and postero-laterally directed, with their distal extent placed posteriorly to the posterior plane of their centrum (1).
350): Sacral neural spines: unfused (0); fused into a lamina (1). (Holtz 2000).
351): Caudal vertebrae, median and distal centra, mediolateral width of the distal articular surface: less than (0); more than (1); 3/2 of the dorsoventral diameter of the same articular surface. (Modified from Rauhut and Xu 2005).
352): Caudal vertebrae, number: more than (0); no more than (1) 27. (Modified from Holtz 2000; O'Connor 2009).
353): Caudal vertebrae, middle neural spines: present (0); absent (1). (Modified from Holtz 2000).
354): Caudal vertebrae, chevrons, middle elements, anteroventral process: absent ("L-shaped" chevron) (0); present ("T-shaped" chevron) (1). (Modified from Holtz 2000).
355): Caudal vertebrae, chevrons, middle elements, anteroposterior length: less (0); more (1) than 3/2 centrum length. (Modified from Holtz 2000; Zhou and Zhang 2002).
356): Caudal vertebrae, ribs, number: more than (0); no more than (1) 11. (Modified from Holtz 2000).
357): Caudal ribs, shape of the anterodistal margin in dorsal/ventral view: unenxpanded (0); anteriorly expanded (1). (Modified from Carrano and Sampson 2008).
358): Caudal vertebrae, anterior neural arches, ventral rib laminae: absent (0); present (1).
359): Caudal vertebrae, anterior neural arches, hyposphene: absent (0); present (1).
360): Caudal vertebrae, anterior centra, shape: cilindrical (0); box-like (1). (Rauhut 2003).
361): Caudal vertebrae, distal neural arches, longitudinal groove on the dorsal surface: absent (0); present (1). (Modified from Senter 2010).
362): Caudal vertebrae, anterior centra, longitudinal groove on the ventral surface: absent (0); present (1). (Holtz 2000; Rauhut 2003).
363): Caudal vertebrae, median centra, proximodistal length: less than (0); longer than (1); 3/2 of the length of the proximal posterior centra. (Modified from Holtz 2000).
364): Caudal vertebrae, anterior centra, morphology: amphyplatan/amphycoelous (0); distinctly procoelous (1).
365): Caudal vertebrae, anterior centra, shape of the ventral surface: flattened or slightly convex medio-laterally (0); strongly constricted medio-laterally or keeled (1). (Modified from Rauhut 2003).
366): Caudal vertebrae, median prezygapophyses, anteroposterior overlap on preceding vertebra: less than (0); more than (1) centrum length. (Modified from Holtz 2000).
367): Caudal vertebrae, anterior and middle neural spines, shape of the anterodorsal margin in lateral view: straight (0); concave (1). (Modified from Rauhut 2003).
368): Caudal vertebrae, median neural spines, shape in lateral view: taller than long (0); longer than tall (1).
369): Caudal vertebrae, accessory neural spine (or spur) placed on anterior end of neural arch: absent (0); present and distinct (1). (Modified from Rauhut 2003).
370): Caudal vertebrae, posteriormost centra, fusion (pygostyle): absent (0); present (1).
371): Caudal vertebrae, length of the tail: longer than 5/2 of the length of the femur (0); less than 5/2 of the proximo-distal length of the femur (1).
372): Caudal vertebrae, centra, pleurocoels: absent (0); present (1). (Holtz 2000; Maryańska et al. 2002).
373): Caudal vertebrae, transition point in tail (transition between the morphologies of the anterior and posterior regions of the tail): gradual (0); localised in a restriced portion of the tail (1). (Modified from Gauthier 1986).
374): Caudal vertebrae, proximal and median ribs, inclination in anterior/posterior view: laterally directed or slightly dorso-laterally directed (0); strongly dorso-laterally directed (1). (Canale et al. 2008).
375): Caudal vertebrae, posterior chevrons, distal forking: absent (0); present (1). (Modified from Senter 2010).
376): Ilium, ischial articulation in adult: unossified (0); ossified (1). (Modified from Tykoski 2005).
377): Ilium, preacetabular process, anteriormost extent: placed posteriorly (0); placed anteriorly (1) to the anteriormost extent of the pubic peduncle of the ilium.
378): Ilium, antero-posterior length: less than 3/5 (0); longer than 3/5 (1) of the proximodistal length of the femur.
379): Ilium, acetabulum, shape of the ventral margin in lateral view: straight or convex (0); concave (1). (Modified from Gauthier 1986).
380): Ilium, supracetabular shelf covering the anterodorsal margin of the acetabulum: absent (0); present (1). (Modified from Tykoski 2005).
381): Ilium, lateral horizontal supracetabular crest, development: slightly developed dorsal lip of the acetabulum (0); prominent (1). (Modified from Holtz 2000).
382): Ilium, lateral vertical crest dorsal to the acetabulum: absent (0); present (1). (Rauhut 2003).
383): Ilium, supracetabular crest, posteriormost extent: placed anteriorly (0); dorsally (1) to the ischial peduncle of the ilium.
384): Ilium, dorsal margin, shape in lateral view: straight to convex (0); concave at mid-length (1). (Modified from Holtz 2000; Carrano and Sampson 2008).
385): Ilium, preacetabular process, ventralmost extent: dorsal to (0); at the same level of (1) the iliopubic facet.

386): Ilium, postacetabular process, lateral surface: less (0); more (1) than half supracetabular surface.
387): Ilium, preacetabular process, anterodorsal concavity in lateral view: absent (0); present (1). (Modified from Rauhut 2003).
388): Ilium, pubic peduncle, shape in lateral view: straight to convex (0); concave, with an anterior lip at its ventral margin (1). (Modified from Rauhut 2003).
389): Ilium, pubic peduncle, distal surface: single (0); double, with a pronounced kink between the anterior surface facing almost entirely anteriorly and the posterior surface facing ventrally (1). (Modified from Carrano and Sampson 2008; Rauhut 2003).
390): Ilium, pubic peduncle, anteroposterior diameter: less than (0); subequal to or more than (1) the anteroposterior diameter of the acetabulum.
391): Ilium, ischial facet, anteroposterior diameter relative to the anteroposterior length of the pubic facet: subequal to longer (0); shorter (1).
392): Ilium, border formed by the anterior margin of the pubic peduncle and the posteroventral margin of the preacetabular process, shape in lateral view: wide concavity, describing an arch broader than 35° (0); anteroventrally oriented cleft, describing an arch narrower than 35° (1).
393): Ilium, pubic peduncle, orientation in lateral view (when the ilium is oriented with its anteroposterior axis horizontal): anteroventrally directed (0); posteriorly directed (1).
394): Ilium, pubic peduncle, dorsoventral depth: subequal or less than (0); deeper than (1) the dorsoventral depth of the ischial peduncle.
395): Ilium, processus supratrochantericus placed along the dorsal margin, at the level of the ischial peduncle: absent (0); present (1). (Novas 2001; Norell et al. 2001; Calvo et al. 2004).
396): Ilium, pubic peduncle, distal surface, anteroposterior length: less than (0); more than (1) 2 times its mediolateral width. (Modified from Rauhut 2003). The same condition may be inferred from the proximal surface of the iliac peduncle of the pubis in specimen lacking the pubic peduncle of the ilium.
397): Ilium, postacetabular process, dorsal margin, orientation in lateral view when the sacral column is horizontal: subhorizontal, distinct from posterior margin (0); posteroventrally directed, confluent with posterior margin (1). (Modified from Carrano et al., 2002; Makovicky et al., 2005).
398): Ilium, preacetabular process, anteroposterior extent: not longer (0); longer (1) than the postacetabular process. Ordered. (Modified from Holtz 2000). The posteriormost extent of the preacetabular blade is defined at the level of the anterodorsal margin of the pubic peduncle of the ilium; the anteriormost extent of the postacetabular blade is defined at the level of the posterodorsal margin of the ischial peduncle of the ilium.
399): Ilium, preacetabular processes, orientation in dorsal view: subparallel (0); anteromedially directed, contacting the neural spines of the anterior sacrals (1). (Modified from Holtz 2000; Zanno 2010).
400): Ilium, postacetabular process, anteroposterior length: less than (0); more than (1) its proximal dorsoventral height.
401): Ilium, postacetabular process, ventral margin, orientation in lateral view: posterodorsally to subhorizontally (0); posteroventrally (1) directed.
402): Ilium, postacetabular process, shape in dorsal view: posteriorly directed (0); posterolaterally directed (1). (Senter 2010).
403): Ilium, postacetabular process, fossa for the origin of the M. caudifemoralis brevis: very reduced anteroposteriorly (0); prominent, anteroposteriorly elongate (1). (Modified from Langer and Benton 2006).
404): Ilium, preacetabular process, fossa on the lateroventral margin: very shallow, indistinguible from the rest of the blade (0); present as a marked concavity between the anterior margin of the pubic peduncle of the ilium and the ventral margin of the preacetabular blade (1). (Modified from Holtz 2000).
405): Ilium, postacetabular process, medioventral shelf, anterior half, lateral esposition: absent (0); present (1). (Modified from Carrano et al. 2002).
406): Pubis, proximoanterior margin, shape in lateral view: straight, absence of marked anterior espansion of the iliac peduncle relative to the shaft (0); markedly convex proximally, iliac peduncle expanded anteriorly (1).
407): Pubis, shaft, shape in lateral view: straight to anteriorly concave (0); posteriorly concave (1). (Holtz 2000).
408): Pubis, anteroposterior diameter at mid-shaft: more than 1/5 (0); less than 1/5 (1) of the proximodistal length of the pubis.
409): Pubis, distal foot, posterior process: absent (0); present (1). (Modified from Holtz 2000).
410): Pubis, distal surface, shape in distal view: subtriangular, anteriorly broader (0); quadrangular, with subparallel lateral margins (1). (Modified from Rauhut; 2003).
411): Pubis, distal foot, anterior process: absent (0); present (1). (Modified from Holtz 2000).
412): Pubis, ischial peduncle, obturator perforation: present as foramen or notch (0); solid bone with no distict perforation (1). (Modified from Holtz 2000).
413): Pubis, ischial peduncle, obturator perforations, number: zero or one (0); two (1). (Modified from Rowe and Gauthier 1990). (Tykoski 2005).

414): Pubis, medial contact between hemipubes, proximodistal extent: extended for more than (0); for less than (1) 1/3 of the proximodistal length of pubis. (Holtz 2000; O'Connor 2009).
415): Pubis, distal contact between the hemipubic bones (pubic symphysis) in anterior view: present (0); absent (1).
416): Pubis, pubic apron, median perforation: absent (0); present as a fenestra (1). (Modified from Holtz 2000; Rauhut 2003; Makovicky et al. 2005).
417): Pubis, angle between the proximodistal axis of the proximal half and the anterior direction of the anteroposterior axis of the sacral column: less than (0); more than (1) 120°. (Modified from Holtz 2000; O'Connor 2009).
418): Pubis, supplementary ischial contact placed distally to the acetabular region: absent (0); present (1).
419): Ischium, anteroposterior diameter at mid-shaft: more than 1/5 (0); less than 1/5 (1) of the proximodistal length of the ischium.
420): Ischium, shape in lateral/medial view: straight (0); posterodorsally concave at the level of the obturator process (1). (Modified from Senter 2010).
421): Ischium, proximodistal length: subequal to or more than (0); less than (0) 3/5 of the proximodistal length of the pubis. (Modified from Holtz 2000).
422): Ischium, proximodorsal process (dorsal process placed close to iliac peduncle): absent (0); present (1). (Modified from Forster et al. 1998).
423): Ischium, mediodorsal process placed at mid-shaft and distinct from ischial distal tip: absent (0); present (1). (Modified from Forster et al. 1998; Currie and Zhao 1993a).
424): Ischium, scar on the proximolateral surface: slightly developed (0); prominent, crescentic (1) (Holtz 2000).
425): Ischium, distal half, cross section: laminar, strongly mediolaterally compressed (0); robust, rod-like (1).
426): Ischium, obturator process/lamina, distal margin, cleft/concavity: absent (0); present (1). (Rauhut 2003).
427): Ischium, distal expansion of shaft (ischial foot): absent (0); present (1). (Modified from Holtz 1994).
428): Ischium, distal symphysis: present (0); absent or unossified (1).
429): Femur, shape in lateral/medial view: straight or slightly sygmoidal (0); strongly bowed, posteriorly concave along the entire length (1).
430): Femur, head, distinction from shaft (neck): absent (0); present (1). (Modified from Holtz 2000; Rauhut 2003).
431): Femur, head and neck, proximodistal axis in proximal view, inclination relative to mediolateral axis of distal end: anteromedially directed (angle of more than 30°) (0); slightly anteromedially to medially directed (angle less than 30°) (1). (Modified from Carrano and Sampson 2008; Rauhut 2003).
432): Femur, head and neck, proximodistal axis, inclination relative to shaft main axis, angle in anterior/posterior view: no more than (0); more than (1) 90°. (Holtz 2000).
433): Femur, accessory trochanter: absent (0); present as a anterodistal process of the anterior trochanter (1). (Sereno 1999).
434): Femur, anterior trochanter, presence: absent (0); present (1).
435): Femur, trochanteric shelf, development: poorly developed anterolateral crest (0); prominent, shelf-like (1). (Modified from Tykoski 2005).
436): Femur, "posterior" trochanter: absent (0); present as a posterolateral mound-like eminence (1). (Hutchinson 2002).
437): Femur, fourth trochanter, shape: low rugosity/scar (0); sharp flange (1). (Modified from Sereno 1999; Langer and Benton 2006).
438): Femur, distal end, medial condyle, shape: distally flattened (0); distally rounded (1). (Rauhut 2003).
439): Femur, distal end, anterior margin in distal view: flat to convex (0); concave (1). (Modified from Currie and Carpenter 2000; Holtz 2000).
440): Femur, distal end, anterior intercondylar sulcus, depth: broad and shallow (0); deep and narrow (1).
441): Femur, medial condyle, anteroposterior diameter in distal view: less than (0); subequal or more than (1) the mediolateral diameter of the distal articular surface of the femur.
442): Femur, greater trochanter, shape in lateral and proximal views: anteroposteriorly narrower than the femoral head, widens towards the femoral head (0); anteroposteriorly expanded in lateral view, broader than the femoral head (1). (Modified from Rauhut 2003).
443): Femur, posterodistal fossa (flexor fossa), development in posterior view: posteriorly opened and wider than half the mediolateral diameter of the tibial condyle of the femur (0); narrower than half the mediolateral diameter of the tibial condyle of the femur or closed off posterodistally by contact between the distal condyles (1). (Senter 2010).
444): Femur, posteromedial margin, elliptical scar for the inserton of the M. caudifemoralis longus: slightly developed (0); marked (1). (Modified from Brusatte et al. 2010).
445): Femur, posterodistal fossa in distal view, cruciate ligament: unossified (0); ossified (1). (Currie and Carpenter 2000).
446): Femur, anterior trochanter, shape in lateral view: cone-like to finger-like (0); flange-like (1).
447): Tibia, proximal end, elongation in lateral/medial view: no more (0); more (1) than twice the minimal anteroposterior diameter of the shaft.

448): Fibula, proximomedial surface, shape: flat or slightly concave (0); deeply concave (1). (Modified from Rauhut 2003).
449): Tibia, fibular condyle, posteriormost estent in proximal view: anteriorly to (0); at the same level of (1); the posterior margin of the medial condyle.
450): Fibula, insertion of the M. iliofibularis, position: on the anterolateral margin (0); on the posterolateral margin (1). (Modified from O'Connor 2009).
451): Tibia, fibular condyle in proximal view, anterior process: absent (0); present (1). (Brusatte et al. 2010).
452): Tibia, fibular crest: absent (0); present (1).
453): Tibia, fibular crest, position: in the proximal third (0); extended more distally (1).
454): Tibia, distal end, posterolateral process, calcaneal facet/contact: absent (0); present (1). (Modified from Sereno 1999; Holtz 2000).
455): Tibia, distal end, mediolateral diameter: subequal or less (0); more (1) than the anteroposterior diameter. (Modified from Rauhut 2003).
456): Tibia, medial cnemial crest: absent (0); present (1). (Modified from Senter 2010).
457): Tibia, distal end, fossa/slot for the astragalar ascending process: absent (0); present (1). (Modified from Rauhut 2003).
458): Fibula, distal end, contact with proximal tarsals: present (0); absent (1).
459): Fibula, shaft, width along the proximodistal axis: gradually narrowing from the proximal end to mid-shaft (0), abruptly narrowing below the insertion of M. iliofibularis (1) (Rauhut 2003).
460): Tibia, proximal end, shape: quadrangular (0); rounded (1).
461): Tibia, distal end, anteroposterior length of medial margin: subequal to (0); longer than (1) the anteroposterior length of the lateral margin. (Langer and Benton 2006).
462): Astragalus, anterior surface proximal to condyles, transversal groove: absent (0); present (1). (Holtz 2000).
463): Astragalus, posteromedial process (and corresponding fossa on the posterodistal margin of the tibia): absent (0); present (1).
464): Calcaneum, posteroventral process (and corresponding process on astragalus) placed distal to tibial end: present (0); absent (1).
465): Astragalus, distal condyles, position: completely distally or slighly anterodistally placed (0); mostly anterodistally placed (1). (Modified from Holtz 2000).
466): Tibia, proximal end, posterior cleft between the proximal condyles, development: indistinct (0); deep (1). (Rauhut 2003).
467): Fibula, relationships with the astragalar-tibial complex in adult: unfused or loosely appressed (0); tightly appressed or fused (1).
468): Astragalus, ascending process, mediolateral diameter of the base: no more than (0); more than (1) 1/2 of mediolateral diameter of the astragalar body. (Modified from Rauhut 2003).
469): Astragalus, ascending process, proximodistal diameter: less than (0); more than (1) the mediolateral diameter of the astragalar body. Ordered. (Modified from Rauhut 2003).
470): Astragalus, base of ascending process, anterior platform: absent (0); present (1). (Langer and Benton 2006).
471): Calcaneum, posterolateral process: present (0); absent (1). (Novas 1989).
472): Calcaneum, proximal surface, shape in lateral/medial view: convex (0); concave (1). (Modified from Langer and Benton 2006).
473): Calcaneum, mediolateral diameter: more than 1/3 (0); less than 1/3 (1) of the mediolateral diameter of the astragalus.
474): Distal tarsal 4, lateral projection: absent (0); present (1).
475): Distal tarsals, relationships with the proximal end of mts: unfused (0); fused (1).
476): Mts II-IV, shafts, proximal half, relationships: unfused (0); fused (1). (O'Connor 2009).
477): Mt I, proximodistal length: more than 2/5 (0); less than 2/5 (1) of the proximodistal length of Mt II.
478): Mt III, proximodistal length: less (0); more (1) than 1/2 of tibial length.
479): Mt II, mid-shaft mediolateral diameter: subequal to or more than (0); less than (1) 2/3 of the mediolateral diameter of Mt III at mid-length.
480): Mt II, proximoanterior tubercle: absent (0); present (1). (O'Connor 2009).
481): Mt II, distal articular surface, shape: flat or sligtly concave (0); markedly concave, with distinct extensor groove (1). (Senter 2010).
482): Mt III, shaft, distal half, posterior margin, shape: broad to rounded (0); mediolaterally constricted/sharp (1). (Holtz 2000).
483): Mt III, shaft, proximal half, mediolateral compression relative to mid-shaft width: absent (0); present (1). (Holtz 1995).
484): Mt III, proximal surface, anteroposterior diameter: no more than 5/4 (0); more than 5/4 (1) of the anteroposterior

diameter of the proximal surface of Mt II.
485): Mt III, proximal surface, development: subequal to or more than (0); less than (0); those of the proximal surfaces of both mts II and IV (1).
486): Mt III, proximal surface, anterior margin, position relative to the anterior margins of the proximal surfaces of both mts II and IV: at the same level (0); more posteriorly/plantarly (1). (Modified from O'Connor 2009; Holtz 2000).
487): Mt III, distal articular surface, shape: flat or slightly concave (0); markedly concave, with distinct extensor groove (1). (Senter 2010).
488): Mt III, distal end, mediolateral diameter: subequal to or more than (0); less than (1) the mediolateral diameter of the distal end of Mt II. (O'Connor 2009).
489): Mt II, shaft excluding distal fourth, shape in anterior/posterior view: sygmoidal, mediodistally concave (0); straight (1).
490): Mt IV, shape in anterior/posterior view: sygmoidal, laterodistally concave (0); straight (1).
491): Mt IV, proximal end, medial margin, shape: flat to convex (0); concave (1).
492): Mt IV, mid-shaft, mediolateral diameter: less than (0); more than (1) half of tarsometatarsus mid-shaft width. (Modified from Senter 2010).
493): Mt IV, proximal end in anterior/posterior view, lateral projection clearly distinct from shaft margin: present (0); absent (1). (Modified from Senter 2010).
494): Pedal digit IV, length: longer than (0); subequal to or less than (1) pedal digit II.
495): Mt IV, distal end, mediolateral diameter: subequal to or more than (0) less than (1) 3/5 of the mediolateral diameter of the distal end of Mt III. (Modified from Wilson et al. 2003).
496): Mt IV, lateroposterior margin, longitudinal crest: absent (0); present (1). (Senter 2010).
497): Mt V, proximodistal length: more than (0); less than (1) 2/5 of the proximodistal length of Mt III.
498): Mt I, position: placed medially (0); placed mediopalmarly or fully palmarly (1) to Mt II.
499): Pedal phalanx P1-I, proximodistal length: more than 3/4 (0); no more than 3/4 (1) of the proximodistal length of pedal phalanx P1-III. (Modified from Sereno 1999).
500): Mt I, proximal end, position: at the same level (0); distally to (1) the proximal end of Mt II.
501): Pedal phalanx P1-II, proximodistal length: no more than 3 times (0); longer than 3 times (1) the proximodistal length of its distal trochlear eminence. (Senter 2010).
502): Pedal phalanx P2-II, proximodistal length: more than 2 times (0); no more than 2 times (1) the proximodistal length of its distal trochlear eminence. (Senter 2010).
503): Pedal digit III, penultimate phalanx, proximodistal length: shorter (0); subequal or longer (1) than the preceding phalanx.
504): Pedal phalanx P2-II, proximoventral process: absent (0); present (1). (Modified from Makovicky et al. 2005).
505): Pedal ungual II, overall size: comparable to (0); much larger than (1) pedal unguals III and IV.
506): Pedal phalanx P1-IV, proximodistal length: subequal to or more than (0); less than (1) the proximodistal length of pedal phalanx P1-II. (Senter 2010).
507): Pedal digit V, phalanges: present (0); absent or unossified (1).
508): Pedal unguals II-IV, lateral vascular grooves, shape: simple, unforked (0); proximally forked, producing a pair of distally converging furrows (1). (Modified from Carrano and Sampson 2008).
509): Filamentous tegumentary structures, pattern: all simple (0); simple and branched (1).
510): Filamentous tegumentary structures: absent (0); present (1). (Sereno 1999).
511): Remiges (forelimb feathers with rachis and barbs): absent (0); present (1). (Sereno 1999).
512): Alular feathers: absent (0); present (1). (O'Connor 2009).
513): Rectrices (tail feathers with rachis and barbs): absent (0); present (1). (Sereno 1999).
514): Pes, filamentous feathers: absent (0); present (1).
515): Tibial pennaceous feathers: absent (0); present (1).
516): Tegumentary structures in forelimb, proximodistal length: less than (0); more than (1) the proximodistal length of the ulna.
517): Ischium, shaft, extension distal to obturator process: present (0); absent (1).
518): Manual unguals, flexor tubercles, position of proximal margin: close to (0); distal to (1) the ventral margin of the proximal surface of the ungual. (Sereno 1999).
519): Frontals, paired bones, posteromedial margin, shape in dorsal/ventral view: straight or posteriorly convex (0); notched and markedly concave at mid-length (1).
520): Cervical vertebrae, carotid processes (pair of processes on the ventral surface of the centrum that bound the carotid fossa on either side, arising at the junctions of the parapophyses with the centrum): absent (0); present (1). (Senter 2010).
521): Pubis, ischial peduncle, dorsoventral diameter of the distal articulation: subequal to or more than (0); less than (1) 3/2 of the minimal anteroposterior diameter of the pubic shaft.

522): Skull, anterior bones (premaxilla, maxilla and dentary), medial surface, texture: smooth (0); skulptured and furrowed (1). (Carrano and Sampson 2008).
523): Manual phalanx P1-I, proximoventral margin, paired flexor processes: absent (0); present (1). (Sereno 1999).
524): Jugal, suborbital process, dorsoventral depth: significantly more than its mediolateral width (0); dorsoventrally compressed, slender and rod-like (1). (Senter 2010).
525): Postorbital, anterodorsal process, position: in line with the posterior process (0); strongly upturned, both processes describe a concave postorbital border of the supratemporal fossa (1). (Senter 2010).
526): Articular, pendant medial process: absent (0); present (1) (Sereno 1999).
527): Mt III, proximal end, posterior border, width relative to anterior margin width: much wider (0); comparable or reduced (1).
528): Nasals, posterior end, minimal mediolateral diameter: subequal to or more than (0); less than (1); the mediolateral diameter of the anterior half of the nasal. (Modified from Holtz et al. 2004).
529): Pubis, foot, proximodistal diameter: less than (0); more than (1) 1/4 of the proximodistal length of the pubis.
530): Astragalus, ascending process, fibular articular facet: absent (0); present (1).
531): Mc II, mediolateral diameter at mid-shaft: more than (0); less than (1) 2/3 of the mediolateral diameter mid-shaft od Mc I.
532): Maxilla, maxillary fenestra, dorsal margin, position: at mid-height (0); in the anterodorsal corner (1) of the antorbital fossa. (Senter 2010).
533): Lacrimal, posterodorsal corner, dorsal margin, horn: absent (0); present (1).
534): Basisphenoid, internal pneumatic recesses, development: poorly developed (0); extensive, well developed (1). (Senter 2010).
535): Basioccipital, subcondylar recess: absent (0); present (1).
536): Maxilla, lateral surface, neurovascular foramina: present (0); absent (1).
537): Skull, dorsoventral diameter of the snout at the level of the posterior margin of the external naris: more than (0); less than (1) 2/5 of the dorsoventral diameter of the orbit.
538): Supraoccipital, posterodorsal margin, posteriormost extent: anteriorly to or at the same level of (0); posteriorly to (1) the foramen magnum. (Wilson et al. 2003).
539): Humerus, shape in lateral/medial view: straight (0); sigmoid, with the proximal surface inflected posteriorly (1). (Modified from Holtz 2000; Rauhut 2003; Carrano et al. 2011).
540): Tibia, distal end, posteromedial crest: absent (0); present (1) (Langer and Benton 2006).
541): Caudal vertebrae, anterior chevrons, length relative the anteroposterior length of the proximal posterior centra: less than (0); more than (1) 4 times. (Modified from Senter 2011).
542): Ischium, obturator process, elongation in lateral/medial view: more elongate proximodistally than anteroposteriorly (0); more elongate anteroposteriorly than proximodistally (1). (Makovichy et al. 2005).
543): Caudal vertebrae, pygostyle, length: no more than (0); more than (1) 6 times the average length of the caudalmost free caudal vertebrae. (Modified from O'Connor 2009).
544): Ischium, obturator process, distalmost extent: in the distal half (0); in the proximal half (1) of the ischium. (Langer and Benton 2006).
545): Mt II, trochlea, distal end, position relative to Mt III when articulated: at the level of (0); more proximal than (1) the trochlea of Mt III.
546): Nasal, posterolateral process: absent (0); present (1). (Wilson et al. 2003; Brusatte et al. 2010).
547): Mc II, proximodistal length: no more than (0); more than (1) 1/3 of the proximodistal length of the humerus.
548): Pedal ungual I, size relative to pedal unguals III or IV: smaller (0); subequal or larger (1). Pedal ungual II is excluded from these character conditions to avoid redundancy with other character statements.
549): Jugal, contribution to the antorbital fossa, shape in lateral view: fossa absent or poorly developed (0); half-crescentic with a distinct posterior rim (Rauhut 2003).
550): Manual ungual II, size compared to manual ungual I: not larger (0); larger (1).
551): Dentary, anterodorsal corner, angle between the anterior and the dorsal margins in lateral view: more than (0); less than (1) 65°. (Modified from Senter 2010).
552): Ischium, obturator incisure (foramen or notch), proximodistal diameter: less than (0); more than (1) the anteroposterior diameter of the acetabular margin of the ischium.
553): Maxilla, interfenestral bar (between the antorbital and the maxillary fenestrae), internal cavitation: absent (0); present (1).
554): Supratemporal fossa, angle between the anteroposterior axis and the anteroposterior axis of skull: subparallel (angle < 15°) (0); rostroventrally inclined (angle > 15°) (1). (Modified from Coria and Currie 2002).
555): Cervical vertebrae, centra, anterior surface, shape in anterior view: elliptical or subcircular, dorsally convex (0); kidney-shaped, dorsally concave (1). (Modified from Holtz 2000; Rauhut 2003).
556): Fibula, insertion of the M. ileofibularis, shape: simple process (0); transversely paired processes (1). (Holtz et al.

2004).
557): Cervical vertebrae, posterior centra, parapophyses, position: proximal to the anterior margin of the lateral surface (0); proximally to the mid-point of the anteroposterior axis of the lateral surface (1). (O'Connor 2009).
558): Ulna, olecranon, shape in proximal view: mediolaterally broad and anteroposteriorly low (0); mediolaterally compressed and blade-like (1). (Smith et al. 2008; Benson et al. 2010).
559): Scapula, acromion, inclination of the posterior margin relative to shaft: steeply inclined dorsally (0); gently sloping (1).
560): Mt IV, cross section at mid-shaft, shape: deeper than wide, transversely compressed (0); as wide as deep or wider, uncompressed (1). (Modified from Senter 2010).
561): Tibia, laterodistal end, distalmost extent: proximally to or at the same level of the distal extent of the mediodistal end (0); distally to the distal extent of the mediodistal end (1).
562): Caudal vertebrae, chevrons, anteroproximal process: absent (0); present (1). (Rauhut 2003).
563): Postfrontal: present and distinct (0); absent or unossified (1).
564): Pedal phalanx P2-II, proximodistal length: shorter (0); longer (1) than P1-II.
565): Maxilla, antorbital diverticulum connecting the external naris and the antorbital fossa: absent (0); present (1).
566): Laterosphenoid, postorbital process, ventral depression on lateral surface: absent (0); present (1). (Senter 2010).
567): Mc II, shaft, lateral margin, Intermetacarpal process: absent (0); present (1).
568): Radius, posteroventral margin, proximodistally elongate groove: absent (0); present (1). (O'Connor 2009; modified from O'Connor 2009).
569): Paroccipital process, shape: elongate and slender, with dorsal and ventral edges nearly parallel (0); short, deep with convex distal end (1). (Senter 2010).
570): Maxilla, ventral process, depth: less than (0); more than (1) 1/4 of the ventral length of the maxilla.
571): Lacrimal, ventral process, participation to the posterior margin of the antorbital fossa: present (0); absent (1).
572): Maxillary and dentary teeth, distal serration, shape of denticles: apically smooth (0); apically hooked (1).
573): Femur, distal end, lateral condyle, area placed lateral to the ectocondylar tuber, mediolateral diameter in distal view: less than 1/3 (0); more than 1/3 (1) of the mediolateral width of the lateral condyle of the femur.
574): Lacrimal, dorsal surface: less than (0); more than (1) the prefrontal dorsal surface (1).
575): Tarsometatarsus, proximal surface, plantar expansion (hypotarsus): absent (0); present (1). (Modified from O'Connor 2009).
576): Tibiotarsus, intercondylar groove, mediolateral width: more than (0); less than (1) 1/3 of the mediolateral width of the distal end of the tibiotarsus. (Modified from O'Connor 2009).
577): Pubis, foot, ventral margin, shape in lateral view: straight or slightly convex (0); broadly convex (1).
578): Tibia, anterodistal end, proximodistally elongate medial crest: absent (0); present (1). (Modified from Rauhut 2003).
579): Sternum, lateral margin, shape: convex (0); broadly concave at mid-length (1).
580): Tibiotarsus, complete fusion in adult: absent, proximal tarsals and tibia unfused, sutures clearly visible (0); present, astragalocalcaneum fused to the tibia (1).
581): Tibia, laterodistal end, lateral margin, prominent proximodistal crest (external ligament ridge): absent (0); present (1).
582): Skull, rostrum, mediolateral constriction at the level of the premaxilla-maxilla articulation: absent (0); present (1). (Sereno 1999; Rauhut 2003).
583): Distal tarsal 4, lateroposterior margin, shape in proximal/distal view: convex or slightly concave (0); broadly concave (1).
584): Radius, proximoposterior process, development: poorly developed (0); prominent (1).
585): Ilium, dorsoventral diameter at the level of the ventral margin of the pubic peduncle: subequal to or more than (0); less than 3/5 of the anteroposterior length of the ilium (1).
586): Premaxilla, buccal margin in ventral view, orientation: more anteroposteriorly than mediolaterally (0); more mediolaterally than anteroposteriorly (1). (Modified from Holtz et al. 2004).
587): Axis, neural spine, anterodorsal margin, shape in lateral view: broadly concave or straight (0); broadly convex (1).
588): Humerus, proximoventral tuberosity, development: moderately developed, posteriorly projected (0); hypertrophied, posteromedially projected (1). (Modified from Zanno 2010).
589): Premaxilla, palatal shelf, incisive foramen at mid-length of the medial articulation: absent (0); present (1).
590): Squamosal, development: unreduced and unossified to the braincase (0); reduced as a zygomatic process of the braincase (1). (O'Connor 2009).
591): Tibia, cnemial crest, anterior margin, anteroventral process: poorly developed (0); distinct (1). (Carrano and Sampson 2008).
592): Ilium, brevis fossa, lateral and medial margins, orientation in ventral view and development of fossa: subparallel, narrow fossa (0); posteriorly diverging, expanded fossa (1). (Modified from Holtz 2000; Rauhut 2003).

593): Surangular, preglenoid process, development: poorly developed (0); prominent (1).
594): Anterior trochanter, apex, proximalmost extent when the femur is vertically oriented: distally to (0); at the same level to (1) the dorsal margin of femoral head. (Modified from Holtz, 2000).
595): Femur, anterior trochanter, fusion with the greater trochanter: absent (0); present (1). (Modified from Holtz 2000; O'Connor 2009).
596): Coracoid, laterodistal process (distinct from the anteroventral process): absent (0); present (1). (O'Connor 2009).
597): Mc I, proximal end, extensor process, proximal extent: at the same level (0); more proximally (1) than rest of mc. (Modified from O'Connor 2009).
598): Premaxilla, ventral process, posterior bifurcation: absent (0); present (1). (Rauhut 2003).
599): Maxillary/dentary teeth, crowns, labiolingual diameter relative to mesiodistal diameter at mid-crown: less than (0); more than (1) 3/5. (Modified from Currie and Carpenter 2000; Holtz 2001).
600): Premaxillary teeth, lingual surface, apicobasally elongate median ridge: absent (0); present (1). (Brusatte et al. 2010).
601): Mt II, mid-shaft, width: more (0); less (1) than 1/2 distal end width.
602): Surangular, anterior process projected into the posterior half of the external mandibular fenestra: absent (0); present (1).
603): Ilium, preacetabular process, lateroventral fossa, posteriormost extent: anterior to acetabulum or curves ventrally onto anterior end of pubic peduncle (0); extends far posteriorly, confluent or almost confluent with the acetabular rim (1). (Makovichy et al. 2005).
604): Pubis, shaft, lateral process (tubercle/crest): absent (0); present (1). (Makovichy et al. 2005).
605): Ischium, small tubercle occurring along the anterior edge between the pubic peduncle and the obturator process: absent (0); present (1). (Makovichy et al. 2005).
606): Ilium, posterior margin, posteroventral process (and brevis shelf) projected posteriorly beyond level of mid-height of posterior margin: absent (0); present (1). (Modified from Makovichy et al. 2005).
607): Manual digit I, proximodistal length (sum of the lengths of Mc I and manual phalanges P1-I and P2-I): not less than (0); less than (1) the proximodistal length of Mc II.
608): Humerus, deltopectoral crest, distal margin, shape formed with humeral shaft: broad arch (0); narrow margin, describing a angle close to 90° (1).
609): Premaxillary and dentary teeth, anteriormost teeth, apicobasal axis (when fully erupted), inclination: sub-perpendicular to the anteroposterior axis of the skull (0); mesioapically inclined, procumbent (1).
610): Manual unguals, proximal surface, height-width ratio: less than (0); more than (1) 3/2.
611): Cervical vertebrae, epipophyses, dorsalmost extent: ventrally to (0); at the same level or dorsally to (1) the dorsal surface of the neural spine.
612): Mt III, proximal view, mediolateral constriction at mid-length of its anteroposterior axis: absent or poorly developed (0); present and marked (1). (Modified from Holtz 2000).
613): Ilium, preacetabular process, ventralmost extent, position in lateral view: closer to the anterior margin of the ilium (0); close to the mid-point of the anteroposterior axis of the preacetabular process (1).
614): Maxilla, facet of the nasal, inclination: facing laterally (0); facing ventrally (1). (Wilson et al. 2003).
615): Lacrimal, nasolacrimal duct, position: leading through the body of the ventral process (0); passing lateral to the ventral process (1). (Modified from Rauhut 2003).
616): Frontal, dorsal surface, sagittal crest: absent (0); present at least on the posterior half (1).
617): Pedal phalanx P1-II, distal articular surface, proximodorsal expansion: poorly developed (0); marked (1). (Senter 2010).
618): Pterygoid, contribution to the "pterygoid flange": well developed (0); reduced in size when compared to the ectopterygoid (1). (Modified from Senter 2010).
619): Upper tooth-row, posterior extent relative to dentary tooth-row: at the same level or posterior (0); anterior (1). (Sereno 1999).
620): Manual ungual III: present (0); absent (1).
621): Mt V: present (0); absent or unossified (1).
622): Pedal digit IV, phalanges, mediolateral width at mid-length: subequal to or less than (0); more than (1) the mediolateral width at mid-length of pedal digit III phalanges.
623): Mt III, ossification: ossified for the whole length (0); proximal third unossified (1).
624): Pubis, posterodorsal surface, shape: transversely convex (0); transversely concave (1).
625): Pedal ungual II, shape in lateral view: straight or moderately curved (0); strongly curved (1).
626): Caudal vertebrae, anterior and middle neural arches, prezygocostal lamina: absent (0); present (1).
627): Ischium, obturator foramen, ossification of the ventral border: complete, connecting the pubic peduncle of the ischium with the obturator lamina (0); open notch (1).
628): Ilium, ischial peduncle, distal end, shape in lateral view: broad and flat articular surface (0); subtriangular in

lateral view, terminates in a reduced and convex articular surface (1). (Modified from Rauhut 2003).
629): Caudal vertebrae, posterior prezygapophyses, overlapping of the preceding centrum: no more than (0); more than (1) 30% of the length of the preceding centrum. (Modified from Holtz 2000).
630): Pubis, foot, shape in anterior/posterior view: mediolaterally unexpanded (0); mediolaterally expanded, wider than the mediolateral width of the pubis just proximally to the pubic foot (1).
631): Pituitary fossa, shape, main axis: anteroposteriorly elongate (0); mediolaterally expanded (1). (Rauhut 2004).
632): Occipital condyle, shape in posterior (occipital) view: rounded, dorsally convex (0); kidney-shaped, slightly concave dorsally (1).
633): Exoccipital, participation to the dorsal margin of the foramen magnum, mediolateral diameter: less than 1/2 (0); more than 1/2 (1) of the mediolateral diameter of the foramen magnum. (Modified from Holtz 2000).
634): Mc II, proximomedial margin, shelf overlapping Mc I: absent (0); present (1).
635): Nasal, lateral crest, posterior processes posterodorsally directed: absent (0); present (1).
636): Femur, distal end, medial margin, proximodistally elongate crest: absent (0); present (1). (Modified from Carrano and Sampson 2008).
637): Frontal, dorsal surface, anteromedial eminence: absent (0); present (1). (Modified from Carrano and Sampson 2008).
638): Cervical vertebrae, epipophyses, anterior process: absent (0); present (1). (Coria and Salgado 2000).
639): Caudal vertebrae, anterior chevrons, bridge of bone closing dorsally the hemal canal: absent (0); present (1). (Modified from Holtz 2000).
640): Humerus, shaft, posterior tubercle: absent (0); present (1). (Modified from Zanno 2010).
641): Manual phalanges, ligament pits, development: strongly developed (0); weakly developed (1). (Zanno 2010).
642): Pedal unguals III and IV, proximodistal length: no more than 2 times (0); more than 2 times (1) the proximodistal length of the penultimate phalanges of the same digits.
643): Prearticular, medial process: absent (0); present (1). (Modified from Norell et al. 2001; Carr 2005).
644): Quadrate, mandibular condyles, position: placed distally (0); placed anterodistally (1).
645): Lacrimal, anterodorsal process, dorsoventral depth: subequal to (0); less than (1) the minimal anteroposterior length of the ventral process (0). (Modified from Sereno 1999).
646): Humerus, shaft, proximodistally oriented posterior sulcus: absent (0); present (1).
647): Cervical neural arches, postzygapophyses, anterolateral surface, foramina: absent (0); present (1). (Allain et al. 2007).
648): Scapula, dorsal margin, costolateral expansion compared to the ventral margin: absent (0); present (1).
649): Squamosal, ventral (precotyloid) process, main axis, inclination in lateral view: posteroventrally directed (0); anteroventrally directed (1).
650): Mt I, proximal end: broad and unconstricted (0); constricted, mediolaterally narrower than the distal half of the bone (1).
651): Dentary, anterior half, medial paradental sulcus separing the interdental septa from the lingual bar: absent (0); present (1).
652): Maxilla, ascending process, lateral pneumatic recesses: absent (0); present (1).
653): Clavicula, lateral longitudinal groove: absent, clavicula oval in cross section (0); present, clavicula “V” or “L”-shaped in cross section (1). (Modified from O'Connor 2009).
654): Sternum, posterolateral process, distal end, shape: unexpanded (0); with distinct mediolateral expansion (1).
655): Mt IV, proximodistal length: not shorter (0); shorter (1) than Mt III.
656): Jugal-postorbital contact: present (0); absent (1).
657): Scapula, costal surface, longitudinal groove: absent (0); present (1). (O'Connor 2009).
658): Pedal unguals III and IV, shape in lateral view: ventrally curved (0); straigth (1). (Modified from Senter 2010).
659): Mc IV: present (0); absent or unossified (1).
660): Dorsal vertebrae, accessory centrodiapophyseal lamina: absent (0); present (1). (Benson et al. 2010).
661): Manual unguals, region distal to flexor tubercle, proximodistal length relative to the dorsoventral diameter of the proximal articular surface: more than (0); less than (1) two times. (Modified from Senter 2010).
662): Lacrimal, angle between the anterodorsal and the ventral rami in lateral view: more than (0); less than (1) 60°. (Sereno 1999).
663): Ischio-pubic medioventral shelves, development: broad and widely contacting medially (pelvic foramen reduced) (0); reduced (wide pelvic fenestra) (1). (Modified from Sereno 1999).
664): Manual ungual I, proximodistal length: less than (0); more than (1) 2/5 of the proximodistal length of the humerus.
665): Caudal vertebrae, median neural spines, dorsoventral diameter: subequal to or less than (0); more than (1) the sum of the dorsoventral diameters of centrum and neural arch.
666): Manual phalax P2-II, length: longer (0); not longer (1) than Mc II. (Modified from Senter 2010; Zanno 2010).

667): Femur, acetabular articular surface, ventral expansion along head: absent, surface only on the proximodorsal end (0); extended in the ventral region (1). (Langer and Benton 2006).
668): Presacral vertebrae, anterior surface, peduncolar fossae placed laterally to the neural canal: absent (0); present (1).
669): Ulna, lateroproximal fossa for the insertion of the M. brachialis, development: very shallow (0); marked (1). (O'Connor 2009).
670): Presacral vertebrae, neural arch, dorsal surface, lateral fossae: absent (0); present (1).
671): Manual unguals, ventral surface, proximal half, transversally expanded fossa/e: absent (0); present (1).
672): Pedal ungual II, collateral grooves, position: placed symmetrically (0); placed asymmetrically, the leteral is closer to the dorsal margin than the medial (1).
673): Mt II, distal fourth, shape in anterior/posterior view: aligned to the proximodistal axis of the proximal half (0); strongly curved medially near its distal end (1). (O'Connor 2009).
674): Mt I, shape: straight or slightly medially flexed (0); markedly flexed medially (1). (Modified from O'Connor 2009).
675): Mt III, distal end, medial condyle, posterior projection in distal view: comparable to (0); more marked than (1) the plantar projection of the lateral condyle of the same Mt. (O'Connor 2009).
676): Mt III, distal end, posterior view, triangular/tonguelike raised processes just proximal to articular surface: absent, distinct intercondylar sulcus present (0); present (1). (Modified from Currie and Dong 2001).
677): Anterior presacral centra, posterior half of centrum, pneumatic recess, development: simple fossa without rim (0); invagined fossa with a distinct rim (1). (Wilson et al. 2003).
678): Jugal, medial surface, recess placed at the level of the postorbital bar: absent (0); present (1). (Currie and Carpenter 2000; Rauhut 2003; modified from Senter 2010).
679): Dentary, alveoli, number: no more than (0); more than (1) ten. (The number of the alveoli is used instead of the number of teeth in order to include also the toothless OTUs that show vestigial tooth sockets [see for example Currie et al. 1993])
680): Caudal vertebrae, median ribs, posterior margin, shape in dorsal/ventral view: straight or slightly convex (0); concave (1). (Coria and Salgado 2000).
681): Tibia, lateral surface, relationships between fibular condyle and cnemial crest: confluent, lateral surface flat to convex (0); condyle offset from the crest by a fossa (1). (Modified from Rauhut 2003; Wilson et al. 2003).
682): Dentary, lateral groove, anteroposterior extent: limited to posterior half (0); extended to more than 2/3 of the dentary (1).
683): Basipterygoid processes, inclination: anteroventrally directed (0); lateroventrally directed (1). (Senter 2010).
684): Cervical vertebrae, centra, articular facets: concavo-convex (0); saddle-shaped (1). (Carrano and Sampson 2008; O'Connor 2009).
685): Tibia, proximal surface, anteroposterior diameter: more (0); less (1) than 9/5 of the mediolateral diameter of the same surface.
686): Mc I, shape in extensor/flexor view: straight (0); mediodistally curved (1).
687): Pedal phalanx P1-II, proximodistal length: subequal to or more than (0); less than (1) 1/4 of the proximodistal length of Mt II.
688): Humerus, deltopectoral crest, fenestra: absent (0); present (1). (Chiappe et al. 1999).
689): Tibiotarsus, anterodistal surface, supratendineal bridge: absent (0); present (1). (O'Connor 2009).
690): Pubis, proximal end, origin of the M. ambiens, development: present as a scar (0); present as a prominent tuberosity (1).
691): Ischium, minimal anteroposterior diameter at mid-length (excluded the obturator region and the distal tip): subequal to (0); less than (1) the minimal anteroposterior diameter of the pubis at mid-shaft. (Holtz et al. 2004).
692): Dentary-surangular complex: unfused (0); fused (1).
693): Femur, laterodistal end, posterior projection, development: poorly developed (0); marked (1). (O'Connor 2009).
694): Ischium, acetabular margin, anteroposterior length: subequal to or more than (0); less than (1) the dorsoventral diameter of the ischio-pubic articulation.
695): Premaxilla, region anterodorsal to narial fossa, slot-shaped foramen: absent (0); present (1). (Yates 2006).
696): Articular, erect, tab-like dorsal process, immediately posterior to the opening of the chorda tympanic foramen: absent (0); present (1). (Modified from Yates 2006).
697): Premaxilla, subnarial process, slenderness: shorter than (0); longer than (1) 4 times its proximal depth.
698): Maxilla, antorbital fossa, anterior margin, shape in lateral view: broadly rounded (0); squared, with anteroventrally acute and anterodorsally obtuse corners (1). (Rauhut 2003; Senter 2011).
699): Articular, dorsal surface, attachment area for the M. depressor mandibulae, shape: transversely convex (0); transversely concave (1). (Yates 2006).
700): Axis, neural spine, anterior tip, position: anteriorly to (0); at the same level or posterior to (1) the prezygapophyses. (Tykoski 2005).

701): Sternum, anteroposterior length: less than 3/2 (0); more than 3/2 (1) of the mediolateral width of the anterior half.
702): Sternum, prominent anterolateral processes: absent (0); present (1). (Modified from O'Connor 2009).
703): Predentary (mentomeckelian ossification): absent (0); present (1).
704): Mc I, medial margin, proximal half, shape in extensor/flexor view: unconstricted relative to distal half (0); constricted and sloping proximolaterally (1).
705): Astragalus, ascending process, anterolateral margin, groove converging with astragalar base: absent (0); present (1). (Ezcurra and Novas 2007).
706): Scapula, glenoid fossa, posterodorsal margin, tuberosity: absent (0); present (1). (Ezcurra and Novas 2007).
707): Maxilla, anteromedial processes, development: short and deep, with little lateral exposure (0); long and low, laterally exposed (1). (Modified from Sereno 1999).
708): Astragalus, ascending process, shape: anteroposteriorly deeper than mediolaterally wide (0); mediolaterally wider than antero-posteriorly deep (1). (Yates 2006)
709): Premaxilla, narial fossa: absent (0); present (1). (Modified from Langer and Benton 2006).
710): Axis, intercentrum, atlantal articular facet, shape: saddle-shaped (0); concave, with upturned lateral borders (1). (Langer and Benton 2006).
711): Maxilla, anterior process, promaxillary sinus, extension into process: absent (0); present (1) (Sereno 1999).
712): Articular, mandibular glenoid, shape in dorsal view: longer than wide (0); mediolaterally expanded (1). (Rauhut 2003).
713): Mt II, posterodistal surface, fossa for Mt I: absent (0); present (1). (O'Connor 2009).
714): Dorsal vertebrae, ossified connective tissue bridging the transverse processes: absent (0); present (1). (O'Connor 2009).
715): Coracoid, shape in proximal view: anteroposteriorly compressed (0); mediolaterally compressed (1). (O'Connor 2009).
716): Basisphenoid, ventral recess, shape: single (0); divided into two small, circular foramina by a thin bar of bone (1) (Senter 2010).
717): Premaxilla, participation to the nasal crest: absent (0); present (1). (Modified from Senter 2010).
718): Premaxilla, internarial process, proximal half, inclination in lateral view: posterodorsally directed (0); dorsally or anterodorsally directed (1).
719): External mandibular fenestra, shape in lateral view: anteroposterior length more than maximus dorsoventral height (0); maximus dorsoventral height more than anteroposterior length (1).
720): Maxillary/dentary teeth, interdenticular sulci (blood grooves) in serrations, development: reduced to denticle margin (0); elongate (1).
721): Maxillary/dentary teeth, area adjacent to the marginal carinae, shape: slightly to strongly mesiodistally convex, especially at the mesial carina (0); flat or even slightly concave area adjacent to the marginal carinae (1).
722): Maxilla/dentary, alveoli, shape in apical view: elliptical or suboval (0); quadrangular (1). (Wilson et al. 2003).
723): Dentary, Meckelian groove, mediolateral depth: marked (0); moderate (1). (Modified from Senter 2010).
724): Ilium, supracetabular crest, shape in dorsal/ventral view: semicircular (0); quadrangular (1). (Holtz et al. 2004).
725): Postacetabular process, posterodorsal margin, mediolateral thickness: comparable to the rest of the ilium (0); margin thickened when compared to preacetabular margin (1).
726): Manual phalanx P1-II, proximodistal length: less than 5/2 (0); more than 5/2 (1) of the mediolateral width at mid-shaft of the same phalanx.
727): Scapula, acromion, shape in anterior view: dorsoventrally deeper than costolaterally wide (0); costolaterally wider than deep (1). (O'Connor 2009).
728): Humerus, head, shape: expanded more lateromedially than proximodistally (0); proximally inflated (1).
729): Humerus, lateral tuberosity, position: proximally to the medial tuberosity (0); at the same level or distally to the medial tuberosity (1). (Modified from Wilson et al. 2003).
730): Premaxilla, oral margin with denticles, number of crenulations: no more (0); more (1) than 3.
731): Maxilla, anteroventral margin, dorsomedial curvature: absent (0); present (1). (Tykoski 2005).
732): Maxilla, first alveolus, inclination: opens ventrally (0); opens anteroventrally (1). (Tykoski 2005).
733): Nasal, paired laterodorsal crests: absent (0); present (1). (Modified from Holtz 2000).
734): Lacrimal, posterodorsal horn, development in adult: low rugosity (0); prominent, taller than long (1).
735): Femur, distal end, tibiofibular crest (ectocondylar tuber): distinct (0); indistinct (1) from fibular condyle. (Modified from Tykoski 2005).
736): Lacrimal, ventral process, dorsoventral diameter: no more than 3/4 (0); at least 3/4 or more (1) of the maximum preorbital skull height. (Modified from Rauhut 2003).
737): Post-temporal opening, dimension: large aperture (0); reduced foramen/incisure (1). (Langer and Benton 2006).
738): Axis, intercentrum, mediolateral width: less (0); more (1) than the width of the centrum. (Sereno 1999).
739): Cervical vertebrae, anterior neural arches, posterior surface, shape: smooth (0); with an excavation on the

posterolateral surface (1). (Langer and Benton 2006).
740): Tibia, distal end, anteromedial corner, angle: subequal or more than (0); less than (1) 90°. (Langer and Benton 2006).
741): Fibula, mid-shaft, mediolateral width: more than 1/2 (0); less than 1/2 (1) of mid-shaft width of the tibia. (Modified from Gauthier 1986).
742): Pubis, proximal surface, ischio-acetabular groove: absent (0); present (1). (Ezcurra and Novas 2007).
743): Femur, head, shape in proximal view: oval in contour (0); subtriangular (1). (Ezcurra and Novas 2007).
744): Femur, proximal surface, transversely extended groove: absent (0); present (1). (Ezcurra and Novas 2007).
745): Femur, head, tuberosity that laterally bounds the ligament of the femoral head, development: prominent (0); reduced (1). (O'Connor 2009).
746): Femur, head, posterior surface, oblique ligament groove, development: very shallow (0); present and deep, bound medially by a posterior lip (1). (Modified from Rauhut 2003).
747): Presacral vertebrae, neural canal, shape: small rounded (0); large oval (taller than 1/3 of centrum depth) (1). (Modified from O'Connor 2009).
748): Presacral vertebrae, middle neural arches, dorsoventral diameter: subequal to or less than (0); more than (1) 6/5 of the dorsoventral diameter of the anterior articular facet of the centrum.
749): Manual ungual I, transversely expanded proximodorsal lip: absent (0); present (1). (Senter 2010).
750): Premaxilla, nasal process, contribution to the margin of the external naris: more than (0); less than 1/2 (1) of the anterodorsal border of the external naris. (Modified from Holtz 2000).
751): Maxilla, anterior process, anterolateral margin, tab-like process: absent (0); present (1).
752): Premaxilla, subnarial process, length: subequal to or more than (0); less than (1) the length of the buccal margin of the premaxilla. (Tykoski 2005).
753): Maxilla, interfenestral strut, postmaxillary recess posterior to maxillary recess: absent (0); present (1).
754): Maxilla, anteromedial process, medial surface: smooth (0); bears longitudinal ridges (1). (Sereno 1999).
755): Frontal-parietal, dorsal contact area, medial fossa in depression: absent (0); present (1). (Tykoski 2005).
756): Lacrimal, ventral process, lateral lamina, anterior margin, shape and relationships with the medial lamina: straight, placed posteriorly to medial lamina (0); sinuous, protrudes anteriorly beyond medial lamina (1). (Tykoski 2005).
757): Basisphenoid, transverse intertuberal lamina, shape: simple wall (0); bears small median spur that projects anteriorly along the roof of basisphenoidal recess (1). (Tykoski 2005).
758): Dentary, anterior tip, dorsal edge: continuous with mid-dentary (0); is raised conspicuously relative to middle and posterior parts of dentary (1). (Sereno 1999).
759): Presacral vertebrae, postaxial centrodiapophyseal laminae: absent (0); present (1). (Tykoski 2005).
760): Dorsal vertebrae, transverse processes, anteroposterior expansion of base: narrow (0); broad, extending to lateral margin of prezygapophysis (1) (Tykoski 2005).
761): Humerus, shaft torsion, angle between the trasverse axes of proximal and distal ends when viewed proximally/distally: subequal to or less than (0); more than (1) 25°. (Modified from Holtz 2000).
762): Ilium, preacetabular process, mediolateral tickness: stout and thick (0); relatively thin and blade-like (1) (Tykoski 2005).
763): Pubises (conjoined elements), mid-shaft, mediolateral width: more than 1/4 (0); less than 1/4 (1) of proximoposterior shaft length. (Tykoski 2005).
764): Ischium, antitrochanter, development: small, indistinct (0); large and protrudes anterolaterally into acetabulum, giving 'notched' profile to posteroventral margin of acetabulum (1). (Tykoski 2005; Sereno 1999).
765): Femur, posterodistal (popliteal) fossa in adults, infrapopliteal ridge between medial (=tibial) distal condyle and tibiofibular crest: absent (0); present (1). (Tykoski 2005).
766): Fibula, proximomedial surface, oblique (posteroproximal to anterodistal) ridge that overlaps proximal part of medial fibular groove: absent (0); present. (Tykoski 2005).
767): Lacrimal, posteroventral process, development: short, indistint (0); elongate (1).
768): Fronto-parietal, transversely oriented crest: absent (0); present (1).
769): Postorbital, participation to the supratemporal fossa: wide (0); reduced to the margin of the fossa (1). (Sereno 1999).
770): Squamosal, otic incisure, shape in lateral view: broad and posteriorly directed (0); "inverted-U" shaped and posteroventrally directed (1).
771): Quadrate, distal condyles, helical groove, development: deep and distinct (0); very low and shallow (1).
772): Humerus, distal condyles, intercondylar groove: wider (0); narrower (1) than 1/2 of the mediolateral width of the lateral condyle. (Zanno 2010).
773): Jugal, suborbital process, lateral crest: absent (0); present (1).
774): Maxilla, maxillary fenestra, ventral margin, position: dorsally to (0); at the same level of or ventrally to (1) the ventral margin of the antorbital fenestra. (Brusatte et al. 2010).

775): Ischium, shaft, anteroventral surface, low longitudinal crest placed distally to the obturator process: absent (0); present (1).
776): Fibula, insertion of the M.ileofibularis, position: in the proximal third (0); in the distal 2/3 (1) of the bone.
777): Maxillary/dentary teeth, lingual base, marked low eminence: absent (0); present (1).
778): Pubis, proximal shaft, cross-section, proportion: as deep as wide, or deeper (0); wider than deep (1). (Modified from Senter 2007; O'Connor 2009).
779): Mc I, proximolateral margin, shelf overlapping ventrally Mc II: absent (0); present (1).
780): Jugal, participation to the posterior border of the orbit: present (0); excluded by the postorbital (1).
781): Ischium, obturator process, pubic contact, extent: limited to the proximal half (0); extended distally (1). (Modified from Zanno et al. 2009). (Char. # 781).
782): Cervical vertebrae, anterior centra, posteriormost extent: at the same level or anteriorly than (0); extending posteriorly (1) the posterior extent of the neural arch. (Senter 2010).
783): Manual ungual I, dorsal margin, high arching over dorsal extremity of proximal articular facet: absent (0); present (1). (Senter 2010).
784): Manual ungual II, dorsal margin, high arching over dorsal extremity of proximal articular facet: absent (0); present (1). (Senter 2010).
785): Premaxilla, nasal processes, distal end, direction in dorsal view: laterally directed, diverging (0); medially directed, appressed (1). (Brusatte et al. 2010).
786): Humerus, shaft distal to deltopectoral crest, tuber on anterolateral margin: absent (0); present (1). (Loewen et al. 2013).
787): Maxilla, antorbital fossa, ventral margin, depth: decreases anteroposteriorly (0); uniform along most of its length (1). (Modified from Brusatte et al. 2010).
788): Nasal, posterior (frontal) processes, number: no more than 2 (0); more than 2 (1). (Brusatte et al. 2010).
789): Surangular, accessory posterior foramen: absent (0); present (1).
790): Postorbital-quadratojugal contact: absent (0); present (1).
791): Pedal digit I: present (0); absent (1).
792): Manual unguals, collateral grooves, form: simple, unforked (0); proximally forked, producing a pair of distally converging furrows (1).
793): Premaxillary teeth, cross section, major axis of elongation: mesiodistal (0); labiolingual (1).
794): Femur, tibiofibular (ectocondylar) condyle, mediolateral diameter: less than (0); more than (1) the width of the medial condyle.
795): Femur, head, shape in lateral/medial view: rounded (0); hook-shaped (1).
796): Manual phalanx P1-I, proximodistal length: subequal to or less than (0); more than (1) the length of manual phalanx P1-II.
797): Dorsal vertebrae, posterior postzygapophyses, distalmost extent: at the same level or anteriorly to (0); posteriorly to (1) the posterior end of the centrum. (Maryańska et al. 2002).
798): Preorbital skull, antorbital fenestra, proportions: taller than long or as long as tall (0); longer than tall (1). (Modified from Senter et al., 2004).
799): Humerus, distal lateral epicondyle, lateral expansion, development: poorly developed, confluent with distal surface (0); prominent and distinct from distal surface (1). (Senter, 2007).
800): Mt II and IV, proximal end, anterior view, contact: absent (0); present (1). (Holtz 2000).
801): Frontal, supraorbital rim: absent (0); present (1). (Senter 2010).
802): Dorsal ribs, capitular facets, dorsoventral expansion, development: moderate (0); hypertrophied, anteroventrally-posterodorsally oriented long axes measuring more than half the height of their respective centra (1). (Zanno 2010).
803): Preacetabular process, anteroposterior length: no more than (0); more than (1) 6/5 of its proximal dorsoventral height. The proximal height of the preacetabular blade is measured at the level of the anterodorsal margin of the pubic peduncle of the ilium.
804): Femur, proximal articulation, shape in anteromedial view: rounded or convex (0); flattened (1).
805): Frontal, supratemporal fossa, anterior margin, shape: straight or slightly curved (0); strongly sinusoidal (1). (Senter 2010).
806): Humerus, shaft between deltopectoral crest and distal condyles, proximodistal length: subequal to or less than (0); more than (1) 5 times minimal shaft diameter. (Modified from Senter 2010).
807): Ulna, shaft, shape in lateral/medial view: straight or slightly sigmoid (0); posteriorly bowed (1). (Gauthier 1986).
808): Ischium, longitudinal ridge dividing lateral surface into anterior and posterior parts: absent (0); present (1). (Modified from Makovicky et al. 2005).
809): Astragalus, articular facet for calcaneum, anterolateral notch: absent (0); present (1).
810): Astragalus, posterolateral ascending process: absent (0); present (1). (Agnolin et al. 2010).
811): Astragalus, ascending process, lateral margin, distinct vertical ridge marking the fibula facet: absent (0); present

(1).
812): Teeth, labial and lingual surfaces, texture: smooth (0); series of slight wrinkles oriented mesiodistally (1). (Modified from Benson et al. 2010).
813): Dorsal vertebrae, hyposphene, step-like ridges on lateral margin: absent (0); present (1). (Smith et al. 2008).
814): Surangular, posterior end, lateral groove: absent (0); present (1). (Smith et al. 2008).
815): Ilium, postacetabular process, brevis shelf (lateroventral crest), development: diminishes anteriorly (0); developed anteriorly (1). (Langer and Benton 2006).
816): Maxillary/dentary teeth, crowns, relative positions: do not overlap (0); partially overlap (1) labially. (Nesbitt 2011).
817): Maxillae, lateral surfaces, orientation toward each in dorsal view: acutely angled (0); subparallel (1): (Rauhut 2003).
818): Frontal, dorsal surface, anterolateral corner of orbital margin, dorsal prominence/horn: flat, process absent (0); convex, process present (1). (Cau et al. 2013).
819): Premaxilla, maxillary process, orientation in lateral and anterior views: faces laterodorsally (0); lies flat in the horizontal plane (1). (Brusatte et al. 2010).
820): Squamosal, quadratojugal process, distal end, shape in lateral/medial view: pointed (0); blunt (1). (Brusatte et al. 2010).
821): Premaxilla, lateral surface: smooth (0); pierced by neurovascular foramen/foramina (1). (Modified from Ezcurra and Novas 2007)
822): Dentary, symphysis, ventral surface, hourglass-shaped depression: absent (0); present (1).
823): Opening for the internal carotid artery: not bordered (0), bordered (1) by a pneumatic fossa. (Currie and Carpenter 2000; Holtz 2000)
824): Maxilla, medial surface, inflated/swollen bulla vestibularis: absent (0); present (1).
825): Mt III, shaft, proximal half, posterior margin, shape: broad to rounded (0); mediolaterally constricted/sharp (1).
826): Tarsometatarsus, proximal vascular foramen between Mt III and IV: absent (0); present (1). (Modified from O'Connor 2009).
827): Radius, distal end, medial expansion: absent (0); present, bearing a medially flared articular surface (1).
828): Maxilla, antorbital fossa, ventral ramus, ornament-like pits and ridges: absent (0); present (1).
829): Mc III, distal articulation: ginglymoid (0); convex (1). (Senter 2010).
830): Mc III, shape in dorsal/ventral view: straight (0); laterally bowed (1). (Gauthier 1986).
831): Distal carpal 1+2 block, articulation with Mc II: articulates (0); fails to articulate (1) with the lateral half of the proximal surface of Mc II. (Modified from Senter 2010).
832): Caudal vertebrae 3-7, anterior chevrons, proximal end, shape: short anteroposteriorly, shaft cylindrical (0); proximal end elongate anteroposteriorly, flattened and plate-like (1). (Senter 2010).
833): Pubis, distal end, marked folding, forming a boot-like expansion that is markedly compressed in anterior view: absent (0); present (1). (Langer and Benton 2006).
834): Radius, shaft, shape: straight (0); sigmoid (1). (Zanno 2010).
835): Cervical vertebrae, postaxial postzygapophyses, anteroventral surface: lacking foramina (0); pierced by foramen/foramina (1). (Tykoski 2005).
836): Fibula, distal end, medial flange overlapping the ascending process of the astragalus: absent (0); present (1). (Tykoski 2005).
837): Mt II, proximal end, insertion of the tendon of the M. tibialis anterioris, position on extensor surface: close to the lateral margin or in the center (0); close to or along the medial margin (1). (Modified from O'Connor 2009).
838): Cervical vertebrae, posterior neural arches, hyposphene-like accessory articulation: absent (0); present (1). (Smith et al. 2008).
839): Maxillary teeth, apicobasal height: highly variable with gaps evident for replacement (0); almost isodont, with no more than a 30% difference in height between adjacent teeth, and with no replacement gaps (1). (Senter 2010).
840): Maxillary/post-symphiesal dentary crowns, lingual surface bearing apicobasally directed ridges/flutes: absent (0); present (1).
841): Premaxilla, medial surface, foramen placed below the narial margin: absent (0); present (1). (Modified from Wilson et al. 2003).
842): Quadratojugal, sharp lateral flange running anterodorsally: absent (0); present (1). (Smith et al. 2008).
843): Cranial nerve V, opening, position: not posteriorly (0); posteriorly (1) to the apex of nuchal (supraoccipital) crest. (Modified from Coria and Currie 2002).
844): Prootic, foramen of facial nerve (Cranial nerve VII), shape: round or slightly anteroposteriorly elongate (0); dorsoventrally elongate (1). (Smith et al. 2008).
845): Cranial nerve VI, median ridge separating exits: present (0); absent (1). (Coria and Currie 2002).
846): Ectopteygoid, ventral recess, shape: medial depression/groove (0); foramen leading from the medial side laterally

into the body of the ectopterygoid (1). (Modified from Gauthier 1986).
847): Vertebrae, pleurocoels, shape: suboval (0); slit-like, dorsoventrally narrow (1). (Modified from Smith et al. 2008).
848): Cervical vertebrae 4-8, postzygodiapophyseal laminae: absent (0); present (1). (Modified from Yates 2006).
849): Premaxilla, subnarial process: present (0); absent (1).
850): Mt IV, distal end, shape in distal view: as broad as deep (0); deeper than broad (1). (Modified from Sereno 1999).
851): Dorsal vertebrae, anterior neural spines, inclination: dorsally or posteriorly directed (0); anterodorsally directed (1).
852): Premaxilla, nasal process, posteriormost extent: at the same level or anteriorly (0); posteriorly to (1) the posterior tip of the ventral (maxillary) process of premaxilla. (Yates 2006).
853): Quadrate, proximodistal (dorsoventral) diameter: more than (0); subequal to or less than (1) 2 times the mediolateral diameter of its distal articulation.
854): Femur, distal end, medial condyle, spike-like process on the proximal surface: absent (0); present (1). (Brusatte et al. 2010).
855): Tibia, proximal end, lateral margin of the lateral condyle, shape in proximal view: uniformly convex (0); indented (1). (Modified from Brusatte et al. 2010).
856): Fibula, proximal (dorsal) margin, shape in medial/lateral view: straight or slightly convex (0); concave, anteriorly upturned (1). (Brusatte et al. 2010).
857): Tibia, proximal end, lateral condyle, anteroposterior estension in lateral view: short, does not reach the anterior margin of the tibial shaft (0); long, reaching the anterior margin of the tibial shaft (1). (Brusatte et al. 2010).
858): Astragalus, ascending process, medially projected spur along the margin: absent (0); present (1).
859): Maxilla, region ventral to external naris, dorsal margin, inclination in lateral view: inclined and facing anterodorsally (0); subhorizontal and facing dorsally (1).
860): Astragalus, ascending process, anterior surface: flat (0); excavated by a proximal fossa, distinct from astragalar base, and bearing one or more foramina (1).
861): Dorsal vertebrae, prezygoparapophyseal lamina: absent (0); present (1). (Yates 2006).
862): Dorsal vertebrae, middle parapophyses, position: ventrally to (0); at the same level to (1) diapophyses. (Yates 2006).
863): Postorbital, posteroventral margin, shape in lateral/medial view: sharply flexed (0); gently concave (1). (Novas et al. 2008).
864): Maxilla, form of articular surface for nasal anteroventral process, and form of nasal anteroventral process: tapered process (0); blunt-tipped anteroventral process (1). (Modified from Sereno and Brusatte 2008).
865): Maxilla, posterior process, inclination of ventral margin under jugal articulation (lateral view): horizontal (0); declined by approximately 20° (1). (Sereno and Brusatte 2008).
866): Maxilla, ventral margin, position of lateral rim relative to the medial rim: ventral (0); at the same level or dorsal (1). (Modified from Holtz et al. 2004).
867): Caudal vertebrae, anterior and median centra, longitudinal crest: absent (0); present (1).
868): Caudal vertebrae, neural canal, mediolateral diameter: no more (0); more (1) than 1/3 of centrum proximal height.
869): Caudal vertebrae, median postzygapophyses, posterior extent: distally (0); proximally (1) to the distal facet of the centrum.
870): Tibia, distal end, articular facet for ascending process of astragalus subdivided by a proximodistally elongate process, and corresponding sulcus on the posterior surface of the ascending process of astragalus: absent (0); present (1).
871): Maxilla, ventral margin of the antorbital fossa: narrower than the ventral process of the maxilla (0); deeper than the ventral process of the maxilla (1).
872): Lacrimal, posterodorsal process, cornual boss: absent (0); present (1). (Loewen et al. 2013).
873): Maxilla, dorsal process, anterodorsal margin, shape in lateral view: arched, dorsally convex (0); angular (1).
874): Eminasals, relationships: unfused (0); fused (1).
875): Prefrontal: present (0); absent (1).
876): Jugal, quadratojugal process, posterodorsal process, anteroposterior length: less than (0); subequal to or more than (1) the posteroventral process.
877): Interorbital septum, extensive ossification: absent (0); present (1). (Coria and Currie 2002).
878): Quadrate, quadratojugal contact in posterior view, cleft of the paraquadrate foramen, dorsoventral axis: less than (0); more than (1) 1/3 ventral width of quadrate.
879): Quadrate, quadratojugal contact in posterior view: interrupted by a cleft (0); continuous (1).
880): Quadratojugal and quadrate: unfused (0); fused (1).
881): Basipterygoid processes, relationship with the pterigoids: unfused (0); fused (1).
882): Palatine, jugal process, distal expansion: absent (0); present (1). (Currie and Carpenter 2000).
883): Ectopterygoid, position: mostly anteriorly to the palatine (0); laterally to the palatine (1).

884): Maxillary/dentary teeth, serration, distal density / mesial density index: less than (0); more than (1) 1.25.
885): Dentary teeth, first tooth, size: comparable to (0); smaller than (1) teeth 4th to 6th.
886): Maxillary and dentary teeth (excluding anteriormost three), position of the largest tooth: close to the anterior end (0); close to the middle (1) of tooth row.
887): External mandibular fenestra: present (0); absent (1).
888): Dentary, posterior half, medial paradental sulcus separing the interdental septa from the lingual bar: absent (0); present (1).
889): Dentary, medial surface, foramina at the anterior end of the Meckelian groove, number: one (0); two (1). (Benson et al. 2010).
890): Sacral vertebrae, zygapophyses: unfused (0); fused, forming a sinuous ridge in dorsal view (1). (Senter 2010).
891): Sacral vertebrae, centra, ventral surface, longitudinal sulcus: absent (0); present (1).
892): Splenial, mylohyoid foramen, size: small (0); wide fenestra (1).
893): Splenial, mylohyoid foramen, shape: anteroventrally opened notch (0); closed foramen (1).
894): Dorsal vertebrae, anterior centra, hypapophyses, number: single process (0); paired processes (1).
895): Dorsal vertebrae, posteriormost centra, parapophyses, position: ventrally to (0); at the same level and joined to (1) the prezygodiapophyseal lamina. (Coria and Salgado 2000).
896): Scapula, distal end, distinct “shoulder” (dorsoventral expansion) relative to rest of shaft: present (0); absent (1).
897): Coracoid, tubercle, direction: anterolaterally (0); medially (1). (O'Connor 2009).
898): Coracoid, supracoracoid nerve foramen: present (0); absent (1).
899): Ulnare: present (0); absent (1) distally to the ulna.
900): Manual phalanx P1-II, shaft, strong dorsoventral compression: absent (0); present (1). (O'Connor 2009).
901): Mc II and III, distal ends: unfused (0); fused (1).
902): Mc III, proximal end, ossification: present (0); absent (unossified) (1).
903): Sternum, paired posteromedial processes, posteromedial contact with median process enclosing two fenestrae: absent (0); present (1).
904): Sternum, posteromedian process in taxa with posteriorly acuminate sternum, distal end, shape: tapering (0); expanding mediolaterally (1).
905): Postacetabular process, posterior margin, posterodorsal process projected posteriorly beyond level of mid-height of posterior margin: asbent (0); present (1).
906): Pubis, emipubic shelves, medial contact: present (0); absent (1).
907): Ischium, mediodorsal process, shape: tubercle (0); proximodistally elongate crest (1).
908): Femur, shaft, surface area placed distally to the anterior trochanter: smooth (0); bearing a proximodistally elongate ridge (1).
909): Tibia, fibular crest, relationship with the proximal condyles of the tibia: separated (0); joined (1). (Modified from Rauhut 2003).
910): Mt I, distal end, position: proximally to (0); at the same level of (1) the distal end of Mt II.
911): Astragalus, fibular articular facet, orientation: proximolaterally (0); laterally (1). (Modified from Rauhut and Xu 2005).
912): Ilium, ischial peduncle, shape and orientation in lateral/medial view: short and posteroventrally directed (0); elongate and ventrally directed (1).
913): Paroccipital process, dorsal margin, shape: straight (0); twisted anterolaterally at distal end (1). (Senter 2010).
914): Maxilla, maxillary recess, medial wall: unfenestrated (0); fenestrate and leading to maxillary antrum (1).
915): Nasal, posterior end, shape in dorsal view: the medial projections extend as far or further posteriorly than the lateral projections (0); the lateral projections extend further posteriorly than the medial projections (1). (Holtz et al. 2004).
916): Dentary, anterodorsal margin, shape in lateral/medial view: angled (0); strongly beveled (1). (Modified from Senter 2010).
917): Caudal vertebrae, median neural spines, inclination of dorsoventral axis: posterodorsally (0); subvertical (1).
918): Caudal vertebrae, median and posterior centra, length: less (0); more (1) than 5 times their anterior height. (Wilson et al. 2003).
919): Parietal, nuchal plate, orientation with respect to frontal–parietal–postorbital suture: not parallel (0); parallel (1). (Modified from Coria and Currie 2002).
920): Supraoccipital, participation to the dorsal margin of the foramen magnum: present (0); absent (1).
921): Laterosphenoid, antotic crest separating lateral wall of braincase from orbital and temporal spaces: absent or indistinct (0); present and robust and rugose (1). (Brusatte et al. 2010).
922): Mc I, proximolateral margin, shape in dorsal/ventral view: continuous with the proximomedial face (0); strongly sloped laterally (1).
923): Astragalus, ascending process, angle between the proximomedial corner and the transverse axis of the astragalus:

no more than (0); more than (1) 45°.
924): Radius/ulna (excluding olecranon process), proximodistal diameter: subequal to or more than (0); less than (1) 6 times its mid-shaft diameter.
925): Caudal vertebrae, chevrons: present (0); absent (1).
926): Caudal vertebrae, median zygapophyses, articulation between preceding vertebrae: present (0); absent (1). (Modified from O'Connor 2009).
927): Caudal vertebrae, ribs, position: at the level or dorsally to (0); ventrally to (1) the mid-height of the centrum.
928): Caudal vertebrae, centra, ventral half, internal structure: spongy (0); hollow (1).
929): Caudal vertebrae, anterior and median ribs, major axis of elongation, length: less (0); more (1); than 7/5 of the length of the centrum. (Modified from Canale et al. 2008).
930): Caudal vertebrae, anterior and median neural arches, space between the prezygapophyese and the proximal base of the neural spine, shape: narrow prespinal fossa (0); narrow and robust prespinal lamina bordered laterally by the spinozygapophyseal laminae (1).
931): Humerus, anterodistal end, distinct brachial fossa: absent (0); present (1). (Modified from O'Connor 2009).
932): Femur, posterior trochanter, size: eminence (0); shelf (1). (Modified from O'Connor 2009).
933): Tarsometatarsus, intercotylar eminence: absent (0); present (1). (O'Connor 2009).
934): Egg, geometry: symmetrical (0); asymmetrical (1). (Modified from Grellet-Tinner and Makovichy 2006).
935): Egg, ratio of the two diameter: less than (0); more than (1) 3/5. (Grellet-Tinner and Makovichy 2006).
936): Eggs in nest, pattern: absent (0); paired (1). (Grellet-Tinner and Makovichy 2006).
937): Clutch, morphology: two or more layers of eggs (0); one layer of eggs (1). (Grellet-Tinner and Makovichy 2006).
938): Clutch and/or nest, morphology: absence of empty space in the center (0); presence of empty space in the center (1). (Grellet-Tinner and Makovichy 2006).
939): Egg, shell, ornamentation: absent (0); present (1). (Grellet-Tinner and Makovichy 2006).
940): Egg, shell, number of layers: one (0); more than one (1). (Grellet-Tinner and Makovichy 2006).
941): Egg, shell, nature of the boundary between layers 1 and 2: aprismatic (0); prismatic (1). (Grellet-Tinner and Makovichy 2006).
942): Dorsal vertebrae, anterior neural arches, base of prezygapophyses, pneumatic recesses: absent (0); present (1).
943): Dorsal vertebrae, prespinal and postspinal laminae, dorsal extent: terminate at the same level to (0); ventrally to (1) of neural spine. (Modified from Senter 2010).
944): Ulna, proximal surface, shape: a single continuous articular facet (0); divided into two distinct fossae separated by a median ridge (1). (Senter 2010).
945): Mc III, proximal end, position relative to the proximal end of Mc II: laterally (0); ventral (1). (Modified from Senter 2010).
946): Premaxillary teeth, pattern of arrangement: aligned, not overlapping (0); patrially overlapping en-echelon (1).
947): Maxilla, paradental plates, exposition in medial view: relatively tall, broadly exposed (0); low and partially obscured by lamina of maxilla (1). (Modified from Carrano and Sampson 2008).
948): Radius and ulna, distal ends, shape: mediolaterally unexpanded and flattened (0); mediolaterally expanded and hemispherical (1). (Tykoski 2005).
949): Postorbital, ventral (jugal) process, posterior margin, inclination relative to dorsal surface on lateral view: perpendicular (0); anteroventrally directed, forming an angle of more than 25° (1). (Pol and Rauhut 2012).
950): Ilium, postacetabular process, notch between the supracetabular crest and the ventrolateral margin of the postacetabular blade: present (0); absent (1). (Modified from Tykoski 2005).
951): Maxilla, articular surface with the premaxilla, inclination in lateral view: angled strongly posterodorsally (0); subvertical (1). (Brusatte and Sereno 2008).
952): Maxilla, anterior paradental plates, dorsoventral depth: less (0); or more (1) than 3/2 their antero-posterior width. (Modified from Brusatte and Sereno 2008).
953): Squamosal, ventral (= precotyloid) process, length relative to the posterior (= postcotyloid) process in lateral view: longer (0); subequal (1). (Brusatte and Sereno 2008).
954): Dentary, posterior end of principal neurovascular foramina row, location: parallels the tooth row (0); curves ventrally as it extends posteriorly (1). (Brusatte and Sereno 2008).
955): Gastralia, distal end of medial element, shape: tapered (0); club-shaped prominence (1). (Brusatte and Sereno 2008).
956): Gastralia, number of sets of fused medial elements: zero or one (0); more than one (1). (Brusatte and Sereno 2008).
957): Ilium, anterior margin of preacetabular process, profile: gently convex (0); subvertical, straight (1). (Brusatte and Sereno 2008).
958): Ischium, proximodorsal process, lateral view, relationships with iliac peduncle: distinct by cleft (0); confluent (1). (Brusatte and Sereno 2008).

959): Femur, lateral distal condyle, form: flat to bulbous (0); cone-shaped (1). (Brusatte and Sereno 2008).
960): Nasal, premaxillary process, anterodorsal end, notch: absent (0); present (1). (Brusatte et al. 2010).
961): Nasal, transverse section, shape: uniformly convex (0); "D"-shaped (1). (Brusatte et al. 2010).
962): Nasal, posterolateral process, exposition: present (0); covered by the lacrimal (1). (Carr 2005).
963): Maxillary fenestra, anteroposteror axis: less than twice height (0); more than twice (1) height.
964): Nasal, posteromedial process: present (0); absent (1). (Brusatte et al. 2010).
965): Femur, tibiofibular crest (ectocondylar tuber), shape and orientation in posterior view: narrow, longitudinal (0), broad, oblique (1). (Carrano and Sampson 2008).
966): Skull, postorbital, lacrimal and jugal, lateral surfaces: smooth (0); sculptured (1). (Carrano and Sampson 2008).
967): Pedal ungual II, flexor tubercle, proximoventral cleft: absent (0); present (1). (Senter 2010).
968): Nasal–frontal contact, posteriormost extent, position: anterior to base of nasal process (0); at the level of or posterior to base of nasal process (1). (Modified from Carrano and Sampson 2008).
969): Supraoccipital, couple of foramina for middle cerebral vein on either side of posterior supraoccipital crest, position: laterally spaced (0); closely appressed medially (1). (Tortosa et al. 2013).
970): Postorbital, ventral process, anteroventral margin, morphology: confluent with remainder of process (0); step and fossa present (1). (Carrano and Sampson 2008).
971): Postorbital–squamosal contact, appareance in lateral view: contact edges visible (0), edges covered by dermal expansions (1). (Carrano and Sampson 2008).
972): Lacrimal, antorbital fossa, exposition: exposed laterally (0), covered by dermal ossifications (1). (Carrano and Sampson 2008).
973): X cranial nerve opening, position: through otoccipital (0); onto occiput (1). (Carrano and Sampson 2008).
974): Occipital condyle, dorsal groove, size: wide (0); narrow (1). (Carrano and Sampson 2008).
975): Splenial, anterior end, prongs, number: one (0), two (1). (Carrano and Sampson 2008).
976): Dentary, lateral groove, position: at mid-height or dorsally (0), in ventral half (1). (Carrano and Sampson 2008).
977): Cervical vertebrae, transverse processes, dorsal surface, accessory fossa: present (0), absent (1). (Carrano and Sampson 2008).
978): Dorsal vertebrae, paradiapophyseal lamina, development: poorly developed (0); pronounced (1). (Carrano and Sampson 2008).
979): Femur, laterodistal end, laterally protruding prominence: absent (0); present (1).
980): Cervical ribs, shaft bifurcation: absent (0), present (1). (Carrano and Sampson 2008).
981): Coracoid, posteroventral process, proximodistal diameter: less than (0); more than (1) twice the diameter of the glenoid. (Modified from Carrano and Sampson 2008).
982): Pubis, foot, dorsal surface, mid-line shape: convex (0); concave (1). (Carrano and Sampson 2008).
983): Fibula, insertion of M. iliofibularis, size: moderate (0), large (1). (Carrano and Sampson 2008).
984): Lacrimal, lateral dorsal recess, anteroposterior diameter in lateral view: no more than (0); at least (1) two times its posterior height. (Brusatte et al. 2010).
985): Lacrimal, lateral dorsal recess, dorsoventral diameter: no more than (0); more than (1) the dorso-ventral diameter of the lacrimal above the recess. (Brusatte et al. 2010).
986): Lacrimal, medial recess: absent (0); present (1). (Brusatte et al. 2010).
987): Postorbital, orbital margin of the adult, shape in lateral view: straight (0); concave (1). (Modified from Brusatte et al. 2010).
988): Preorbital skull, antorbital fenestra length: less than (0); subequal to or more than (1) 1/4 skull length. (Tykoski 2005).
989): Scapula, acromion, tip, shape: rounded/blunt (0); hooked (1). (O'Connor 2009).
990): Caudal vertebrae, anterior and median chevrons, proximoposterior process, development: indistinct (0); pronounced (1). (Modified from Sereno 1999).
991): Distal end, posterior (olecranal) fossa, development: moderately developed (0); well developed and confluent with the humerotricipitalis groove (1). (Modified from Chiappe 2001).
992): Dorsal ribs, number of pair articulating with the sternum: no more than two (0); three or more (1).
993): Angular, exposition in lateral view: exposed almost to end of mandible, reaches or almost reaches articular (0); excluded from posterior end of articular, suture turns ventrally and meets ventral border of mandible anterior to glenoid (1). (Senter 2010).
994): Premaxillo-maxilla suture, lateral view, fenestra at the level of the external naris (dorsal to subnarial foramen, when present): present (0); absent (1).
995): Palatine-pterygoid-ectopterygoid bar, shape: straight and almost covered by cheek margin (0); arching below ventral cheek margin (1). (Senter 2010).
996): Scapula, blade, orientation and position in articulated specimen: posterodorsally inclined and not close to the vertebral column (0); subhorizontal and close to the vertebral column (1).

997): Mt V, shape: straight (0); anterodistally curved (1). (Modified from Rauhut 2003).
998): Fibula, proximal end, width: less than 3/4 (0); more than 3/4 (1) of the proximal width of the tibia. (Holtz 2000).
999): Tibia, distal end, medial malleolus, development: mediolateral development: less than (0); more than (1) its proximodistal extent. (Modified from Sereno 1999).
1000): Femur, distal end, mediodistal process, development: ridge (0); broad flange/shelf (1). (Modified from Carrano and Sampson 2008).
1001): Frontals, dorsal surface, shape: straight laminae (0); dorsoventrally vaulted, posteroventrally flexed (1).
1002): Lacrimal, ventral process, lateral foramen, position: near the base (0); at mid-height (1). (Sereno 1999).
1003): Humerus, proximal end, posterior surface, capital incisure between head and internal (medial) tuberosity: absent (0); present (1).
1004): Femur, head, medial surface, fovea capitalis (for attachment of capital ligament): absent (0); present (1). (O'Connor 2009).
1005): Humerus, distal end, lateral condyle, transversal axis, inclination relative to proximodistal axis of humerus: less (0); more (1) than 45°. (Modified from O'Connor 2009).
1006): Humerus, distal margin, inclination: approximately perpendicular to long axis of humeral shaft (0); mediodistal margin projected significantly distal to laterodistal margin, distal margin angling strongly medially (sometimes described as a well-projected flexor process) (1). (Modified from O'Connor 2009).
1007): Humerus, distal end, strong anteroposterior compression: absent (0); present (1). (O'Connor 2009).
1008): Anterior presacral centra, anterior pneumatic recess, number of openings: single opening (0); multiple openings (1). (Modified from Harris 1998; Brusatte and Sereno 2008).
1009): Tibiotarsus, anterodistal end, tendinal groove, development: very shallow (0); prominent (1). (Modified from Senter 2010).
1010): Ulna, lateral tuberosity, development: small mound (0); hypertrophied and robust (1). (Smith et al. 2008).
1011): Manual phalanx P1-I, ventral surface, shape: relatively flat or weakly concave (0); strongly concave with deep ventral furrow (1). (Smith et al. 2008).
1012): Radius, proximoanterior process, development: reduced (0); prominent, subtriangular in proximal view (1). (Smith et al. 2008).
1013): Radius, posteromedial edge, ulnar process at mid-length: absent (0); present (1).
1014): Exoccipital-opisthotic, crista tuberalis (=metotic strut), mediolateral width across opposing cristae in posterior view: less than (0); more than (1) 1/2 the dorsoventral depth of the braincase from the dorsal tip of the supraoccipital to the ventral tip of the basal tubera. (Brusatte et al. 2014).
1015): Metotic foramen: open (0); closed (1). (Holtz et al. 2004).
1016): Caudal vertebrae, pre- and postspinal laminae: absent (0); present (1).
1017): Cervical vertebrae, centra, ventral surface, mediolateral width: more than 1/3 (0); less than 1/3 (1) of centrum mid-height width. (Longrich and Currie 2009b).
1018): Femur, posterolateral ridge running from greater trochanter to femoral shaft, position: posterolateral margin (0); lateral surface (1). (Xu et al. 2012).
1019): Mc III, diaphysis, length: more (0); subequal or less (1) than 2 times distal epiphysis width.
1020): Maxillary fenestra, shape: rounded (0); crescentic/slit-like (1).
1021): Tibiotarsus, distal end, posterior extension of articular surface for distal tarsals/tarsometatarsus: absent, articular restricted to distalmost edge of posterior surface (0); well-developed posterior extension, sulcus cartilaginis tibialis (sensu Baumel and Witmer 1993), distinct surface extending up the posterior surface of the tibiotarsus (1). (Clarke and Norell 2002).
1022): Tibiotarsus, sutures between ascending process of astragalus and distal tibia: visible (0); not visible, obliterated (1).
1023): Tibia/tarsal distal condyles, tuberositas retinaculi extensoris (indicated by short medial ridge or tubercle proximal to the condyles close to the midline and a more proximal second ridge on the medial edge): absent (0) or present (1). (O'Connor 2009)
1024): Ilium, preacetabular process, medial ridge, development: slightly reduced (0); prominent (1). (Holtz et al. 2004).
1025): Humerus, head, long axis in proximal view: collinear with the plane of the proximal expansion of the humerus (0); oriented slightly obliquely (1).
1026): Mc I, proximal end, lateral proximolateral process: poorly developed (0); prominent (1).
1027): Scapula, medial surface, anteroventral margin above the glenoid, rugose ossification: absent (0); present (1).
1028): Femur, distal end, expanded lateral supracondylar ridge, which ends in a well developed proximal tubercle: absent (0); present (1).
1029): Postorbital, medial surface, articular facet for the laterosphenoid, shape and development: shallow (0); deep concavity (1). (Modified from Sereno and Brusatte 2008).
1030): Humerus, proximal end, distinction between head and deltopectoral crest: absent (0); present (1).

1031): Ischium, obturator process/flange (medioventral lamina): absent, indistinct from shaft (0); present and distinct from shaft (1).
1032): Caudal vertebrae, median ribs, shape in dorsal/ventral: narrow-based and subrectangular (0); wide-based and prominent, alariform (1). (Novas et al. 2004).
1033): Caudal vertebrae, median and posterior ribs, dorsal surface: flat (0); excavated (1). (Novas et al. 2004).
1034): Caudal vertebrae, median neural spines, dorsal surface: mediolaterally narrow (0); broad (1).
1035): Caudal vertebrae, anterior neural spines, shape: sheet-like (0); rod-like (1). (Carrano and Sampson 2008).
1036): Fibula, proximomedial end, fossa/groove, posterior margin: closed by a lip (0); open (1). (Modified from Carrano and Sampson 2008).
1037): Sternum, plates in articulated adult specimens: unossified (0); ossified (1).
1038): Sternum, paired plates, ventral surface: less than or subequal to (0); more than (1), that of the coracoids.
1039): Frontal, lacrimal suture, shape of edge: smooth (0); notched (1). (Senter 2010).
1040): Dorsal vertebrae, anterior transverse processes, size and inclination: long, thin and inclined (0); short, wide, and only slightly inclined (1). (Senter 2010).
1041): Frontal, ventral surface, olfactory bulbs, position: widely spaced (0); closely appressed medially (1).
1042): Coracoid, constricted neck between scapular facet and rest of bone: absent (0); present (1).
1043): Orbitosphenoid: present/ossified (0); absent/unossified (1). (Holtz et al. 2004).
1044): Frontal, interfrontal suture in adults: open, visible (0); closed, coossified (1). (Holtz 2000).
1045): Frontal, postorbital process, anterior limit of the supratemporal fossa, pronounced pit: absent (0); present (1). (Senter 2010).
1046): Tibia, distal end, lateral malleolus, anteroposterior expansion relative to medial malleolus: absent (0); present (1). (Longrich and Currie 2009).
1047): Humerus, head, proximal surface, shape in anterior/posterior view: straight or convex (0); concave (1). (Modified from O'Connor 2009).
1048): Fibula, shaft, relationships with tibia: separated (0); appressed (1).
1049): Skull, elongation in adult: shorter (0); longer (1) than 3 times the occipital height. (Sereno 1999).
1050): Premaxillary-maxillary oral margin: continuous (0); interrupted by a gap (1).
1051): Cervical vertebrae, centra 3–6, proximodistal length: subequal to (0); more than (1) 10% of the length of the axis. (Yates 2006).
1052): Cervical vertebrae, centra 7–9, proximodistal length: subequal to (0); more than (1) 10% of the length of the axis. (Yates 2003; modified from Gauthier 1986).
1053): Frontal-postorbital facet, anterior depth: less (0); more (1) than 2/5 facet length.
1054): Distal tarsal 4, posteromedial prong, shape: blunt, with a straight to rounded medial margin in proximal/distal view (0); pointed (1). (Modified from Langer and Benton 2006).
1055): Ilium, preacetabular process, anteroventral corner with distinc ventral projection (antiliac process): absent, anteroventral margin rounded (0); present, anteroventral margin acuminate (1).
1056): Ilium, pubic peduncle, posterodistal margin of lateral surface, mound-like eminence: absent (0); present (1).
1057): Olfactory bulbs, greatest diameter: length (0); depth (1). (Zelenitsky et al. 2008).
1058): Cerebral hemisphere, greatest diameter: depth (0); length (1). (Zelenitsky et al. 2008).
1059): Olfactory ratio (%): more than 45 (0); less than 45 (1). (Zelenitsky et al. 2008).
1060): Pubis, proximodistal length: subequal to or less than (0); more than (1) 2/3 of that of the femur.
1061): Dorsal vertebrae, anterior neural arches, hyposphene-hypantrum articulation: absent (0); present (1).
1062): Manual ungual I, flexor tubercle, ventral surface, transverse groove: absent (0); present (1).
1063): Femur, tibiofibular crest (ectocondylar tuber), posteriormost extent in distal view: anteriorly to the posteriormost extent (0); at the same level or more posteriorly than (1) the posteriormost extent of the medial condyle.
1064): Astragalus, parapet anterior to ascending process and ascending process base, depression: absent (0); present as a semilunate fossa (1). (Rauhut and Xu 2005).
1065): Pedal unguals, ventral fossa: absent (0); present (1).
1066): Pedal unguals II and IV, marked asymmetry among the external surfaces: absent (0); present (1).
1067): Pedal digit IV, intermediate phalanges, shape: longer than broad (0); broader than long (1).
1068): Pedal digit IV, medial surface, proximal half, marked fossa: absent (0); present (1).
1069): Pedal unguals, collateral groove, confluence with the ventral surface: absent (0); present (1).
1070): Mt I, shape: long and slender, longer than 4 times its distal width (0); short and robust, long no more than 4 times its distal width (1).
1071): Mc II and III, mediodistal condyle, marked laterodistal lips: poorly developed (0); present, directed proximomedially (1).
1072): Cervical vertebrae, middle centra, posterior surface, mediolateral width: less than (0); subequal to or more than (1) 6/5 of the dorsoventral diameter of the same surface. (Modified from Sereno 1999).

1073): Dorsal vertebrae, neural spines, spinodiapophyseal basal webbing: absent (0); present (1). (Modified from Sereno 1999).
1074): Dorsal vertebrae, anterior neural spines, shape: longer than tall or as tall as long (0); taller than long (1).
1075): Basioccipital, posterior surface, median vertical crest: present (0); absent (1). (Canale et al. 2008).
1076): Premaxilla and maxilla, paradental laminae, depth along the tooth row: increases anteriorly since the posterior end of the toothrow (0); homogeneous along all the tooth row length (1). (Canale et al. 2008).
1077): Maxilla/jugal articulation, inclination in lateral view: less than (0); subequal or more than (1) 45° relative to ventral margin. (Canale et al. 2008).
1078): Splenial, anteroventral process, length relative to the anterodorsal one: larger or subequal (0), less (1). (Modified from Canale et al. 2008).
1079): Jugal, ventral margin, shape in lateral/medial view: nearly flat or slightly convex (0); strongly convex (1). (Canale et al. 2008).
1080): Skull, supratemporal fenestra, proportions: longer than wide or as long as wide (0); wider than long (1). (Modified from Canale et al. 2008).
1081): Postorbital, anterodorsal ramus, development: slender, as long as or longer than thick (0); robust, thicker than long. (Modified from Canale et al. 2008).
1082): Postorbital and squamosal, direction of dorsal margins (when the skull is oriented horizontally): posteriorly oriented (0); strongly oriented ventrally (1). (Canale et al. 2008).
1083): Cervical vertebrae, postzygapophyses, elongation: posteriorly short, not surpassing the posterior end of the vertebral centra (0); swept back posteriorly widely surpassing the posterior end of vertebral centra (1). (Carrano and Sampson 2008).
1084): Axis, pleurocoels, position: ventrally to (0); posteriorly to (1) the diapophyses. (Canale et al. 2008).
1085): Axis, postzygodiapophyseal lamina, development: poorly developed (0); prominent (1). (Canale et al. 2008).
1086): Cervical vertebrae, diapophyses, shape: rod-like and anteroposteriorly narrow (0); with anteroposteriorly extended lateral surfaces (1). (Canale et al. 2008).
1087): Dorsal vertebrae, neural arch base, shape: dorsoventrally low and laterally expanded (0); dorsoventrally tall and laterally compressed (1). (Canale et al. 2008).
1088): Caudal ribs, posterodistal margin, shape in dorsal/ventral view: unenxpanded (0); posteriorly expanded (1).
1089): Manual non-ungual phalanges, distal surfaces, development: well-defined condyles (0); flattened (1). (Modified from Canale et al. 2008).
1090): Mt III, distal end, shape: ginglymoid, dorsoventrally extended, distinct from mt shaft (0); mediolaterally wide and dorsoventrally low, being its dorsal margin continuous with shaft when viewed laterally (1). (Modified from Novas et al. 2004).
1091): Caudal vertebrae, ribs, ventral surface, parasagittal ridge on lateral margin: absent (0); present (1).
1092): Maxilla, preantorbital process, lateral subcutaneous surface, proportion: taller than long (0); longer than tall (1).
1093): Femur, distal half, tickness: as tick as (0); clearly ticker than (1) proximal half. (Xu et al. 2009).
1094): Caudal vertebrae, anterior ribs, shape in dorsal view: plate-like, quadrangular with subparallel anterior and posterior margins (0); rod-like, triangular with distally converging anterior and posterior margins (1). (Xu et al. 2009).
1095): Lacrimal, posterodorsal process, orientation: perpendicular (0); posterodorsally to subvertical (1). (Senter 2010).
1096): Scapula, acromion, dorsal margin: continuous with blade (0); anterior edge laterally everted (1). (Senter 2010).
1097): Retroarticular process, direction: points posteriorly (0); curves posterodorsally (1). (Senter 2005).
1098): Scapula, flange on supraglenoid buttress (Senter 2005): absent (0); present (1).
1099): Scapula, proximal end, medial curvature: present, lateral surface of the proximal end significantly medial to that of the scapular blade (0); absent, about the same level (1). (Xu et al. 2009).
1100): Scapula, articular facet for the coracoid, acromial participation, extent: wide (0); the dorsal portion of the facet extremely thin transversely (1). (Modified from Xu et al. 2008).
1101): Cranial nerve VII, position relative to prootic lateral depression, when present: outside (0); inside (1). (Turner et al. 2012).
1102): Pedal phalanx P4-IV, length: subequal or shorter (0); longer (1) than preceding two phalanges. (This character is not co-variant with char. # 503).
1103): Scapula, blade, lateral surface, longitudinal sulcus: absent (0); present (1).
1104): Scapula, blade robustness: straplike for the distal half, both dorsal and ventral margins sharply ridged (0); relatively robust, only sharply ridged along the dorsal margin close to the distal end (1). (Xu et al. 2009).
1105): Ulna, robustness relative to tibiotarsus: significantly more slender than (0); as robust as (1) tibiotarsus. (Xu et al. 2009).
1106): Ulna, proximal end, articular surface for ulnar condyle: flat mediolaterally and longer anteroposteriorly than transversely (0); a bowl-like fossa, subequal in anteroposterior and mediolateral width (1). (Xu et al. 2009).
1107): Ulna, proximal end, medial process: weakly developed (0); prominent (1). (Xu et al. 2009).

1108): Ulna, proximal third of shaft, anterior margin, thick ridge from coronoid (anterior/sigmoid) process: absent (0); present (1). (Smith et al. 2008; Xu et al. 2008).
1109): Ulna, distal end, proximal extension of distal facet along the lateral margin: weak, distal margin nearly straight in posterior view (0); significant, distal margin convex in posterior view (1). (Modified from Xu et al. 2009).
1110): Ulna, distal end, anteroposteriorly thickest portion, location: near the medial margin (0); near the mid-length (1). (Xu et al. 2009).
1111): Ulna, distal end, transverse width: less (0); more (1) than two times anteroposterior length. (Modified from Xu et al. 2009).
1112): Radius, distal end, lateral flange: present (0), absent (1). (Xu et al. 2009).
1113): Tibia, lateral cnemial crest: poorly developed (0); prominent (1).
1114): Tibia, lateral cnemial crest, orientation: mainly anteriorly directed (0); mainly laterally directed (1). (Xu et al. 2009).
1115): Surangular, anterior foramen in groove, development: smaller than groove (0); as large as groove (1).
1116): Pedal unguals, dorsal surface, shape: continuously convex (0); with dorsoproximal concavity (1). (Brusatte et al. 2010).
1117): Dorsal vertebrae, posterior centra, ventral keel: absent (0); present (1).
1118): Distal carpals 1-2 in adult articulated specimens: present, ossified (0); absent, unossified (1).
1119): Pedal phalanx P2-II, proximoventral process: small and asymmetrically developed only on medial side of vertical ridge subdividing proximal articulation (0); long and lobate, with extension of midline ridge extending onto its dorsal surface (1). (Makovichy et al. 2005).
1120): Long bones, internal cavitation: moderate (0); extreme (1). (Sereno 1999).
1121): Pubis, shaft close to the proximal end, anteroposterior width: less than (0); more than (1) 2 times of the mediolateral width. (Modified from Xu et al. 2009).
1122): Mt II, lateral surface in proximal view: straight (0); concave (1). (Brusatte et al. 2008).
1123): Dentary, anteroventral margin, form: smooth, convex (0); marked by a projecting flange, forming a ‘dentary chin’ (1). (Brusatte and Sereno 2008).
1124): Odontoid, foramen/depression on anterolateral surface: absent (0); present (1). (Brusatte et al. 2008).
1125): Axis, neural spine, lateral foramen/foramina: absent (0); present (1). (Brusatte et al. 2008).
1126): Post-axial cervical centra, marked rim around the anterior convexity in opistocoelous forms: absent (0); present (1).
1127): Dorsal vertebrae, hyposphene, shape in posterior view: subtriangular (0); rectangular (1). (Modified from Brusatte et al. 2008).
1128): Post-axial cervical vertebrae, epipophyses, position: distally on postzygapophyses, dorsal to postzygapophyseal facets (0); placed proximally, anterior to postzygapophyseal facets (1). (Senter 2010).
1129): Sacral vertebrae, neural spine, pneumaticity: absent (0); present (1). (Carrano and Sampson 2008).
1130): Cervical vertebrae, hypapophyses in posterior centra, development: poorly developed (0); prominent (1).
1131): Postorbital, frontal (anterodorsal) process, shelf overhanging orbit: absent (0); present (1).
1132): Femur, anterior cleft between anterior and greater trochanters, elongation: short, less than half (0); elongate, more than half (1) dorsoventral depth of femur head.
1133): Furcula, hypocleidum, cross section: rounded (0); keeled (1). (Nesbitt et al. 2009).
1134): Furcula, symphysis, cross section: rounded (0); anteroposteriorly compressed (1). (Nesbitt et al. 2009).
1135): Ischium, distal expansion, anteroposterior diameter: less (0); more (1) than twice minimum ischial shaft anteroposterior diameter.
1136): Maxilla, contribution to the narial fossa: absent (0); present (1). (Longrich and Currie 2009a).
1137): Maxilla, postantral wall, lateral exposition: concealed in lateral view (0); posteriorly projecting into antorbital fenestra (1). (Longrich and Currie 2009a).
1138): Maxilla, palatal shelf, lateral exposition: concealed in lateral view (0); projecting dorsally into the antorbital fenestra and visible in lateral view (1). (Longrich and Currie 2009a).
1139): Scapula, acromion, anteroposterior extent: less (0); more (1) than twice proximal shaft depth.
1140): Basioccipital, tubera, posterior surfaces, shape: flat or smoothly concave (0); basioccipital tubera with distinct, ovoid depressions on the posterior surface (1). (Longrich and Currie 2009a).
1141): Ischium, medial surface, ridge connecting proximodorsal process and iliac peduncle: absent (0); present (1). (Longrich and Currie 2009a).
1142): Ilium, preacetabular process, medial ridge, anteroposterior length: less (0); subequal (1) to the length of the postacetabular process.
1143): Ilium, pubic peduncle, dorsoventral depth to basal anteroposterior length ratio: deeper than long (0); longer than deep (1). (Modified from Longrich and Currie, 2009).
1144): Mt IV, distal end, ventral surface, prominent tuber proximal to distal articular surface: absent (0); present (1).

(Longrich and Currie 2009b).
1145): Caudal vertebrae, pygostyle, anterior end, dorsal bifurcation: absent (0); present (1). (O'Connor 2009).
1146): Premaxilla-maxilla articulation, shape in lateral view: simple (0); interdigitate (1). (Benson et al. 2010).
1147): Caudal vertebrae, posterior centra, lateral excavation: absent (0); present (1).
1148): Mt II, proximal half, lateral expansion over posterior margin of Mt III: absent (0); present (1).
1149): Tibia, distal end, medial malleolus, shape in anterior/posterior view: angular or rounded (0); truncated (1).
1150): Postorbital bar, anteroposterior diameter at mid-height: subequal to (0); more than (1) the anteroposterior diameter of the lacrimal at mid-height. (Brusatte et al. 2010).
1151): Basisphenoid, pronounced muscle scar flanking the ventral recess: absent (0); present (1). (Brusatte et al. 2010).
1152): Quadratojugal, posterior border, posteroventral overlapping the quadrate: absent (0); present (1). (Modified from Brusatte et al. 2010).
1153): Mt III, distal half, dorsal view, shape of medial margin: straigth (0); bearing a medial expansion/bulge (1).
1154): Occipital condyle, distinct neck: absent (0); present (1).
1155): Maxilla, orientation of the groove for the dental lamina (paradental groove) on the medial surface: horizontal across its length (0); horizontal for most of its length but curves ventrally at its anterior extent (1). (Benson et al. 2010).
1156): Braincase, facial (VII) nerve foramen, number: one (0); two (1). (Benson et al. 2010).
1157): Braincase, fenestra ovalis, primary orientation: medio-lateral, such that it opens on the lateral wall of the braincase (0); antero-posterior, and located on the web of bone linking the crista tuberalis and the paroccipital process, such that it opens mostly anteriorly (1). (Modified from Coria and Currie 2002).
1158): Axis, centrum, anteroposterior length: elongate, longer than 1.2 times the height of the posterior articular face (0); short, less than 1.1 times the height of the anterior articular face (1). (Benson et al. 2010).
1159): Ilium, postacetabular process, medioventral shelf, development: developed as a ridge (0); prominent shelf ventrally projected (1).
1160): Astragalus, lateral condyle, antero-proximal extension of the articular face as a rounded triangular process: absent (0); present (1).
1161): Ischium, obturator notch (in taxa with a ventrally opened notch), shape in lateral/medial view: "U"-shaped (0); with diverging sides (1). (Modified from Holtz et al. 2004).
1162): Cervical vertebrae, interpostzygapophyseal lamina: absent (0); present at least in anterior vertebrae (1). (Zanno 2010).
1163): Mc I, mediodistal condyle, development: well formed (0); rudimentary (1). (Brusatte et al. 2010).
1164): Humerus, distal end, medial condyle, mediolateral width: comparable (0); larger (1) than lateral condyle. (Brusatte et al. 2010). (Char. # 1164).
1165): Dorsal vertebrae, neural spines, dorsal view: quadrangular/trapezoid (0); spine anteriorly and posteriorly bifurcated, medially pinched in dorsal view (1). (Zanno 2010).
1166): Humerus, anterodistal surface, anterior tuberosity proximal to medial epicondyle: absent (0); present (1). (Zanno 2010).
1167): Humerus, distal half, anterolateral margin, groove ascending dorsal to medial epicondyle: absent (0); present (1). (Zanno 2010).
1168): Ilium, pubic peduncle, shape of cross section: quadrangular (0); roughly triangular in outline (1). (Modified from Zanno 2010).
1169): Ilium, ischial peduncle of ilium and antitrochanter form a hypertrophied and spherical boss: absent (0); present (1). (Zanno 2010).
1170): Ischium, articular surface for ilium, shape: flat or slightly concave (0); iliac peduncle of ischium with deep cavity for insertion of peg-shaped, ventrally tapering ischiadic peduncle of ilium (1). (Carrano and Sampson 2008; Zanno 2010).
1171): Fibula, proximal end, anterior and posterior margins: subequal in transverse width (0); transverse width of proximal fibula narrows posteriorly (1). (Zanno 2010).
1172): Dorsal vertebrae, middle and posterior postzygapophyses, small, flange-like lateral extensions of postzygapophyseal facets: absent (0); present (1). (Benson et al. 2010).
1173): Coracoid, lateral fossa ventrodistal to glenoid (subglenoid fossa): absent (0); present (1). (Benson et al. 2010).
1174): Ilium, large external pneumatic foramina and internal spaces: absent (0); present (1). (Benson et al. 2010).
1175): Maxilla, promaxillary recess, exposition in lateral view: present (0); absent (1).
1176): Tibia, proximolateral condyle, anterolateral process, orientation: horizontally projected (0); curves ventrally (1). (Modified from Benson et al. 2010).
1177): Ulna, posterior surface distal to olecranon process: rounded (0); sharp (1). (Smith et al. 2008).
1178): Atlas, neural arch, pneumatic foramen in dorsolateral surface: absent (0); present (1). (Benson et al. 2010).
1179): Femur, distal end, morphology: central depression connected to crista tibiofibularis by a narrow groove (0); anteroposteriorly oriented shallow trough separating medial and lateral convexities (1). (Benson et al. 2010).

1180): Astragalus, fibular articular facet, orientation: proximolaterally (0); laterally (1). (Modified from Rauhut and Xu 2005).
1181): Squamosal, dorsotemporal fossa: absent or flat (0); convex (1). (Brusatte et al. 2010).
1182): Squamosal, pneumatic sinus: absent (0); present (1). (Brusatte et al. 2010).
1183): Ectopterygoid, jugal process: not inflated (0); inflated (1). (Brusatte et al. 2010).
1184): Ectopterygoid, surface adjacent to pneumatic recess: flat (0); lip (1). (Modified from Brusatte et al. 2010).
1185): Caudal vertebrae, anterior neural arches, pneumatic recesses: absent (0); present (1).
1186): Ilium, antiliac (anteroventral) process, shape in lateral view: subtriangular (0); half-crescentic, with a distinct posterior concavity (1).
1187): Maxilla, pneumatic region on medial side posteroventral to maxillary fenestra: absent (0); present (1). (Benson et al. 2010).
1188): Maxilla/dentary, paradental laminae: extend apically as far as (0); fall more basally than (1) ventral level of lateral wall of maxilla. (Benson et al. 2010).
1189): Nasal, antorbital fossa: visible in lateral view (0); occluded in lateral view by a ventrolaterally overhanging lamina (1). (Benson et al. 2010).
1190): Quadrate, depression and foramen on medial surface, adjacent to mandibular condyle, at base of pterygoid process: absent (0); present (1). (Benson et al. 2010).
1191): Basioccipital apron, fossa ventral to occipital condyle: narrow and groove-like (0); broad depression approximately two-thirds the width of the occipital condyle (1). (Benson et al. 2010).
1192): Basipterygoid processes, position: located anterior or anteroventral to basal tubera (0); located ventral to basal tubera (1). (Benson et al. 2010).
1193): Maxillary/dentary, mesial carina, basal half, serration: present (0); absent (1). (Modified from Benson et al. 2010).
1194): Middle cervical vertebrae, pleurocoel penetrates centrum through parapophysis: no (0); yes (1). (Benson et al. 2010).
1195): Axis, parapophyses, development: poorly developed (0); prominent (1). (Benson et al. 2010).
1196): Sacrum, fenestrae between sacral neural spines: absent (0); present (1). (Benson et al. 2010).
1197): Ilium, acetabular margin of pubic peduncle: mediolaterally convex or flat (0); mediolaterally concave (1). (Benson et al. 2010).
1198): Femur, long axis of medial condyle in distal view: oriented anteroposteriorly (0); inclined posteromedially (1). (Benson et al. 2010).
1199): Tibia, proximal end, medial condyle, shape: bulbous eminence, not continuous with posterior surface of head (0); extends distally as a ridge that merges with posterior surface of proximal end (1). (Benson et al. 2010).
1200): Tibia, fibular flange shape: transversely narrow flange (0); oval mound (1). (Benson et al. 2010).
1201): Fibula, proximal end, lateral surface, posterior sulcus/trough: absent, surface convex (0); present (1). (Modified from Benson et al. 2010).
1202): Femur, distal end, lateral condyle, distalmost extent: does not project further distally than (0); projects distinctly further than (1) medial condyle. (Modified from Benson et al. 2010).
1203): Femur, distal end, muscle scar situated medially on anterior surface, development: suboval rugose patch not extending to distal end of femur (0); large oval depression, bound medially by a lamella (1). (Modified from Rauhut 2003).
1204): Manual phalanges, proximal end, ventral process, development: poorly developed (0); prominent and mediolaterally expanded (1).
1205): Manual ungual I: present (0); absent (1).
1206): Ilium, supracetabular crest, extent along the pubic peduncle: extensive (0); almost entirely excluded by the acetabular rim of the pubic peduncle (1).
1207): Cervical vertebrae, anterior and middle parapophyses, relationship with the diapophyses articular facet: well separated (0); closely placed (1).
1208): Mt II, shaft, cross section: rounded to elliptical (0); laminar, mediolaterally compressed (1).
1209): Ischium, symphysis, proximodistal extent: limited to the distal end (0); proximally expanded as an apron (1).
1210): Pramaxilla, maxilla and dentary, lateral surface, neurovascular foramina, position: well distant to the occlusal margin (0); very close to the occlusal margin (1). (Modified from Sereno and Brusatte 2008).
1211): Cervical vertebrae, diapophyses, posterior border, angle with the anteroposterior axis of the neural arch in dorsal view: less than (0); subequal to (1) 90°.
1212): Cervical vertebrae, prezygapophyses, shape of infraprezygapophyseal space in dorsal view: "V"-shaped, diverging sides (0); "U"-shaped, sub-parallel sides (1).
1213): Tooth crowns, height to crown base length ratio of tallest fully erupted crown: more (0); less (1) than 5/3.
1214): Caudal vertebrae, anterior and median neural arch base relative to centrum proportions: smaller (0), equal or

more (1). (Modified from Carrano and Sampson 2008).
1215): Parietal, participation to supratemporal fossa: present (0); absent (1). (Brusatte et al. 2010).
1216): Scapula, shaft, dorsal margin distal to the acromion, shape in lateral view: uniformily straight or slightly kinked (0); markedly kinked, with a distinct dorsal bend (1).
1217): Scapholunare, distal surface, orientation (and radial angle): laterodistally facing (radial angle < 45°) (0); strongly laterodistally facing (radial angle > 45°) (1). (Modified from Sullivan et al. 2010).
1218): Tooth, implantation: free at the base of the tooth (0); teeth fused to the bone of attachment at the base (1). (Modified from Nesbitt et al. 2010).
1219): Femur, popliteal (posterodistal) fossa, proximodistal extent: less than (0); more than (1) 1/3 femur length. (Nesbitt et al. 2010).
1220): Supraoccipital, rugose ridge on the anterolateral edges: absent (0); present (1). (Nesbitt et al. 2010).
1221): Exoccipital, lateral vertical crest (metotic strut) placed anteriorly to both foramina of cranial nerve XII: absent (0); present (1). (Nebitt et al. 2010).
1222): Jugal, postorbital process, contact with the squamosal: absent (0); present (1).
1223): Pubis, proximal end, lateral surface, texture: smooth (0), rugose (1). (Benson et al. 2010).
1224): Caudal vertebrae, median postzygapophyses, epipophyses: absent (0); present (1). (Carrano and Sampson 2008).
1225): Mc II, distal articulation: ginglymoid (0); convex (1).
1226): Femur, proximolateral surface, prominent flange proximodistally elongate, distinction from greater trochanter: gradual (0); proximal notch in anterior/posterior views (1). (Xu et al. 2012).
1227): Caudal vertebrae, anterior neural arches, proportion: low and wide (0); narrow and tall (1).
1228): Anterior presacral centra, anterior half of centrum, lateral pneumatic recess: absent (0); present (1).
1229): Cervical vertebrae, middle neural arches, prezygapophyses and diapophyses, relative positions: prezygapophyses dorsally directed, placed above the diapophyses (0); prezygapophyses anteriorly directed, placed at the same level of the diapophyses (1).
1230): Mcs I-III, distal end, transverse lip bordering the proximal margin of the extensor surface: absent (0); present (1). (Modified from Ezcurra et al. 2010).
1231): Mcs I-III, distal end, collateral ligament pits, development: well developed and distint (0); shallow, poorly developed (1). (Ezcurra et al. 2010).
1232): Femur, head, anteromedial surface, tuber: absent (0); present (1). (Modified from Nesbitt et al. 2009).
1233): Dorsal vertebrae, middle and posterior prezygapophyses, anteroventral process: absent (0); present, pendant (1). (Coria and Salgado 2000).
1234): Dorsal vertebrae, middle and posterior hyposphene, size in lateral view: less (0); comparable to (1) the postzygapophyses. (Novas et al. 2008).
1235): Dorsal vertebrae, anterior and middle neural arches, anterior infraprezygapophyseal fossae, development: shallow (0); deep (1).
1236): Dorsal vertebrae, neural spines, height, transition from middle to posteriormost: gradual (0); markedly abrupt (1).
1237): Caudal vertebrae, chevrons, proximal articular surface, distinct transverse ridge dividing surface into anterior and posterior facets: present (0); absent, low mounds may be present, one on each side, laterally (1). (Benson et al. 2010).
1238): Exoccipital, ventral projection in lateral view: short, weak (0); strong, beyond squamosal and approaching ventral end of the quadrate (1). (Longrich et al. 2011).
1239): Dentary posterodorsal process, shape in lateral view: straight or weakly curved (0); strongly bowed dorsally (1).
1240): Dentary, symphysis, posteroventral surface, posterior process: poorly developed (0); prominent (1). (Longrich et al. 2011).
1241): Dentary, anteroventral margin, shape in lateral/medial view: straight or weakly downturned (0); strongly downturned (1).
1242): Dentary, lateral surface, fossa: absent (0); present (1).
1243): Surangular, anteroposteriorly elongate flange on the ventral edge: absent (0); present (1).
1244): Ilium, vertical crest above the acetabulum, inclination: dorsally directed (0); dorsoposteriorly directed (1). (Brusatte et al. 2010).
1245): Jugal, postorbital process, pronounced ridge on the lateral surface, which borders the postorbital posteriorly: absent (0); present (1). (Brusatte et al. 2010).
1246): Distal carpals 1+2, shape in dorsal/ventral view: quadrangular (0); semilunate, with distinctly convex/rounded proximal margin (1).
1247): Ulna, proximal surface, anteroposterior diameter: more than (0); less than (1) 3/2 mediolateral width.
1248): Mc III, proximal end, heel-like process at base: absent (0); present (1). (Sereno 1999).
1249): Radius, proximal end, articular facet for ulna, inclination relative to long axis of bone: reclined (0), subvertical

(1). (Gishlick 2002).
1250): Remiges, vanes: symmetrical (0); asymmetrical (1).
1251): Mc I, proximal end, radial flange: absent (0); present (1). (Gishlick 2002).
1252): Dorsal vertebrae, neural spine, ventral half, shape: straight (0); anteroposteriorly expanded, anteriorly convex (1).
1253): Humerus, M. brachialis origin, position relative to shaft: proximal (0); distal (1). (Gishlick 2002).
1254): Ulna, medial surface, M. brachialis insertion scar: absent (0); present (1). (Gishlick 2002).
1255): Radius, bicipital scar, size: wide area (0); reduced (1). (Gishlick 2002).
1256): Radius, medial surface, pronator muscle scar: absent (0); present (1). (Gishlick 2002).
1257): Mc I, radiocarpo-matacarpal ligament insertion: absent (0); present (1). (Gishlick 2002).
1258): Ulna, M. extensor metacarpi ulnaris origin, size: wide (0); reduced (1). (Gishlick 2002).
1259): Mc II, M. extensor metacarpi ulnaris insertion: absent (0); present (1). (Gishlick 2002).
1260): Teeth, root, mesiodistal diameter along the apicobasal axis: uniform (0); markedly constricted close to the crown (1). (Barrett 2009).
1261): Dentary, laterodorsal process, mediolateral development: ridge (0); prominent shelf (1). (Barrett 2009).
1262): Dentary, laterodorsal process, anteriormost extent: posterior (0); anterior (1) to the mid-length of the buccal surface. (Barrett 2009).
1263): Lacrimal brow, form: horizontal shelf (0); ventrolaterally beveled surface (1). (Wilson et al. 2003).
1264): Antorbital fossa, external rim on anterior process of lacrimal: present (0); absent (1). (Wilson et al. 2003).
1265): Quadrate lateral flange, maximum width: approximately 1/2 of (0); subequal to (1), transverse width of distal condyles. (Wilson et al. 2003).
1266): Supraoccipital nuchal wedge and parietal alae, position of dorsal extremity: slightly (0); considerably (1) above frontoparietal skull table. (Wilson et al. 2003).
1267): Dentary-surangular articulation, form: narrow V-shaped notch (0); broad U-shaped socket (1). (Wilson et al. 2003).
1268): Dentary, medial articular prong for surangular (separate from dorsal prong that is exposed laterally): absent (0); present (1). (Wilson et al. 2003).
1269): Axis, intercentrum length: less than 1/3 (0); more than 1/3 (1), of axial centrum length. (Sereno 1999).
1270): Axis, spinopostzygapophyseal lamina, form: straight or gently concave (0); deeply notched (1). (Wilson et al. 2003).
1271): Cervical epipophyses, form: ridgelike or subconical (0); at least, mid cervical epipophyses anteroposteriorly extended with anterior corner (1). (Wilson et al. 2003).
1272): Cervical epipophyses, mediolateral thickness: robust (0); thin (1).
1273): Cervical vertebrae, middle (C4-6) neural spines, orientation: vertical (0); dorsoposteriorly inclined (1). (Wilson et al. 2003).
1274): Sacral neural arches, development of paramedian fossae: poorly developed (0); divided by vertical septa (1). (Wilson et al. 2003).
1275): Cervical ribs, form of lateral process for articulation with successive rib spine in mid cervicals: ridge (0); flange (1). (Wilson et al. 2003).
1276): Sacral vertebrae, posterior ribs, attachment position: ventral margin (0); angled toward dorsoposterior corner (1), of postacetabular process. (Sereno 1999).
1277): Tibia, distal half, crest placed distal to tibiofibular crest with flattened articular edge for fibular shaft: absent (0); present (1). (Wilson et al. 2003).
1278): Fibula, shaft ventral to tibiofibular crest, position relative to tibial shaft: lateral (0); anterior (1). (Wilson et al. 2003).
1279): Pubis, shaft, distal half, transverse width of blade-shaped medial portion: subequal to (0); twice the width of (1), rod-shaped lateral portion. (Sereno 1999).
1280): Mc II, distal condyles, distal projection: subequal (0); leteral condyle more developed (1).
1281): Premaxilla, posterior half, teeth: present (0); absent (1).
1282): Nasal, premaxillary articular surface, extent: less than (0); subequal to or more than (1) 1/2 of nasal length. (O'Connor 2009).
1283): Quadrate, pterygoid process, shape: broad and trapezoidal (0); sharp and pointed (1). (O'Connor 2009).
1284): Quadrate, distal end: with two transversely aligned condyles (0); with a triangular, condylar pattern, usually composed of three distinct condyles (1). (O'Connor 2009).
1285): Dorsal vertebrae, middle and posterior centra, lateral side, excavation distinct from pleurocoel: weakly or not excavated (0); deeply excavated by a groove/fossa (1). (Modified from O'Connor 2010).
1286): Sacral vertebrae, short vertebrae with dorsally directed parapophyses just anterior to the acetabulum: absent (0); present (1). (O'Connor 2009).

1287): Caudal vertebrae, pygostyle, posterior constriction: absent (0); present (1). (O'Connor 2009).
1288): Coracoid, scapular articulation, position: at the shoulder (proximal) end (0); placed more distally (1). (O'Connor 2009).
1289): Scapulocoracoid, angle between the humeral articular facets of the coracoid and the scapula: placed in the same plane (0); forming a sharp angle (1). (O'Connor 2009).
1290): Coracoid, proximal end, peg-like process (acrocoracoidal tubercle): absent (0); present (1). (O'Connor 2009).
1291): Coracoid, sternal margin: convex (0); straight to concave (1). (Modified from O'Connor 2009).
1292): Scapula, acromion, anterior margin in lateral/costal view: blunt (0); tapered (1). (O'Connor 2009).
1293): Pedal phalanx P1-I, proximal end, size compared to distal end of mt I: comparable (0); much larger, expanded mediolaterally (1).
1294): Furcula, omal tips, shape: straight (0); curved dorsally (1). (O'Connor 2009).
1295): Furcula, omal tips, expansion in lateral view: absent (0); present (1). (O'Connor 2009).
1296): Conjoined pubes in anterior/posterior view, mediolateral width: gradually narrowing distally, lateral margin of pubis gently curved (0); abruptly narrowing a mid-length, lateral margin of pubis sigmoid (1).
1297): Sternum, posterolateral process, inclination: parallel or nearly parallel to the long axis of the sternum (0); directed laterodistally so that the distal ends are located lateral to the anterior half of the sternum (1). (O'Connor 2009).
1298): Humerus, proximoanterior surface, well-developed circular fossa on midline: absent (0); present (1). (O'Connor 2009).
1299): Humerus, insertion of the m. coracobrachialis anterioris, circular scar on anterior surface: absent (0); present (1). (O'Connor 2009).
1300): Humerus, anterior surface, distal end of bicipital crest, pit-shaped fossa for muscular attachment: absent (0); present (1). (O'Connor 2009).
1301): Carpometacarpus, ventral surface, supratrochlear fossa deeply excavating proximal surface of pisiform process: absent (0); present (1). (O'Connor 2009).
1302): Ischium, proximodorsal process, iliac contact: absent (0); present (1). (Modified from O'Connor 2009).
1303): Tibiotarsus, distal end, medial surface of medial condyle deeply excavated by a pit-like epicondylar depression (depressio epicondylaris medialis): absent (0); present (1). (O'Connor 2009).
1304): Tarsometatarsus, proximal half, anterior fenestra between Mt III and IV: absent (0); present (1).
1305): Palatine, spatial development: mainly along a palatal plane (0); developed along three axes, perpendicular to each other (1). (Modified from Maryańska et al. 2002).
1306): Pterygoid, basal process for contact with the basisphenoid: absent (0); present (1). (Maryańska et al. 2002).
1307): Ectopterygoid, contact with lacrimal: absent (0), present (1). (Maryańska et al. 2002).
1308): Ectopterygoid, shape: short with a hook-like process (0); elongate and slender, without a hook-like process (1). (Maryańska et al. 2002).
1309): Jugal, postorbital process, inclination: posterodorsally (0), strictly dorsally (perpendicular to ventral margin of jugal) (1).
1310): Maxilla, anteromedial process, position: ventral, immediately dorsal to interdental plates (0); dorsal, immediately ventral to dorsal surface of maxillary anterior process (1). (Benson et al. 2010).
1311): Palpebral ossification: absent (0); present (1). (Currie and Carpenter 2000).
1312): Postorbital, anterodorsal process, participation to supratemporal fossa: present (0); absent (1). (Modified from Benson et al. 2010).
1313): Manual digit II, phalanges, number: 3 (0); 2 or less (1).
1314): Quadratojugal, ascending process apex, anteriormost extent relative to infratemporal fenestra: close to posterior margin of fenestra (0); close to anterior margin of fenestra (1). (Modified from Brusatte et al. 2010).
1315): Maxilla, promaxillary recess, position in antorbital fossa: anterior or anterodorsal margin (0); in the anteroventral corner (1). (Brusatte et al. 2010).
1316): Maxilla, maxillary fenestra, position in medial view: does not (0); does (1) abut the dorsal border of maxillary antrum. (Brusatte et al. 2010).
1317): Premaxilla, narial fossa, anterior margin: shallow (0); invaginated as a deep groove (1). (Brusatte et al. 2010).
1318): Premaxilla, anterodorsal margin at the level of the anterior margin of external naris, shape in lateral view: gently convex (0); distinctly inflected posterodorsally, describing a slightly obtuse or rigth corner (1). (Modified from Brusatte et al. 2010).
1319): Quadratojugal, posteromedial flange running along quadrate articulation, dorsoventral extent: elongate (0); short, limited to the ventral margin (1). (Choiniere et al. 2010).
1320): Postorbital, ventral (jugal) process, cross section: robust, broader than long or as broad as long (0); flat and slender, longer than broad (1).
1321): Manual phalanx P1-I, distal end, mediolateral axis, clockwise torsion relative to the proximal surface, angle: less than (0); more than (1) 30°. (Martinez et al. 2011).

1322): Frontal, supratemporal fossa, anterior margin, crest bisecting the surface: absent (0); present (1). (Brusatte and Sereno 2008).
1323): Frontal, internal pneumatic sinus: absent (0); present (1).
1324): Maxilla, posterior view, lateromedial separation between interfenestral and postantral struts: wider (0); or narrower (1) than the combined width of interfenestral and postantral struts. (Eddy and Clarke 2011).
1325): Nasal, lateral view, naso-maxillary process: absent (0); present (1). (Eddy and Clarke 2011).
1326): Joined frontals, mediolateral width across the anteromedial margins of supratemporal fossae: more than (0); less than (1) 2/5 of the width of the paired frontals in that point.
1327): Frontal in adult, participation to dorsal orbital margin: estensive (0); extremely reduced or obliterated (1).
1328): Dentary, dorsal surface, shape in lateral/medial view: flat to convex (0); anteriorly concave (1).
1329): Frontal, anterior margin of supratemporal fossa, orientation: mainly dorsally (0); posterodorsally (1).
1330): Frontal, nasal processes: present and elongate (0); strongly shortened (1).
1331): Mt IV, distal end, lateral surface, accessory crest: absent (0); present (1). (Turner et al. 2009).
1332): Frontal, dorsal surface: smooth (0); rugose (1).
1333): Frontal, lateral surface, dorsal margin: uniformly curved (0); markedly convex at the level of the lacrimal/prefrontal contact (1).
1334): Mandible, ventral margin, shape in lateral view: straight to moderately convex ventrally (0); markedly convex ventrally, with a distinct bend at the dentary-angular contact (1). (Senter 2011).
1335): Tibia, distal end, anteromedial margin, shape in distal view: rounded (0); marked by a proximodistally oriented ridge.
1336): Astragalus, proximal articular facet for fibula, extent: more than (0); less than (1), 3/10 of the transverse width. (Langer and Benton 2006).
1337): Anterior presacral centra, anterior half of centrum, pneumatic recess, development: not perforated medially (0); perforated medially (1). (Modified from Rauhut 2003).
1338): Axis, neural spine, posterodorsal apex, position relative to anterodorsal apex: dorsal (0); at the same height (1).
1339): Femur, fourth trochanter, proximal and distal ends, inclination relative to shaft: similar slope (trochanter symmetrical) (0); distal margin more steeply inclined (trochanter asymmetrical) (1). (Langer and Benton 2006).
1340): Maxilla, dorsal process, posterolateral margin, antorbital fossa: exposed laterally (0); concealed by a thin lamina (1). (Sues et al. 2011).
1341): Distal carpal 5, posteroventral process overlapping distal carpal 4: absent (0); present (1). (Martinez et al. 2011).
1342): Pubis, apron, lateral margin, shape: straight or uniformly curved (0); sinusoidal (1). (Martinez et al. 2011).
1343): Frontal, medial margin of supratemporal fossae and presence of a posteriorly directed traingular plate of bone: subparallel, plate absent (0); diverging anteriorly, plate present (1). (Modified from Rauhut 2003).
1344): Ethmoidals: unossified (0); ossified (1).
1345): Posterior tympanic recess, position: on anterior surface of paroccipital process (0); extends into opisthotic posterodorsally to fenestra ovalis, confluent with this fenestra (1). (Modified from Senter 2010).
1346): Lacrimal, ventral process, lateral lamina, anteriormost point, position: at mid-height (0); in the dorsal half (1). (Smith et al. 2008).
1347): Dorsal vertebrae, posterior neural spines, mediolateral width at mid-height: more (0); less (1) than 1/12 of spine height.
1348): Axis, neural arch, lateral surface, pneumatic recess: absent (0); present (1).
1349): Dorsal vertebrae, anterior neural arches, lateral surface, pneumatic recesses: absent (0); present (1).
1350): Dorsal vertebrae, middle and posterior centra, pneumatic recesses: absent (0); present (1).
1351): Dorsal vertebrae, middle and posterior neural arches, lateral surface, pneumatic recesses: absent (0); present (1).
1352): Sacral vertebrae, neural arches, lateral surface, pneumatic recesses: absent (0); present (1).
1353): External mandibular fenestra, dorsal margin, shape in lateral view: straigth to convex (0); concave (1).
1354): Articular, mandibular glenoid, shape in lateral view: flat to concave (0); convex (1).
1355): Dentary, symphysis, proportions in dorsal/ventral view: as wide as long (0); longer than wide (1).
1356): Dentary, interdental septa: present, at least labially (0); absent (1).
1357): Calcaneum, articulation with astragalus: open (0); fused (1).
1358): Dentary, posterodorsal process, depth: shallower (0); deeper (1) than posteroventral process.
1359): Dentary, posteroventral process, shape in lateral view: straigth (0); ventrally bowed (1).
1360): Dentary, internal pneumatic sinus: absent (0); present (1).
1361): Surangular, posterior half, depth: more (0); less (1) than angular posterior depth.
1362): Lacrimal, ventral process, medially inset relative to dorsal process: absent (0); present (1).
1363): Jugal, quadratojugal process, position relative to apex of postorbital process: posterior (0); ventral (1).
1364): Maxilla, promaxillary recess, maximum diameter: less than (0); more than (1) 1/3 of anterior end of antorbital fossa dorsoventral depth. (Modified from Longrich and Currie 2009a).

1365): External mandibular fenestra, posterodorsal corner, position: posterior or ventral (0); anterior (1) to surangular coronoid eminence.
1366): Mt III, dorsal surface proximal to distal condyles, bony 'tab' on lateral margin: poorly developed (0); pronounced (1). (Zanno et al. 2011).
1367): Mc IV, shape: comparable to remaining mcs (0); conical, distally tapering (1).
1368): Parietal, mediolateral width: less (0); more (1) than frontal interorbital width.
1369): Dorsal ribs, distal end: unexpanded (0); expanded (1) relative to remaining of rib.
1370): Frontal, postorbital process, dorsal eminence: absent (0); present (1). (Modified from Carrano and Sampson 2008).
1371): Jugal, postorbital process: present (0); absent (1).
1372): Surangular, posterolateral foramen: present (0); absent (1).
1373): Sternum, carina: absent (0); present (1).
1374): Sternum, carina, extent: limited to the caudal half of sternum (0); estending along the whole length of the sternum (1).
1375): Scapula, articular facet for the coracoid, acromial participation: present (0); absent (1). (Modified from Xu et al. 2009).
1376): Sternum, costal processes, number: 3 or less (0); 4 or more (1).
1377): Humerus, proximal end, anterior surface, "transverse groove" placed proximally to the humeral bicipital tubercle, shape: deep sulcus (0); low subtriangular depression (1).
1378): Humerus, bicipital crest, distal end, muscular attachment, development: pit placed anterodistally (0); fossa placed posterodistally (1). (Modified from O'Connor 2009).
1379): Manual unguals, flexor process, shape: tubercle (0); keel (1).
1380): Manual unguals, flexor process; present (0); absent (1).
1381): Accessory tympanic recess extension of the posterior tympanic recess: absent (0); present (1).
1382): Anterior tympanic recess, position relative to the basipterygoid process: posterior (0); at same level (1).
1383): Ilium, postacetabular process, lateral surface, M. ileofemoralis fossa, posteriormost extent: reachs the posterior margin of the ilium (0); stops anteriorly to the posterior margin of the ilium. (Tykoski 2005).
1384): Furcula, width: less (0); more (1) than 4/5 scapula proximal width.
1385): Furcula, hypocleidum: absent (0); present (1).
1386): Furcula, hypocleidum, length: less (0); more (1) than 1/3 clavicular rami length.
1387): Manual phalanges, penultimate phalanx on digits, diaphysis just proximal to the distal epiphysis, diameter: comparable to proximal half diameter, distal epiphysis expanded proximodistally (0); narrower, distal epiphysis expanded dorsoventrally (1).
1388): Manual phalanges, penultimate phalanges on digits, diaphysis, shape: straight (0); ventrodistally curved (1).
1389): Maxilla, ventral process, posterior to the ascending process, ventral margin, shape: rounded (0); sharp (1). (Choiniere et al. 2010).
1390): Basipterygoid processes, lateral surface, pneumatic depression: absent (0); present (1).
1391): Crista interfenestralis, position relative to middle ear opening: not depressed (0); depressed (1).
1392): Mandible, internal mandibular fenestra, size: slit-like (0); wide (1).
1393): Dorsal vertebrae, transverse processes, inclination: subhorizontal (0); ventrally pendant (1). (Zanno 2010).
1394): Ilium, antitrochanter: absent (0); present (1).
1395): Mt II, shaft, posterior surface, medial margin, proximodistally directed crest: absent (0); present (1). (Choiniere et al. 2010).
1396): Jugal, participation to antorbital fenestra: less than (0); subequal or longer than (1) maxilla participation.
1397): Manual non-ungual phalanges, diaphysis, length: more (0); subequal or less (1) than distal epiphysis length.
1398): Furcula, shape: "V"-shaped (0); "U"-shaped (1). (O'Connor 2009).
1399): Quadratojugal, ascending process, lateral surface, anterior margin, dorsoventrally oriented crest: absent (0); present (1). (Brusatte et al. 2010).
1400): Quadratojugal, jugal process, anterior end, shape in lateral view: tapered to blunt (0); forked (1). (Modified from Brusatte et al. 2010).
1401): Quadrate, distal end, lateral condyle, extension on lateral surface of bone: limited (0); extended dorsally (1). (Brusatte et al. 2010).
1402): Prefrontal-nasal contact: present (0); absent (1). (Brusatte et al. 2010).
1403): Dentary, first tooth, position: in the anterior end (0); posteriorly inset (1).
1404): Premaxilla/maxilla, ventral view: deep sulcus between palatal shelf and paradental laminae: absent (0); present (1).
1405): Maxilla, medial view, shape of ridge across interdental plates: straight (0); sinuous (1). (Eddy and Clarke 2011).
1406): Nasal, narial fossa, posterior margin: distinct (0); covered by rugosity (1). (Modified from Eddy and Clarke

2011).
1407): Postorbital, frontal (anterodorsal) process, dorsal surface, vascular groove: absent (0); present (1). (Eddy 2008).
1408): Prefrontal-frontal facet, shape: triangular (0); rounded (1). (Eddy and Clarke 2011).
1409): Dorsal vertebra 12, neural spine, apex, contact with neural spine apex of dorsal 11: absent (0); present (1).
1410): Humerus, anterior surface, distal end, area at the level of lateral condyle, distinct fossa: absent (0); present (1). (Benson et al. 2010).
1411): Caudal vertebrae, anterior centrocostal lamina, anterior end: unexpanded (0); expanded anterolaterally forming a lateral spur (1). (Rauhut 2011).
1412): Caudal vertebrae, centroprezygapophyseal laminae, development: weakly developed (0); robust and leading to the neural canal (1). (Rauhut 2011).
1413): Caudal vertebrae, anterior centra, ventral surface, longitudinal sulcus, depth: shallow (0); deep with distinct margins (1). (Modified from Rauhut 2003).
1414): Coracoid, ventrolateral surface, texture: smooth (0); skulptured (1). (Agnolin et al. 2012).
1415): Caudal vertebrae, anterior centra, lateral surface, anterior half, subcircular depression: absent (0); present (1). (Agnolin et al. 2012).
1416): Coracoid, posteroventral process, direction relative to rest of coracoid: aligned (0); medially deflected (1). (Agnolin et al. 2012).
1417): Astragalus, ascending process (and corresponding articular facet in tibia), anterior view, shape: triangular (0); quadrangular (1).
1418): Radius, proximal end, lateral process, development: poorly developed (0); proximolaterally directed (1).
1419): Radius, shaft, lateral margin, “osseous process”: absent (0); present (1).
1420): Maxilla, maxillary fenestra, anterior half, overlapped by lateral lamina of antorbital fossa: absent (0); present (1). (Brusatte et al. 2010).
1421): Maxilla, ventral process, lateral surface, lateral foramina, relationships: distinct (0); set in a longitudinal groove (1). (Brusatte et al. 2010).
1422): Articular, mediolateral width of jaw muscle attachment site: less than (0) or equal to more than (1) width of glenoid for articulation with quadrate (Brusatte et al. 2010).
1423): Premaxillary teeth, lingual surface: concave (0); straight (1). (Brusatte et al. 2010).
1424): Cervical vertebrae, anterior and middle centra, posterior centrodiapophyseal lamina, orientation: posteroventrally (0); posteriorly (1). (Brusatte et al. 2010).
1425): Ilium, lateral surface, dorsoventrally directed crest above the acetabulum, dorsal extent: does not (0); does (1) reach the dorsal margin of ilium.
1426): Coracoid, tubercle, position: ventrolateral surface, apex ventral to glenoid (0); anterolateral corner, apex dorsal to glenoid (1).
1427): Mt IV, distal end, condyles: symmetrical (0); asymmetrical, with medial condyle prominent and lateral condyle reduced (1).
1428): Sternum, posterior margin, in taxa bearing a distint posteromedian process, shape in ventral view: medially acuminate (0); flat to convex, mediolaterally expanded (1). (Modified from O'Connor 2009).
1429): Tarsometatarsus, proximal surface, inclination relative to proximodistal axis of metatarsus: perpendicular (0); partially inclined, facing anteroproximally (1). (O'Connor 2009).
1430): Calcaneum, fibular notch: present (0); absent (1).
1431): Tibiotarsus/astragalus, distal condyles, lateral condyle, width: subequal or less (0); more than (1) medial condyle width. (Modified from O'Connor 2009).
1432): Mt III, shaft, lateral surface, distal half, contact with Mt IV: absent (0); present (1).
1433): Pedal unguals lateral surface, laterally projecting ridge: absent (0); present (1). (O'Connor 2009).
1434): Maxilla, promaxillary fenestra, medial surface: unfenestrated (0); fenestrated and leading to medial surface (1).
1435): Maxilla, preantorbital ramus, lateral surface, dorsoventral depth at mid-length, more (0); subequal (1) to the depth of the maxilla ventral to the antorbital fossa. (Modified from Turner et al. 2007).
1436): Maxilla, ascending ramus, base, lateral surface, development: large, plate-like (0); reduce lip of bone between nasal facet and antorbital fossa (1). (Modified from Turner et al. 2007).
1437): Ilium, lateral surface, vertical crest dorsal to the acetabulum, anteroposterior width: less (0); more (1) than ¼ blade height. (Modified from Brusatte and Benson 2013).
1438): Posterior dorsal and anterior caudal vertebrae, postzygapophyses, position relative to the level of the prezygapophyses: about at the same level (0); clearly dorsally (1). (Modified from Brusatte and Benson 2013).
1439): Fibula, distal end, anteroposterior length: more (0); less (1) than 9/5 mid-shaft width. (Modified from Benson et al. 2010).
1440): Pubis, foot, maximum longitudinal axis, angle formed with the distal half of pubis in lateral view: more (0); less (1) than 75°.

1441): Quadrate, shaft, proximal half, inclination relative to rest of shaft: straight (0); posteriorly curved (1). (Ezcurra and Novas 2007).
1442): Femur, anterior trochanter, separation from shaft: absent or minimal (0); present and extensive (1). (Nesbitt et al. 2009).
1443): Manual phalanges P1-III and P2-III, relationships: distinct (0); fused (1).
1444): Cervical vertebrae, lamina connecting posteroventral margin of diapophysis and posteroventral rim of centrum: absent (0); present (1). (Rauhut 2003).
1445): Premaxillary tooth 2, size relative to teeth 3 and 4: comparable (0); larger (1). (Senter 2010).
1446): Dentary, dorsal and ventral margins in lateral view: diverging posteriorly (0); parallel for most of their length (1). (Senter 2010).
1447): Maxilla, lateral view, angle between anterodorsal and ventral margins: more than (0); less than (1) 80°. (Modified from Ezcurra and Novas 2007).
1448): Lacrimal, exposed on skull roof in dorsal view: absent (0); present (1). (Gauthier 1986).
1449): Ulna, distal end, articular surface, shape and extent: flat to spatulate, limited to the distal facet (0); bulbous, expanded in the distal end of the cranial surface (1)
1450): Pedal phalanges, distal extensor pits, development: shallow (0); deep with defined margins (1). (Turner et al. 2009).
1451): Lacrimal: present (0) absent (1).
1452): Parietal, dorsal surface: flat (0); convex, posteroventrally directed (1).
1453): Intermediate sacral (middle sacral) centra, length: comparable to (0); longer than (1) the others sacrals and anteriormost caudals.
1454): Astragalus, fibular facet, size: large, expanded anteroposteriorly (0); reduced, confined anteriorly (1). (Modified from Smith et al. 2008).
1455): Dentary, symphysis, medial surface, broad horizontal groove, anteriorly upturned and bounded ventrally by two ridges: absent (0); present (1).
1456): Tibia, lateral cnemial crest, dorsal/proximal margin, orientation: parallel to dorsal/proximal margin of medial condyle, or moderately upturned (0); strongly upturned (directed proximally) (1).
1457): Femur, proximal end, anterior trochanter major axis, angle formed with head major axis: more (0); less (1) than 45°. (Modified from Osi and Buffetaut 2011).
1458): Maxilla, subcutaneous flange bordering the antorbital fossa laterally on the posterior end of the main body, resulting in a fossa forming a channel between the flange and the main body: absent (0); present (1). (Brusatte et al. 2010).
1459): Jugal, lateral surface, cornual process/boss: absent (0); present (1).
1460): Postorbital, supraorbital ("cornual") process, position: overhanging orbit (0); posteroventral to dorsal orbit margin (1).
1461): Femur, distal end, medial surface, longitudinal crest, distal bifurcation at the level of the medial condyle: absent (0); present (1). (Brusatte et al. 2010).
1462): Nasal, lateral surface, fossae/fenestrae, number: less than (0); more than (1) three.
1463): Sphenethmoid-orbitosphenoid contact: present (0); absent (1). (Paulina Carabajal and Currie 2012).
1464): Femur, posterior trochanter, position: along the posterolateral margin (0); centered on posterior surface (1). (Xu et al. 2012).
1465): Femur, shaft, medial margin, eminence just proximal to distal end: absent (0); present (1). (Xu et al. 2012).
1466): Mt II, shaft, distal end, anterior exposition: wide, broadly visible (0); barely visible due to plantar displacement (1) in articulated specimens. (Xu et al. 2012).
1467): Premaxillary and anterior dentary teeth, lingual surface, apicobasally oriented furrows/striations: absent (0); present (1).
1468): Skull, premaxilla-maxilla suture, lateral surface, subnarial foramen, shape: foramen (0); dorsoventrally directed channel (1). (Carrano et al. 2012).
1469): Maxilla, ventral process, lateral surface, lateral foramina, number of rows: less than two (0); two (1). (Carrano et al. 2012).
1470): Maxilla, jugal articulation, lateral shelf: absent (0); present (1). (Carrano et al. 2012).
1471): Jugal, lacrimal articulation, flange overlapping lacrimal: absent (0); present (1). (Carrano et al. 2012).
1472): Postorbital-squamosal articulation, shape: planar (0); helical spiralling along its length (1). (Carrano et al. 2012).
1473): Laterosphenoid-frontal articulation: present (0); absent (1). (Modified from Carrano et al. 2012).
1474): Prefrontal-frontal articular surface: planar (0); peg-in-socket (1). (Carrano et al. 2012).
1475): Quadrate, proximal end, shape in proximal view: rounded/oval (0); quadrangular (1). (Modified from Carrano et al. 2012).
1476): Paroccipital process, ventral margin, shape of curve described with stapedial groove/fenestra ovalis: broad arch

(0); narrow/acute curve (1). (Carrano et al. 2012).
1477): Cervical vertebrae, anterior and middle centra, parapophysis, position: close to the anterior (0); close to middle (1) of centrum lateral surface. (Carrano et al. 2012).
1478): Dorsal vertebrae, anterior centra, pleurocoel, size: larger than a nutritive foramen but covering less than half of the lateral surface (0); hypertrophied, as large or larger than half lateral surface (1). (Carrano et al. 2012).
1479): Sacral vertebrae, neural spines, dorsal surface, mediolateral width: comparable (0); wider (1) than remainder of spine. (Carrano et al. 2012).
1480): Manual digit V, phalanges: present (0); absent (1). Inapplicable if mc V is absent.
1481): Pubis, ischial peduncle, obturator perforation, longest axis, length: less (0); more than (1) ¾ of acetabular margin of pubis. (Modified from Carrano et al. 2012).
1482): Fibula, insertion of M. ileofibularis, shape: tubercle (0); anterolaterally curved flange (1). (Modified from Carrano et al. 2012).
1483): Humerus, deltopectoral crest, anterior margin, orientation: anterior (0); curved anterolaterally (1).
1484): Basisphenoid, indentation between basal tubera and basipterygoid processes, shape in lateral view: deep notch (0); shallow emabyement (1). (Carrano and Sampson 2008).
1485): Premaxilla, ventral margin, shape in lateral view: straight to convex (0); concave (1).
1486): Scapula, anterior end, lateral surface, supraglenoid fossa, development: shallow, with poorly defined margins (0); deep, dorsoventrally oriented and with defined margins (1). (Pol and Rauhut 2012).
1487): Squamosal, participation to the nuchal crest: absent or minimal (0); extensive (1). (Pol and Rauhut 2012).
1488): Pubis-iliac articulation, facets, shape: planar (0); peg-in-socket (1).
1489): Mcs II and III, distal end, lateral condyle, ventrolateral process projected proximally: poorly developed (0); well-developed (1). (Modified from Pol and Rauhut 2012).
1490): Mc III, distal end, collateral shelves protruding dorsal to the collateral fossae: absent (0); present (1). (Ezcurra et al. 2010).
1491): Mc II and III, distal end, flexor fossa, development: deep with distinct margins (0); shallow, poorly defined (1). (Modified from Ezcurra et al. 2010).
1492): Humerus, proximal end, lateral tuberosity, development: well-developed, giving the lateral margin a straight profile in anterior/posterior view (0); reduced, giving the lateral margin a convex profile in anterior/posterior view (1). (Modified from Ezcurra et al. 2010).
1493): Frontal, prefrontal facet, position: extended posterolaterally, approaching the postorbital facet (0); limited anteromedially and excluded from orbital rim (1).
1494): Fronto-lacrimal suture, orientation in dorsal view: mainly anteroposteriorly (0); mainly mediolaterally (1).
1495): Frontal, supratemporal fossa, anteriormost margin, position: in the center or lateral half (0); in the medial half (1) of fossa. (Sampson and Carrano 2007).
1496): Frontal, prefrontal/lacrimal facet, dorsoventral thickening: absent (0); present (1).
1497): Frontal, prefrontal/lacrimal facet, dorsoventral thickening, position: closer to postorbital process (0); closer to nasal process (1).
1498): Frontal, postorbital process, anterolateral corner, discrete articular surface facing anteriorly: absent, sharp corner (0); present and distinct from rest of the laterally-facing articular surface of process (1).
1499): Manual ungual I, ventrodistal curvature in lateral view: marked (0); reduced (1).
1500): Frontal, nasal process, overlapping by nasal, extent: absent or limited (0); extensive, in particular medially, on almost or all the process dorsal surface (1).
1501): Caudal vertebrae, middle zygapophyses, direction in lateral view: moderately curved and suborizontally oriented (0); distinctly bowed dorsally (1).
1502): Caudal vertebrae, anterior centra, length to anterior height ratio: less than (0); equal or more than (1) 2.
1503): Ischium, lateral surface, longitudinal groove: absent (0); present (1). (Senter 2011).
1504): Mt II, distal end, medial condyle, position relative to lateral condyle: at the same level (0); strongly offset proximally (1). (Senter 2011).
1505): Pedal unguals III and IV, flexor tubercle, development: poorly developed (0); prominent and clearly defined relative to ventral surface (1). (Modified from Senter 2011).
1506): Mcs II-III, distal end, dorsoventrally oriented intercondylar sulcus, depth: deep, well-defined (0); shallow (1).
1507): Maxillary/post-symphyseal dentary tooth crowns, labial surface, shape: smooth (0); bearing apicobasally directed ridges/flutes (1). (Modified from Senter 2011).
1508): Maxillary teeth ventral to antorbital fenestra: present (0); absent (1).
1509): Maxillary teeth anterior to antorbital fenestra: present (0); absent (1).
1510): Ilium, acetabulum, dorsal margin, position relative to the plane passing for the ventral margins of pre- and postacetabular processes: at the same level or dorsal (0); distinctly ventral (1).
1511): Caudal vertebrae, middle prezygapophyses: present (0); absent (1).

1512): Caudal vertebrae, middle and posterior prezygapophyses, forked end: absent (0); present (1). (Modified from Senter 2011).
1513): Nasal, dorsal narial margin, position relative to dorsal margin of orbit in articulated skull: ventral (0); dorsal (1). (Modified from Senter 2011).
1514): Jugal, postorbital (ascending) process, base, anteroposterior extent: narrow (length less than half process height) (0); broad (length more than half process height) (1).
1515): Pedal phalanx P2-II, distal facet, size: comparable to proximal surface (0); less than half the size of the proximal surface (1). (Turner et al. 2012).
1516): Pubis, proximal end, medial surface, elliptical fossa: shallow (0); deep and with distinct margins (1).
1517): Pedal ungual I, ventral margin, shape in lateral/medial view: straight to poorly curved (0); strongly curved ventrally (1).
1518): Jugal, anterior end, projection ventral to the antorbital fenestra, fitting into a maxillary cleft: absent (0); present (1).
1519): Dentary, lateral surface, sulcus bearing neurovascular foramina, shape: dorsoventrally narrow (0); dorsoventrally expanding posteriorly (1).
1520): Dentary, lingual bar: present (0); absent (1).
1521): Mc II, ventral surface, proximal end, pisiform process: absent (0); present (1).
1522): Vomer, dorsoventral position relative to palatine: at the same level (0); ventral (1).
1523): Maxilla, dentigerous margin, mediolateral position: labially (0); lingually emarginated (1) relative to lateral surface.
1524): Manual ungual I, collateral groove, confluence with ventral surface: absent (0); present (1). (Longrich and Currie 2009b).
1525): Dorsal vertebrae, infradiapophyseal fossa, size: not hypertrophied, infrazygapophyseal fossae exposed in lateral view (0); hypertrophied, infrazygapophyseal fossae not exposed in lateral view (1). (Longrich and Currie 2009b).
1526): Dorsal vertebrae, postzygapophyses, orientation in posterior view: subhorizontal (0); medioventrally inclined (1). (Longrich and Currie 2009b).
1527): Postorbital, suborbital process, anterior margin, dorsoventral depth: shallow, process acuminate anteriorly (0); deep, process blunt anteriorly (1).
1528): Teeth, root, diameter along apicobasal axis: uniform (0); narrowing basally (1).
1529): Humerus, distal end, tubercle placed proximal to the lateral epicondyle: absent (0); present (1). (Clarke and Norell 2002).
1530): Exoccipital, posterior surface, fossa housing the X and XII cranial nerves: absent (0); present (1). (Longrich and Currie 2009a).
1531): Humerus, distal end, medial margin, anteroposteriorly directed ridge: absent (0); present (1).
1532): Long bones, adult external texture: smooth (0); vowen and rugose (1).
1533): Astragalus, small process protruding through a circular opening in edge of calcaneum to reach lateral margin of tarsus: absent (0); present (1). (Lü et al. 2013).
1534): Caudal vertebrae, posteriormost ribs, shape in dorsal/ventral view: unexpanded (0); expanded (1) at their lateral margin.
1535): Mt IV, proximal end, lateral side, shape: flat (0); convex (1). (He et al. 2013).
1536): Frontal, prefrontal facet, shape in dorsal view: flat to arched (0); deep notch (1). (Loewen et al. 2013).
1537): Femur, distal end, lateral condyle, anterior bulge that is slightly separated from the remainder of the condyle: absent (0); present (1). (Brusatte et al. 2010).
1538): Mcs I-III, distal condyles, extent along dorsal surface of mcs: present (0); absent (1).
1539): Ilium, ischial peduncle, antitrochanter, position: posteriorly (0); posterodorsally (1) to acetabulum. (Turner et al. 2012).
1540): Basioccipital, basal tubera, dorsoventral depth: subequal or less (0); more (1) than occipital condyle midline depth. (Modified from Brusatte et al. 2010).
1541): Basioccipital, basal tubera, ventral notch between tubera, proportion in posterior view: wider than deep (0); as deep or deeper than wide (1).
1542): Braincase, ala overlapping the lateral surface of the basisphenoid, laterosphenoid participation: absent (0); present (1). (Chure and Madsen 1998).
1543): Cervical vertebrae, postaxial zygapophyses, shape and elongation: anteroposteriorly elongate (0); longest in the medio-lateral direction, with lateral halves expanded craniocaudally (1). (Farke and Sertich 2013).
1544): Cervical vertebrae, middle centra, centrodiapophyseal lamina, joining with centrum, position: in posterior half (0); in the middle or anterior half (1). (Farke and Sertich 2013).
1545): Dorsal vertebrae, middle and posterior centra, horizontal lamina bisecting the infradiapophyseal fossa: absent (0); present (1). (Farke and Sertich 2013).

1546): Tibiotarsus, distal condyles, anterior projection: medial condyle more anteriorly projected (0); condyles equally projected anteriorly (1). (Modified from Longrich and Currie 2009b; O'Connor 2009).
1547): Tibiotarsus, distal condyles, shape of surfaces bordering intercondylar sulcus, gradually sloping toward midline: present (0); absent, 'U-shaped' sulcus in distal view (1). (O'Connor 2009).
1548): Ilium, preacetabular process, lateroventral fossa, rimmed margin: absent (0); present (1).
1549): Ilium, preacetabular process, ventral surface, posterior end: narrow (0); mediolaterally expanded (1).
1550): Posterior cervical and cervicodorsal vertebrae, transverse processes, large ventral foramina: absent (0); present (1).
1551): Maxilla, medial surface, medial antorbital fossa: absent (0); present (1).
1552): Tibia, cnemial crest, anterior end, lateral surface, proximodistally oriented ridge: absent (0); present (1).
1553): Humerus, deltopectoral crest, lateral surface, biceps scar along distal margin: absent (0); present (1).
1554): Ischium, acetabular rim, shape: convex/beveled (0); concave/depressed (1).
1555): Premaxilla, narial fossa, development: slightly expanded anteroventrally to the external naris (0); extensive, covering almost the whole lateral surface of the premaxillary body (1). (Modified from Langer and Benton 2006).
1556): Maxilla, ascending process, pneumatic recesses, development: shallow fossa closed medially (0); medially open fenestra (1).
1557): Nasal, median crest/eminence, development: restricted to nasal mid-length (0); extending over most of the nasal (1).
1558): Nasal, narial fossa, development: poorly developed beyond narial margin (0); expanded posteriorly (1). (Rauhut 2003; Wilson et al. 2003; Eddy 2008).
1559): Lacrimal, posterodorsal process, length: less (0); more (1) than 1/3 of lacrimal height.
1560): Frontal, dorsal surface, supratemporal fossa, extent: limited to the posterior third of the bone (0); extended for more than the posterior third of the bone (1). (Modified from Sereno 1999; Norell et al. 2001).
1561): Parietal, posterodorsal projection (nuchal plate), development: slightly developed (0); hypertrophied (1). (Wilson et al. 2003).
1562): Postorbital, frontal (anterodorsal) process, dorsal surface, vascular groove, extent: along anterior half (1); along whole surface (1). (Eddy 2008).
1563): Postorbital, suborbital process bordering ventrally the eyeball, development: anteroposteriorly reduced, long no more than 1/3 of the maximum orbital anteroposterior length (0); pronounced, long more than 1/3 of the maximum orbital anteroposterior length (1). (Modified from Wilson et al. 2003; Currie and Carpenter 2000).
1564): Squamosal, participation to the supratemporal fossa, extent: marginal (0); extensive (1). (Hwang et al. 2004; Benson et al., 2010).
1565): Quadratojugal, posteroventral process, length: no more than (0); more than (1) 1/2 of the anteroventral process of the quadratojugal. (Modified from Holtz et al. 2004).
1566): Basisphenoid, ventral recess, depth: shallow (0); deep (1). (Holtz 2001; Rauhut 2003).
1567): Dentary, posterodorsal process, length: less than (0); more than (1) 1/2 of the posteroventral process. (Modified from Holtz 2000).
1568): Surangular, anterior process projected into the posterior half of the external mandibular fenestra, shape and elongation: short projection (0); elongate process (1).
1569): Mandible, dorsoventral diameter at the level of the coronoid process: less than (0); more than (1) 1/3 of mandibular anteroposterior length. (Modified from Norell et al. 2001).
1570): Surangular, laterodorsal shelf, depth: shallow (0); deep (1). (Modified from Holtz 2000).
1571): Prearticular, medial process, elongation: short (0); elongate (1). (Modified from Norell et al. 2001; Carr 2005).
1572): Axis, epipophyses, posterolateral extent: does not (0); does (1) overhang the postzygapophyses. (Rauhut 2003).
1573): Postaxial cervial prezygoepipophyseal lamina, development: low ridge (0); prominent (1). Ordered. (Modified from Carrano et al. 2002).
1574): Postaxial cervial epipophyses, development: small ridges (0); overhanging the postzygapophyses (1). (Rauhut 2003).
1575): Caudal vertebrae, transition point in tail, extent: more (0); less (1) than three vertebrae. (Modified from Gauthier 1986).
1576): Caudal vertebrae, anterior neural arches, ventral rib laminae, development: slightly developed (1); prominent and bordering deep fossae (1).
1577): Sternum, posterolateral processes, elongation: do not reach (0); do reach (1) the posteriormost extent of the posteromedian process of the sternum.
1578): Coracoid, tubercle, lateral development: slightly developed (0); strongly developed (1). (Modified from Holtz 2000).
1579): Ilium, lateral vertical crest dorsal to the acetabulum, development: single (0); double (1).
1580): Ilium, processus supratrochantericus placed along the dorsal margin, at the level of the ischial peduncle,

development: poorly developed tubercle (0); large and rugose process (1). (Novas 2001; Norell et al. 2001; Calvo et al. 2004).
1581): Ilium, antitrochanter, development: low and small (0); prominent (1).
1582): Ilium, postacetabular process, medioventral shelf, posterior half, lateral esposition: absent (0); present (1). (Modified from Carrano et al. 2002).
1583): Pubis, distal foot, anterior process, anteroposterior length: less (0); more (1) than 1/5 of the proximodistal length of the pubis. (Modified from Holtz 2000).
1584): Pubis, distal foot, posterior process, anteroposterior length: less than (0); more than (1) 1/5 of the length of the pubis. (Modified from Holtz 2000).
1585): Ischium, proximodorsal process, shape: low triangular tubercle (1); hypertrophied quadrangular process (1). (Modified from Forster et al. 1998).
1586): Tibiotarsus, distal end, posterior surface, posteriorly projecting medial and lateral crests: absent (0); present (1). (Clarke and Norell 2002).
1587): Tarsometatarsus, proximal surface, hypotarsus, posterior sulci: absent (0); present (1). (Modified from O'Connor 2009).
1588): Premaxilla, lateral surface pierced by neurovascular foramina, number: one, above the second premaxillary tooth (or in a comparable position in toothless forms) (0); several neurovascular foramina (1). (Modified from Ezcurra and Novas 2006).
1589): Nasal, pneumatisation development: unfenestrated (0); fenestrated (1).
1590): Postorbital, ventral process, ventral end, dorsoventrally oriented sulcus: absent, process single (0); present, process forked (1). (Novas et al. 2013).
1591): Cervical vertebrae, anterior and middle postzygodiapophyseal laminae, orientation in lateral view: posterodorsally (0); subvertical (1). (Modified from Novas et al. 2013).
1592): Dorsal ribs, pneumatic recess: absent (0); present (1). (Novas et al. 2013).
1593): Ulna, olecranon process, shape in lateral/medial view: quadrangular with subparallel dorsal and ventral margins (0); trapezoidal, distally tapering (1).
1594): Manual unguals I and II, ventral surface, median ridge running distal and connecting to the flexor tubercle: absent (0); present (1). (Novas et al. 2013).
1595): Femur, distal view, angle between posterior margin of lateral condyle and lateral surface of ectocondylar tuber: wide, subequal or more than 90° (0); narrow, acute (1). (Novas et al. 2013).
1596): Mt III, distal end, extensor fossa, development: shallow and poorly defined (0); deep and crescentic in anterior view (1). (Novas et al. 2013).
1597): Femur, proximal end, lateral border, shape: broad rounded/squared (0); tapering (1). (Modified from Novas et al. 2013).
1598): Manual phalanx P1-I, shape in proximal view: triangular, broadest ventrally (0); quadrangular, dorsal surface as wide or wider than ventral (1). (Modified from Novas et al. 2013).
1599): Mt III, proximal epiphysis, mediolateral width: more (0); subequal or less (1) than shaft width. (Novas et al. 2013).
1600): Humerus, deltopectoral crest, proximoanterior margin, shape in medial/lateral view: straight to convex, crest confluent with level of head (0); concave, crest abruptly projected distal to head (1).
1601): Cerebral hemisphere, dorsal indentation (wulst): absent (0); present (1).
1602): Astragalus, distal end, anterior margin, lateral half, shape: slightly concave (0); markedly convex, anteriorly protruding (1). (Novas et al. 2013).
1603): Dentary, medial surface, Meckelian sulcus, dorsoventral depth: wide sulcus (0); narrow groove (1). (Brusatte et al. 2010).
1604): Cervical vertebrae, infrapostzygapophyseal fossa, position relative to posterior centrodiapophyseal lamina: fossa placed posterior to lamina (0); fossa placed dorsally to lamina (1). (Brusatte et al. 2010).
1605): Caudal vertebrae, anterior neural arches, anterolateral surface, deep triangular prezygocostal fossa delimited by two laminae: absent (0); present (1). (Modified from Brusatte et al. 2010).
1606): Mt III, distal end, lateral surface, large and rugose oval scar for mt IV: absent (0); present (1). (Brusatte et al. 2010).
1607): Femur, distal end, ectocondylar tuber, shape in distal view: rounded to quadrangular (0); kidney-shaped, concave posteriorly (1). (Modified from Novas et al. 2013).
1608): Dorsal vertebrae, middle-posterior parapophyses, development: distinct and well-developed (0); small, knob-like (1). (Stromer 1934).
1609): Jugal, posterior (infratemporal) process, depth: as deep or shallower (0); deeper (1) than suborbital process. (Carrano et al. 2012).
1610): Quadrate, dorsoventral axis of bone relative to mediolateral axis of distal condyles in posterior view:

perpendicular (0); medially inclined (1). (Carrano et al. 2012).
1611): Posterior dorsal vertebrae, hyposphene, step-like ridges on lateral margin, development: short, poorly developed (0); long and prominent, bisecting the infrapostzygapophyseal fossa (1). (Modified from Carrano et al. 2012).
1612): Atlas, epipophyses, development: small (0); prominent (1). (Carrano et al. 2012).
1613): Cervical ribs, anterior process, length: short (0); prominent (1). (Carrano et al. 2012).
1614): Interdental septa in premaxilla and anterior dentary, spacing: regular (0); alternate (alveoli result paired) (1).
1615): Mts IV, distal end, shape of medial margin: flat to convex (0); markedly concave (1).
1616): Mt III, shaft, dorsal (extensor) surface, shape: flat to concave (0); transversely convex (1). (Modified from O'Connor 2009).
1617): Mt II, distal end, extensor fossa, development: relatively small (0); proximodistally elongated, covering most of distal end and defined by distinct raised margins (1). (Modified from Brusatte et al. 2013).
1618): Mt II, distal end, articular surface width: subequal or larger (0); narrower (1) than maximum width of mt distal end.
1619): Mt II, insertion of the tendon of the M. tibialis anterioris, proximodistal position along shaft: in the proximal fourth (0); more distally (1).
1620): Jugal, surface medial to the anterior pneumatic recess, shape: flat (0); excavated by a fossa (1). (Brusatte et al. 2010).
1621): Orbit, main plane orientation relative to anteroposterior axis of skull in articulated specimens: lateral (0); anterior, due to mediolateral expansion of postorbital region (1). (Modified from Loewen et al. 2013).
1622): Maxilla, palatal shelf, ventral surface, occlusal pits: absent (0); present (1). (Modified from Loewen et al. 2013).
1623): Squamosal, postquadratic process, lateral view, anteroposterior width perpendicular to main proximodistal axis: less (0); more (1) than bone length. (Modified from Loewen et al. 2013).
1624): Jugal, suborbital process at base of postorbital process: absent (0); present (1). (Modified from Loewen et al. 2013).
1625): Quadratojugal, anterior process, dorsoventral expansion overlapping the jugal laterally: absent (0); present (1). (Loewen et al. 2013).
1626): Supraoccipital, dorsal process, dorsal surface, shape: unforked (0); forked (1). (Modified from Loewen et al. 2013).
1627): Palatine, anterior/vomerine process: absent/indistinct (0); present/distinct (1). (Loewen et al. 2013).
1628): Prearticular, shape in lateral/medial view: gently concave dorsally (0); “U”-shaped (1). (Loewen et al. 2013).
1629): Prearticular, anterior end, dorsoventral depth relative to mid-length depth: less (0); more (1) than 11/5. (Loewen et al. 2013).
1630): Prearticular, mid-shaft cross section, proportions: dorsoventrally taller than mediolaterally wide (0); as wide as tall (1). (Modified from Loewen et al. 2013).
1631): Fibula, shaft distal to M. ileofibularis insertion, medial surface, shape: flat to convex (0); concave due to presence of groove (1). (Loewen et al. 2013).
1632): Ilium, postacetabular process, brevis fossa, pneumatic foramen: absent (0); present (1). (Zanno and Makovicky 2013).
1633): Knee joint, patella: absent or unossified (0); present and ossified (1).
1634): Ilium, pubic peduncle, mediolateral constriction: moderate (0); marked, producing a hook-like peduncle (1). (O'Connor 2009).
1635): Splenial, posterodorsal margin, shape in lateral/medial view: acute corner distinct from posterior margin (0); notched/concave margin with the posterior corner (1). (Tortosa et al. 2013).
1636): Middle dorsal vertebrae, infradiapophyseal fossa, dorsoventral depth: less (0); more (1) than centrum depth. (Tortosa et al. 2013).
1637): Scapula, ventral margin just distal to glenoid, shape in lateral/medial view: straight to convex (0); with a distinct concavity (1). (Tortosa et al. 2013).
1638): Tibia, fibular crest, orientation: straight, proximodistal (0); curved anteroproximally (1). (Modified from Tortosa et al. 2013).
1639): Prootic, tuberosity on the margin of the crista prootica (otosphenoid crest): absent (0); present (1). (Tortosa et al. 2013).
1640): Quadrate, anterior surface, large funnel-like recess: absent (0); present (1). (Brusatte et al. 2010).
1641): Coracoid, procoracoid process, position: in the proximal third (0); more distal (1).
1642): Maxilla, ventral process, posterior extent relative to the lacrimal (preorbital) bar: posterior (0); ventral (1).
1643): Scapula, fossa placed posterodorsal to subglenoid buttress (when present), shape: elliptical (0); triangular (1). (Kobayashi and Barsbold 2005).
1644): Coracoid, infraglenoid buttress placed ventrodistal to glenoid, eventually forming a cleft with posteroventral process: absent (0); present (1).

1645): Coracoid, dorsal margin, distinct mediolateral thickening compared to the rest of bone: absent (0); present (1).
1646): Tarsometatarsus, proximal vascular foramen between Mt II and III: absent (0); present (1). (Modified from Clarke and Norell; 2002).
1647): Tarsometatarsus, distal vascular foramen between Mt III and IV: absent (0); present (1).
1648): Coracoid, triosseal canal passing ventromedial to scapular facet: absent (0); present (1). (Longrich et al. 2011).
1649): Coracoid, tubercle, furcular facet: absent (0); present (1). (Longrich et al. 2011).
1650): Sacrum, articular facets: amphicoelous (0); procoelous (1).
1651): Sacrum, anteriormost centra, ventral surface: flat or bearing a slight ridge (0); bearing a deep keel (1). (Modified from Longrich and Currie 2009b).
1652): Sacrum, anteriormost centrum, proportion in anterior view: as wide as deep (0); wider than deep (1).
1653): Coracoid, supracoracoid nerve foramen, position relative to subglenoid fossa: outside (0); inside (1). (O'Connor 2009).
1654): Tarsometatarsus, distal end in taxa with completely fused metatarsi, surface between mt III and IV, interosseus canal: absent (0); present (1).
1655): Dentary, lateral surface, anterior half, accessory longitudinal groove placed just above ventral margin: absent (0); present (1).
1656): Mandible, medial view, Meckelian groove in articulated specimens: partially exposed (0); completely covered by splenial (1). (O'Connor 2009).
1657): Sacrum: primordial sacral 1 and 2, relationships: adjacent (0); separated by one or more “insertion” vertebrae (1).
1658): Pedal ungual IV, length: more (0); less (1) than 2/3 of pedal ungual III length. (Modified from O'Connor 2009).
1659): Maxilla, maxillary fenestra, area in lateral view: less (0); more (1) than half of surface of anterior antorbital fossa.
1660): Quadrate-prootic contact: absent (0); present (1). (Clarke and Norell 2002).
1661): Maxilla, ascending ramus, lateral surface, dorsoventrally oriented neurovascular groove (“anterior groove” of Sereno et al. 2004): absent (0); present (1).
1662): Maxilla, lateral surface ventral to antorbital fenestra and anterior to jugal contact, series of dorsoventrally oriented neurovascular grooves (“curved grooves” of Sereno et al. 2004): absent (0); present (1).
1663): Maxilla, lateral surface, jugal ramus, anastomosing pattern of grooves (“posterior groove” of Sereno et al. 2004): absent (0); present (1).
1664): Cervical vertebrae, epipophyses, extent along column: limited to anterior cervicals (0); present along whole series (1).
1665): Maxilla, antorbital fossa, foramen dorsal to the promaxillary recess: asbent (0); present (1).
1666): Epipterygoid: present (0); absent (1). (The presence of the epipterygoid may be inferred by the corresponding facets on pterygoid and laterosphenoid).
1667): Dentary, symphysis, anterior margin in dorsal/ventral view, median notch: absent (0); present (1). (O'Connor 2009).
1668): Teeth, enamel microstructure, enamel tubules, abundance: absent or rare (0); common (1). (Modified from Hendrickx and Mateus 2014a).
1669): Teeth, enamel microstructure, parallel crystallites development: predominant type (0); not predominant (1). (Hendrickx and Mateus 2014a).
1670): Teeth, enamel microstructure, boundary between first and second enamel types from the enamel-dentine junction: parallel to enamel-dentine junction (0); jagged, varies in distance from enamel-dentine (1). (Hendrickx and Mateus 2014a).
1671): Teeth, enamel microstructure, basal unit layer: present (0); absent (1). (Hendrickx and Mateus 2014a).
1672): Teeth, enamel microstructure, basal unit layer: poorly developed (0); well-developed, with distinct planes of separation between adjacent units (1). (Hendrickx and Mateus 2014a).
1673): Teeth, enamel microstructure, incremental lines: absent (0); present (1). (Modified from Hendrickx and Mateus 2014a).
1674): Mt II, distal end, proximomedial margin of medial condyle, tuber: absent (0); present (1).
1675): Maxilla, ascending process, posterodorsal end, shape in lateral view: single (0); forked (1).
1676): Maxilla/dentary, paradental laminae, shape in medial view: triangular, apically acuminate (0); quadrangular, apically flat (1). (Hendrickx and Mateus 2014b).
1677): Maxilla, antorbital fossa, lateral surface, anteroposterioly directed ridge ventral to the maxillary recess: absent (0); present (1). (Hendrickx and Mateus 2014b).
1678): Dentary, posteroventral process, torsion: absent, lateral surface facing laterally (0); present, lateral surface facing lateroventrally (1). (Lamanna et al. 2014).
1679): Premaxilla, narial fossa, anteroventral corner, large pneumatic foramen: absent (0); present (1). (Lamanna et al.

2014).
1680): Retroarticular process, proximal end, proportions: as wide as deep or wider than deep (0); much deeper than wide (1). (Modified from Lamanna et al. 2014).
1681): Humerus, shaft in anterior/posterior view, shape: straight with subparallel margins (0); bowed laterally (1). (Lamanna et al. 2014).
1682): Maxillary/dentary teeth, mesial carina, denticle at 2/3 of the carina, proportions: longer apicobasally than mesiodistally (0); mesiodistally as wide or wider than apicobasally long (1). (Modified from Hendrickx and Mateus 2014a).
1683): Maxillary/dentary teeth, distal carina, denticle at 1/2 of the carina, proportions: as long or longer apicobasally than mesiodistally (0); mesiodistally wider than apicobasally long (1). (Modified from Hendrickx and Mateus 2014a).
1684): Ulna, proximal view: orientation of olecranon process of the ulna: in same plane as coronoid (anterior/sigmoid) process (0); significantly everted medially, angle between olecranon and coronoid processes close to 120°(1). (Smith et al. 2008).
1685): Tibia, lateral surface, fibular crest, proximal end, shape: single crest (0); forked crest delimiting a proximal fossa (1).
1686): Mt III, proximal end, insertion of the tendon of the M. tibialis cranialis, development: as a scar (0); as a tubercle (1). (Modified from O'Connor 2009).
1687): Mt II, medial condyle, prominent ventral (plantar) projection relative to shaft and lateral condyle, evident in both distal and medial view: absent (0); present (1). (O'Connor et al. 2014).
1688): Mt pennaceous feathers: absent (0); present (1).
1689): Middle caudal vertebrae, neural arches, hyposphene: absent (0); present (1).
1690): Tibia, distal end, anterior surface, tuberosity proximal to astragalar facet: absent (0); present (1). (Ezcurra and Brusatte 2011).
1691): Tibia, distal end, medial surface, anteriorly bowed tuberosity: absent (0); present (1). (Ezcurra and Brusatte 2011).
1692): Maxilla, ventral process, dorsomedial margin, large neurovascular foramen: absent (0); present (1). (Hendrickx and Mateus 2014b).
1693): Distal carpal 1+2, proximal articular surface, transverse groove: absent (0); present at least medially (1). (Modified from Xu et al. 2014).
1694): Distal carpal 3: present (0); absent (1). (Modified from Xu et al. 2014).
1695): Distal carpal 4: present (0); absent (1). (Modified from Xu et al. 2014).
1696): Distal carpal 1+2, dorsomedial process, development: indistint (0); prominent (1). (Modified from Xu et al. 2014).
1697): Distal carpal 3 in adult: separated (0); fused (1) to medial carpals. (Modified from Xu et al. 2014).
1698): Semilunate carpal (1+2), proportion in extensor/flexor view: wider than proximodistally deep (0); as deep or deeper than mediolaterally wide (1). (Modified from Xu et al. 2014).
1699): Semilunate carpal (1+2), lateralmost extent in extensor/flexor view, overlap with mc III: absent or marginal (0); complete (1). (Modified from Xu et al. 2014).
1700): Mc I-distal carpal complex, relationships in adult: unfused (0); fused, suture obliterated (1). (Xu et al. 2014).
1701): Coracoid, supracoracoid nerve foramen, position on bone: centered on lateral surface (0); closer to the anterior/medial margin (1).
1702): Maxilla, facet for subnarial process of premaxilla, position: lateral to anteromedial process, on lateral surface (0); into a slot between anteromedial process and lateral surface (1). (Modified from Wilson et al. 2003).
1703): Premaxilla-maxilla suture, upper portion immediately ventral to the maxillary process of premaxilla, pneumatic spaces: absent (0); present (1). (Modified from Wilson et al. 2003).
1704): Maxilla, palatal shelves, anteroposterior extent: elongate for most of buccal margin (0); short (1).
1705): Lacrimal, anterodorsal process: present (0); absent (1).
1706): Exocipital, fossa for cranial nerves X-XII, depth: shallow, bowl-like (0); deep funnel (1). (Modified from Brusatte et al. 2010).
1707): Fourth sacral vertebra: absent (0); present (1).
1708): Fifth sacral vertebra: absent (0); present (1).
1709): Sixth sacral vertebra: absent (0); present (1).
1710): Seventh sacral vertebra: absent (0); present (1).
1711): Eight sacral vertebra: absent (0); present (1).
1712): Ninth sacral vertebra: absent (0); present (1).
1713): Tenth sacral vertebra: absent (0); present (1).
1714): Eleventh sacral vertebra: absent (0); present (1).
1715): Manual digit 3, non-ungual phalanges, number: three (0); less than three (1).

1716): Sternum, posterolateral process, distal expansion (when present), shape: triangular/fan-shaped (0); forked/branched (1).
1717): Premaxilla, sixth alveolus: absent (0); present (1).
1718): Premaxilla, seventh alveolus: absent (0); present (1).
1719): Scapula, glenoid facet, extent along lateral surface: absent (0); present (1).
1720): Oral margin along maxilla and jugal, ventral margin in lateral view, shape: straight to convex ventrally (0); arched, concave (1).
1721): Scapula, distal end, shape of margins: angular (0); rounded (1). (Modified from Senter et al. 2011).
1722): Pedal phalanx P2-II, diaphysis: distinct from epiphyses (0); indistinct due to extreme proximodistal compression of phalanx (1). (Senter et al. 2012).
1723): Mc III, distal end, position relative to mc II: distal (0); not distal (1).
1724): Mc I, mid-shaft mediolateral diameter: much smaller (0); comparable (1) to humerus shaft diameter.
1725): Caudal vertebrae 1-5, neural spine, morphology: all comparably well-developed (0); abrupt reduction in size of neural spines, from distinct processes to low ridges (1).
1726): Caudal vertebrae, anterior neural arches, zygapophyses, facet orientation: mainly mediolaterally, zygapophyses directed proximodistally (0); mainly dorsoventrally, zygapophyses projected laterally (1).
1727): Ischium, shape, in taxa with posterodorsally concave shaft, lateral view: uniformly rounded (0); with a marked bend (close to 90°) (1).
1728): Mc III distal end, width: not wider (0); wider (1) than distal end of mc II.
1729): Manual phalanx P1III, length: less (0); more (1) than mc III.
1730): Maxilla, antorbital fossa, anterior to antorbital fenestra, ornament-like pits: absent (0); present (1).
1731): Maxillary/post-symphyseal teeth, crown, basal cross section, shape: flat to convex both labially and lingually (0); distinctly concave both sides ("8-shaped") due to marked central depressions (1). (Modified from Hendrickx and Mateus 2014).
1732): Mc II and III, contact along shafts: limited proximally (0); extended for all shaft (1).
1733): Intermetacarpal space in taxa with distally closed carpometacarpus, width: no more (0); more (1) than Mc III mid-shaft width.
1734): Maxilla, articular facet for premaxilla, inclination in dorsal view: mostly anteriorly (0); beveled anteromedially (1).
1735): Maxilla, antorbital fossa, region posteroventral to base of ascending process, lateral surface, fluted margin with lateral ornamentation: absent (0); present (1).
1736): Maxilla, palatal shelf, dorsoventral thickness: shallow shelf (0); thick torus maxillaris confluent with anteromedial process (1).
1737): Mt III, distal end, flexor surface, cruciate ligament ridges: absent (0); present (1).
1738): Premaxilla, anteroventral corner of external naris, position relative to posterodorsal corner of antorbital fenestra in articulated specimens: ventral (0); dorsal (1).
1739): Sternum (in taxa with plates fused medially), anterior margin, rostral spine: absent (0); present (1).
1740): Dorsal vertebrae, anterior parapophyses, size: less (0); more (1) than half depth of anterior facet of centrum. (Brusatte et al., 2014).
1741): Scapula, anterior end, lateral surface dorsal to glenoid, distinct ridge overhanging fossa: absent (0); present (1). (Modified from Brusatte et al., 2014).
1742): Femur, head, anterior surface, anteroposteriorly (horizontally) oriented ridge overhaning distinct fossa/sulcus: absent (0); present (1).
1743): Femur, fourth trochanter, proximal end, confluence with greater trochanter: absent (0); present (1). (Modified from Brusatte et al., 2014).
1744): Quadrate, groove running medial to paraquadrate foramen for one third of body: absent (0); present (1). (Hendrickx et al., 2015).
1745): Quadrate, protuberant ridge dorsal to lateral condyle: absent (0); present (1). (Hendrickx et al., 2015).
1746): Quadrate, quadrate ridge, inclination in posterior view: laterally inclined (0); subvertical (1). (Hendrickx et al., 2015).
1747): Quadrate, quadrate ridge, contact with lateral condyle: asbent (0); present (1). (Modified from Hendrickx et al., 2015).
1748): Quadrate, quadrate ridge, ventral extremity, bifurcation: absent (0); present (1). (Hendrickx et al., 2015).
1749): Quadrate, quadrate ridge, lateral protuberance at 2/3 of ridge: absent (0); present (1). (Hendrickx et al., 2015).
1750): Quadrate, distal end, anterior intercondylar notch: absent (0); present (1). (Modified from Hendrickx et al., 2015).
1751): Quadrate, medial condyle, anterior concavity: absent (0); present (1). (Modified from Hendrickx et al., 2015).
1752): Quadrate, intercondylar sulcus, width: less (0); subequal or larger (1) than medial condyle. (Hendrickx et al.,

2015).
1753): Paraquadrate foramen, shape: not elongate dorsoventrally (0); elongate dorsoventrally (1). (Modified from Hendrickx et al., 2015).
1754): Quadrate, lateral process: present (0); absent (1). (Hendrickx et al., 2015).
1755): Quadrate, lateral process, dorsal extent: reaching (0); not reaching (1) the quadrate head. (Hendrickx et al., 2015).
1756): Tarsometatarsus, distal vascular foramen between Mt III and IV, shape: small foramen (0); very elongate (1).
1757): Dentary, Meckelian groove, anterior end, position: medial (0); ventral (1) surface of bone. (Longrich et al., 2013).
1758): Femur, distal end, laterally protruding prominence, development: tuber-like (0); crest/shelf-like (1).
1759): Premaxilla, fourth alveolus: absent (0); present (1).
1760): Ischium, pubic peduncle, ventrodistal margin in lateral view, notch producing a "hooked" peduncle: absent (0); present (1).
1761): Frontal, postorbital facet, deep longitudinal slot for postorbital: absent (0); present (1).
1762): Postorbital, ventral (jugal) process, lateral surface, tuber/rugosity: absent (0); present (1).
1763): Paramedian osteoderms: present (0); absent (1).
1764): Maxilla, posteroventral ramus, subcutaneous surface ventral to antorbital fenestra, lateral neurovascular foramen larger than other neurovascular foramina (if present): absent (0); present (external maxillary foramen) (1). (Modified from Wang et al. 2016).
1765): Jugal, margin of infratemporal fenestra, lateral surface, fossa: absent (0); present (1). (Modified from Wang et al. 2016).
1766): Quadratojugal, margin of infratemporal fenestra, lateral surface, fossa: absent (0); present (1). (Modified from Wang et al. 2016).
1767): Quadratojugal, lateral surface, rugose ornamentation: absent (0); present (1). (Wang et al. 2016).
1768): Cervical vertebrae, posteriormost neural spines, shape in anterior/posterior view: simple process (0); apically bifurcated (1). (Wang et al. 2016).
1769): Manual digits I-III, proximal phalanx, distal condyles, development: symmetrical (0); asymmetrical, lateral condyle projected more distally than the medial (1). (Wang et al. 2016).
1770): Coracoid, glenoid dorsoventral diameter: more (0); less (1) than ¼ of anteroposterior diameter of coracoid between glenoid and scapular facet. (Modified from Wang et al. 2016).
1771): Tibia, distal end, medial surface when articulated with astragalus, exposition: not exposed (0); exposed (1) in anterior view. (Modified from Brusatte et al. 2014).
1772): Exoccipital-opisthotic, paroccipital process, ventral flange at distal end: absent (0); present (1). (Brusatte et al. 2014).
1773): Ilium, dorsal margin posterodorsally to acetabulum (at level of processus supratrochantericus, when present), lateral surface, inclination in lateral view: laterally oriented (0); curved ventrally (medial surface of blade oriented dorsally) (1).

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Score of *Halszkaraptor* and updated score of *Mahakala* in the Second Phylogenetic data set

See ref. 22 and ref. 51 for details of character statements and complete data matrix.

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Forelimb morphometric data sets

Manual proportion data set

Taxon	Group	ratio 2nd/1st	ratio 3rd/2nd	Source
Adriosaurus	Short-necked aquatic reptile	1.52	1.27	Palci, A. & Caldwell, M. W. Vestigial forelimbs and axial elongation in a 95 million-year-old non-snake squamate. Journal of Vertebrate Paleontology 27, 1-7 (2007)
Alligator	Quadrupedal reptile	1.48	1.06	Maler, G. B. & Alberch, P. Ontogeny of the Limb Skeleton in *Alligator mississipiensis*: Developmental lnvariance and Change in the Evolution of Archosaur Limbs.Journal of Morphology 203, 151-164 (1990)
Allosaurus	Non-avialan tetanuran	1.28	0.72	Madsen, J.H., Jr. *Allosaurus fragilis*—a revised osteology. Utah Geologic Survey Bulletin 109, 1–163 (1976).
Ankylosphenodon	Short-necked aquatic reptile	1.24	1.13	Reynoso, V. H. An unusual aquatic sphenodontian (Reptilia: Diapsida) from the Tlayua Formation (Albian), Centra Mexico. Journal of Paleontology 74, 133-148 (2000).
Araripemys	Long-necked aquatic reptile	1.41	1.22	Meylan, P. A. Skeletal morphology and relationships of the early Cretaceous side-necked turtle, *Araripemys barretoi* (Testudines: Pelomedusoides: Araripemydidae), from the Santana Formation of Brazil. J. Vert. Paleont. 16, 20–33 (1996).
Archaeopteryx	Mesozoic Bird	1.89	0.74	Cast of the Berlin specimen
Balaur	Non-avialan tetanuran	1.54	0.38	Brusatte SL, Vremir M, Csiki-Sava Z, Turner AH,Watanabe A, Erickson GM, Norell MA. 2013. The Osteology *of Balaur bondoc*, an island-dwelling dromaeosaurid (Dinosauria: Theropoda) from the Late Cretaceous of Romania. Bulletin of the American Museum of Natural History 374:1–100.
Callawayasaurus	Long-necked aquatic reptile	2.45	1.08	Caldwell, M. W. From fins to limbs to fins: Limb evolution in fossil marine reptiles. Am. J. Med. Gen. 112, 236–249 (2002).
Caudipteryx	Non-avialan tetanuran	1.64	0.39	Cast of *Caudipteryx* sp.
cf.Parvicursor	Non-avialan tetanuran	0.57	0.95	Choiniere J. et al. A Basal Alvarezsauroid Theropod from the Early Late Jurassic of Xinjiang, China. Science 327, 571-574.
Chamaleo	Quadrupedal terrestrial reptile	1.14	1.13	Gauthier, J. A. et al. Assembling the Squamate Tree of Life: Perspectives from the Phenotype and the Fossil Record. Bulletin of the Peabody Museum of Natural History, 53(1):3-308 (2012).
Chirostenotes	Non-avialan tetanuran	1.59	0.72	Gilmore, G. W. Contributions of vertebrate palaeontology. Geological Survey of Canada, Bulletin 38, 1-89 (1924).
Coelophysis	Bipedal non-tetanuran dinosaur	1.61	1.01	Tykoski, R.S. & Rowe, T. in The Dinosauria (second edition) (eds. Weishampel, D.B., Dodson, P. & Osmolska, H.) 47-70 (University of Californai Press, Berkeley, 2004).

Confuciusornis	Mesozoic Bird	1.65	0.94	Uncatalogued cast housed in Bologna University
Crotaphytus	Quadrupedal terrestrial reptile	1.76	1.3	Gauthier, J. A. et al. Assembling the Squamate Tree of Life: Perspectives from the Phenotype and the Fossil Record. Bulletin of the Peabody Museum of Natural History, 53(1):3-308 (2012).
Cryptoclidus	Long-necked aquatic reptile	1.61	1.12	Caldwell, M. W. From fins to limbs to fins: Limb evolution in fossil marine reptiles. Am. J. Med. Gen. 112, 236–249 (2002).
Dactylosaurus	Long-necked aquatic reptile	1.69	1.3	Caldwell, M. W. From fins to limbs to fins: Limb evolution in fossil marine reptiles. Am. J. Med. Gen. 112, 236–249 (2002).
Deinocheirus	Non-avialan tetanuran	1.19	0.86	Cast of type specimen
Deinonychus	Non-avialan tetanuran	1.57	0.79	Brusatte SL, Vremir M, Csiki-Sava Z, Turner AH,Watanabe A, Erickson GM, Norell MA. 2013. The Osteology *of Balaur bondoc*, an island-dwelling dromaeosaurid (Dinosauria: Theropoda) from the Late Cretaceous of Romania. Bulletin of the American Museum of Natural History 374:1–100.
Diadongosaurus	Long-necked aquatic reptile	1.69	1.26	Caldwell, M. W. From fins to limbs to fins: Limb evolution in fossil marine reptiles. Am. J. Med. Gen. 112, 236–249 (2002).
Dianmeisaurus	Long-necked aquatic reptile	1.57	1.36	Qing-Hua Shang & Chun Li (2015). A new small-sized eosauropterygian (Diapsida: Sauropterygia) from the Middle Triassic of Luoping, Yunnan, southwestern China. Vertebrata PalAsiatica. 53 (4): 265–280 (2015).
Dianmeisaurus	Long-necked aquatic reptile	1.64	1.24	Qing-Hua Shang & Chun Li (2015). A new small-sized eosauropterygian (Diapsida: Sauropterygia) from the Middle Triassic of Luoping, Yunnan, southwestern China. Vertebrata PalAsiatica. 53 (4): 265–280 (2015).
Dolichorhynchops	Short-necked aquatic reptile	1.29	1.05	Caldwell, M. W. From fins to limbs to fins: Limb evolution in fossil marine reptiles. Am. J. Med. Gen. 112, 236–249 (2002).
Dalinghosaurus	Quadrupedal terrestrial reptile	1.57	1.23	Evans, S. E. & Wang, Y. The Early Cretaceous lizard *Dalinghosaurus* from China. Acta Palaeontologica Polonica 50, 725–742 (2005).
Eocathayornis	Mesozoic Bird	2.52	0.69	Zhou, Z. A new and primitive enantiornithine bird from the Early Cretaceous of China. Journal of Vertebrate Paleontology 22: 49-57 (2002).
Eoenantiornis	Mesozoic Bird	2.53	0.67	Zhou, Z., Chiappe L. M., Zhang, F. Anatomy of the Early Cretaceous bird *Eoenantiornis buhleri* (Aves: Enantiornithes) from China. Can. J. Earth Sci. 42: 1331–1338 (2005).
Eoraptor	Bipedal non-tetanuran dinosaur	1.48	1.02	Sereno, P. C., Martínez, R. N. & Alcober, O. A. Osteology of *Eoraptor lunensis* (Dinosauria, Sauropodomorpha). Journal of Vertebrate Paleontology, 32 sup1, 83-179 (2012).
Falcarius	Non-avialan tetanuran	1.49	0.72	Zanno LE. The pectoral girdle and forelimb of the primitive therizinosauroid *Falcarius utahensis* (Theropoda, Maniraptora): analyzing

				evolutionary trends within Therizinosauroidea. Journal of Vertebrate Paleontology 26: 636–650 (2006).
Gallimimus	Non-avialan tetanuran	1.08	0.87	Osmólska, H., E. Roniewicz & R. Barsbold. A new dinosaur, *Gallimimus bullatus* n. gen., n. sp. (Ornithomimidae) from the Upper Cretaceous of Mongolia. Palaeontologica Polonica 27: 103-143 (1972).
Geosaurus	Short-necked aquatic reptile	1.26	1.08	Caldwell, M. W. From fins to limbs to fins: Limb evolution in fossil marine reptiles. Am. J. Med. Gen. 112, 236–249 (2002).
Halszkaraptor	Halszkaraptor	1.84	1.13	This study
Haplocheirus	Non-avialan tetanuran	1.71	0.58	Choiniere J. et al. A Basal Alvarezsauroid Theropod from the Early Late Jurassic of Xinjiang, China. Science 327, 571-574.
Herrerasaurus	Bipedal non-tetanuran dinosaur	1.52	1.12	Novas, F. E. New information on the systematics and postcranial skeleton of *Herrerasaurus ischigualastensis* (Theropoda: Herrerasauridae) from the Ischigualasto Formation (Upper Triassic) of Argentina. Journal of Vertebrate Paleontology 13:400–423 (1994).
Heterodontosaurus	Bipedal non-tetanuran dinosaur	1.65	1.04	Sereno, P. C. Taxonomy, morphology, masticatory function and phylogeny of heterodontosaurid dinosaurs. ZooKeys 226: 1–225 (2012).
Huehuecuetzpalli	Quadrupedal terrestrial reptile	1.56	1.21	Reinoso, R. W. *Huehuecuetzpalli mixtecus* gen. et sp. nov; a basal squamate (Reptilia) from the Early Cretaceous of Tepexi de Rodriguez, Central Mexico. Philosophical Transactions of the Royal Society of London, Series B, 353:477-500 (1998).
Hupesuchus	Short-necked aquatic reptile	1.13	1.11	Carroll, R.L., Dong, Z. *Hupehsuchus*, an enigmatic aquatic reptile from the Triassic of China, and the problem of establishing relationships. Philosophical Transactions of the Royal Society of London Series B-Biological Sciences 331, 131-153 (1991).
Hydrorion	Long-necked aquatic reptile	1.89	1.21	Caldwell, M. W. From fins to limbs to fins: Limb evolution in fossil marine reptiles. Am. J. Med. Gen. 112, 236–249 (2002).
Hyphalosaurus	Long-necked aquatic reptile	1.54	1.17	Gao, K.-Q. & Fox, R. C. A new choristodere (Reptilia: Diapsida) from the Lower Cretaceous of western Liaoning Province, China, and phylogenetic relationships of Monjurosuchidae. Zoolog J Linn Soc 145, 427–444 (2005).
Khaan	Non-avialan tetanuran	0.75	0.95	Balanoff, A. M. & Norell, M. A. Osteology of *Khaan mckennai* (Oviraptorosauria: Theropoda). Bull. Am. Mus. Nat. Hist 372, 1–77 (2012).
Komensaurus	Short-necked aquatic reptile	1.33	1.26	Palci A., Caldwell, M. W. A new basal mosasauroid from the Cenomanian (U. Cretaceous) of Slovenia with a review of Mosasauroid phylogeny and evolution. Journal of Vertebrate Paleontology 27, 863-880 (2007).
Laganemys	Long-necked	1.43	1.1	Sereno, P. C. & ElShafie, S. J. A New Long-Necked

	aquatic reptile			Turtle, *Laganemys tenerensis* (Pleurodira: Araripemydidae), from the Elrhaz Formation (Aptian–Albian) of Niger. Morphology and Evolution of Turtles Proceedings of the Gaffney Turtle Symposium (2009) in Honor of Eugene S. Gaffney 215-250 (2013).
Lariosaurus	Long-necked aquatic reptile	1.41	1.02	Rieppel, O. The status of the sauropterygian reptile genera *Ceresiosaurus*, *Lariosaurus*, and *Silvestrosaurus* from the Middle Triassic of Europe. Fieldiana. Geology 38, 1-46 (1998).
Lariosaurus	Long-necked aquatic reptile	1.59	1.07	Rieppel, O. The status of the sauropterygian reptile genera *Ceresiosaurus*, *Lariosaurus*, and *Silvestrosaurus* from the Middle Triassic of Europe. Fieldiana. Geology 38, 1-46 (1998).
Longipteryx	Mesozoic Bird	2.31	0.55	Wang et al. New material of *Longipteryx* (Aves: Enantiornithes) from the Lower Cretaceous Yixian Formation of China with the first recognized avian tooth crenulations. ZooTaxa 3941, 565–578 (2015).
Macrocnemus	Quadrupedal terrestrial reptile	1.61	1.44	Li, C., Zhao, L., & Wang, L. A new species of *Macrocnemus* (Reptilia: Protorosauria) from the Middle Triassic of southwestern China and its palaeogeographic implication. Science in China, Series D: Earth Sciences, 50, 1601–1605 (2007).
Megalancosaurus	Quadrupedal terrestrial reptile	0.97	1.07	Renesto, S. *Megalancosaurus*, a Possibly Arboreal Archosauromorph (Reptilia) from the Upper Triassic of Northern Italy. Journal of Vertebrate Paleontology 14, 38-52 (1994).
Megaraptor	Non-avialan tetanuran	0.88	0.6	Calvo, J. O., Porfiri, J. D., Veralli, C., Novas, F. & Poblete, F. Phylogenetic status of *Megaraptor namunhuaiquii* Novas based on a new specimen from Neuquen, Patagonia, Argentina. Ameghiniana 41, 565–575 (2004).
Mesosaurus	Short-necked aquatic reptile	1.52	1.1	Modesto, S. P. The postcranial skeleton of the aquatic parareptile *Mesosaurus tenuidens* from the Gondwanan Permian, Journal of Vertebrate Paleontology, 30:5, 1378-1395 (2010).
Meyerasaurus	Long-necked aquatic reptile	1.62	1.29	Smith, A. S. & Vincent, P. A new genus of pliosaur (Reptilia: Sauropterygia) from the Lower Jurassic of Holtzmaden, Germany. Palaeontology 53, 1049-1063.
Microraptor	Non-avialan tetanuran	1.91	0.87	Brusatte SL, Vremir M, Csiki-Sava Z, Turner AH,Watanabe A, Erickson GM, Norell MA. 2013. The Osteology *of Balaur bondoc*, an island-dwelling dromaeosaurid (Dinosauria: Theropoda) from the Late Cretaceous of Romania. Bulletin of the American Museum of Natural History 374:1–100.
Neusticosaurus	Long-necked aquatic reptile	2.06	1.44	Rieppel, O & L Kebang. *Pachypleurosaurs* (Reptilia, Sauropterygia) from the Lower Muschelkalk, and a review of the Pachypleurosauroidea. Fieldiana Geol. N.S. 32, 1-44 (1995).
Nothosaurus	Long-necked	1.53	1.21	Rieppel, O. The status of the sauropterygian reptile

	aquatic reptile			*Nothosaurus juvenilis* from the Middle Triassic of Germany. Palaeontology 37, 733–745 (1994).
Opetiosaurus	Short-necked aquatic reptile	1.39	1.23	Dutchak, A. R. & Caldwell, M.W. A redescription of *Aigialoaurus* (=*Opetiosaurus*) *bucchichi* (Kornhuber, 1901) (Squamata: Aigialosauridae) with comments on mosasauroid systematics. Journal of Vertebrate Paleontology 29, 437-452 (2009).
Pachypleurosaurus	Long-necked aquatic reptile	2.31	1.45	Carroll, R. L. and Gaskill, P. The nothosaur *Pachypleurosaurus* and the origin of plesiosaurs. Phil. Trans. R. Soc. Lond. B 309, 343-393 (1985).
Palmula	Short-necked aquatic reptile	1.33	0.98	Albright, L. B. III, Gillette, D. D., Titus, A. L. Plesiosaurs from the Upper Cretaceous (Cenomanian-Turonian) Tropic Shale of Southern Utah, Part II: Polycotylidae. J. Vert. Paleont. 27, 42–58 (2007).
Paranothosaurus	Long-necked aquatic reptile	1.49	1.18	Caldwell, M. W. From fins to limbs to fins: Limb evolution in fossil marine reptiles. Am. J. Med. Gen. 112, 236–249 (2002).
Pelecanimimus	Non-avialan tetanuran	1.16	0.81	High-resolution photograph of type specimen
Peloneustes	Short-necked aquatic reptile	1.34	1	Caldwell, M. W. From fins to limbs to fins: Limb evolution in fossil marine reptiles. Am. J. Med. Gen. 112, 236–249 (2002).
Plesiopterys	Long-necked aquatic reptile	1.85	1.14	O'Keefe, F. R. Preliminary description and phylogenetic position of a new plesiosaur (Reptilia: Sauropterygia) from the Toarcian of Holzmaden, Germany. J. Paleont. 78, 973–988 (2004).
Physignathus	Quadrupedal terrestrial reptile	1.51	1.23	Gauthier, J. A. et al. Assembling the Squamate Tree of Life: Perspectives from the Phenotype and the Fossil Record. Bulletin of the Peabody Museum of Natural History, 53(1):3-308 (2012).
Plesiosaurus	Long-necked aquatic reptile	2.11	1.37	Caldwell, M. W. From fins to limbs to fins: Limb evolution in fossil marine reptiles. Am. J. Med. Gen. 112, 236–249 (2002).
Prognathodon	Short-necked aquatic reptile	1.22	0.88	Lindgren, J. et al. Soft tissue preservation in a fossil marine lizard with a bilobed tail fin. Nat. Commun. 4:2423 doi: 10.1038/ncomms3423 (2013).
Protarchaeopteryx	Non-avialan tetanuran	1.59	0.75	Ji, Q. & Ji, S.-A. A Chinese archaeopterygian, *Protarchaeopteryx* gen. nov. Chinese Geol. 238, 38–41 (1997).
Protostega	Short-necked aquatic reptile	1.46	1.47	Hay, O. P. (1898). On *Protostega*, the systematic position of *Dermochelys*, and the morphogeny of the chelonian carapace and plastron. American Naturalist, 32, 929–948.
Psittacosaurus	Bipedal non-tetanuran dinosaur	1.44	1.06	Ford, T. L. & Martin, L. D. A semi-aquatic life habit for *Psittacosaurus*. In Ryan, Michael J.; Chinnery-Allgeier, Brenda J.; and Eberth, David A. (editors.). New Perspectives on Horned Dinosaurs: The Royal Tyrrell Museum Ceratopsian Symposium. Bloomington and

				Indianapolis: Indiana University Press. pp. 328–339 (2010).
Sapeornis	Mesozoic Bird	1.99	0.57	Zhou, Z. H. & Zhang, F. C. Anatomy of the primitive bird *Sapeornis chaoyangensis* from the Early Cretaceous of Liaoning. Canadian Journal of Earth Sciences 40, 731–747 (2003).
Scansoriopteryx	Gliding paravian	1.73	1.63	Czerkas, S. A. & Yuan, C. in Feathered Dinosaurs and the Origin of Flight (ed Czerkas, S. J.) 63-95 (The Dinosaur Museum, Blanding, 2002).
Scipionyx	Non-avialan tetanuran	1.69	0.74	High resolution photograph of type specimen
Simosaurus	Long-necked aquatic reptile	1.15	1.35	Rieppel, O & L Kebang. *Pachypleurosaurs* (Reptilia, Sauropterygia) from the Lower Muschelkalk, and a review of the Pachypleurosauroidea. Fieldiana Geol. N.S. 32, 1-44 (1995).
Simosuchus	Quadrupedal terrestrial reptile	0.98	1.04	Sertich, J. J. W. & Groenke, J. R. Appendicular skeleton of *Simosuchus clarki* (Crocodyliformes: Notosuchia) from the Late Cretaceous of Madagascar, Journal of Vertebrate Paleontology 30, 122—153 (2010).
Sinornithomimus	Non-avialan tetanuran	1.09	0.91	Kobayashi, Y. and Lü, J.−C. A new ornithomimid dinosaur with gregarious habits from the Late Cretaceous of China. Acta Palaeontologica Polonica 48: 235–259 (2003).
Staganolepis	Quadrupedal terrestrial reptile	1.39	1.03	Walker, A. D. Triassic reptiles from the Elgin area: *Stagonelepis*, *Dasygnathus* and their allies. Philos. Trans. R. Soc. London, Ser. B 244, 103-204 (1961).
Tanystropheus	Long-necked aquatic reptile	1.67	1.18	High resolution photographs of specimens housed in Milan Natural History Museum
Thecodontosaurus	Bipedal non-tetanuran dinosaur	1.4	0.97	Benton, M. J., Juul, L., Storrs, G.W. & Galton, P. M. Anatomy and systematics of the prosauropod dinosaur *Thecodontosaurus antiquus* from the Upper Triassic of Southwest England. Journal of Vertebrate Paleontology 20: 77–108 (2000).
Tianyulong	Bipedal non-tetanuran dinosaur	1.17	0.87	Sereno, P. C. Taxonomy, morphology, masticatory function and phylogeny of heterodontosaurid dinosaurs. ZooKeys 226: 1–225 (2012).
Ticinosuchus	Quadrupedal terrestrial reptile	1.25	1.14	Krebs, B. Die Triasfauna der Tessiner Kalkalpen, XIX. *Ticinosuchus ferox* nov. gen. nov. sp. Ein neuer Pseudosuchier aus der Trias des Monte San Giorgio. Schweiz. Paläontol., Abh. 81, 1-1 40 (1965).
Trilophosaurus	Quadrupedal terrestrial reptile	1.52	1.29	Spielmann et al. The Late Triassic Archosauromorph *Trilophosaurus*. New Mexico Museum of Natural History and Science Bulletin 43 (2008).
Vallesaurus	Quadrupedal terrestrial reptile	1.38	1.38	Renesto et al. Taxonomy and paleobiology of the drepanosaurs. New Mexico Museum of Natural History and Science, Bulletin 46 (2010).
Velociraptor	Non-avialan tetanuran	1.33	0.82	Ostrom, J. H. *Archaeopteryx* and the Origin of Birds. Biol. J. Linn. Soc. 8: 91-182 (1976).
Vescornis	Mesozoic Bird	2.8	0.67	Zhang, F., Ericson, P. G. P. & Zhou, Z. Description of a new enantiornithine bird from the Early

				Cretaceous of Hebei, northern China. Canadian Journal of Earth Sciences 41, 1097–1107 (2004).
Yabeinosaurus	Quadrupedal terrestrial reptile	1.65	1.06	Evans, S. E. Wang, Y, & Li, C. The early Cretaceous lizard genus *Yabeinosaurus* from China: Resolving an enigma. Journal of Systematic Palaeontology. 3 (4): 319. doi:10.1017/S1477201905001641 (2005)
Yixianosaurus	Non-avialan tetanuran	1.78	0.76	Dececchi T. A., Larsson, H. C. E., Hone, D. *Yixianosaurus longimanus* (Theropoda: Dinosauria) and its bearing on the evolution of Maniraptora and ecology of the Jehol fauna. Vert. PalAsiat. 50(2): 111–139 (2012).
Yunguisaurus	Long-necked aquatic reptile	2.08	1.29	Sato, T., Cheng, Y.-N., Wu, X.-C. & LI , C. Osteology of *Yunguisaurus* Cheng et al., 2006 (Reptilia; Sauropterygia), a Triassic pistosauroid from China. Paleontological Research 14, 179–195 (2010).
Zhongjianornis	Mesozoic Bird	2.03	0.57	Zhou, Z. & Zhang, F. & Li, Z. A new Lower Cretaceous bird from China and tooth reduction in early avian evolution. Proc. R. Soc. B doi:10.1098/rspb.2009.0885 (2009).

Measurements (in mm) of *Halszkaraptor* and 245 extant bird taxa used in the morphometric analysis of the forelimb[53]

Abbreviations: CMCL, carpometacarpus length; CMCMTD, carpometacarpus mid-shaft mediolateral diameter; FP, foot propelled; FW, foot-and-wing propelled; HML, humerus length; HMMSD, humerus mid-shaft anteroposterior diameter; HMMTD, humerus mid-shaft mediolateral diameter; NS, non-swimmer; PL, plumber; SS, surface swimmer; STERL, sternum length; STERW, sternum width; ULL, ulna length; LM, locomotory mode; ULMSD, ulna mid-shaft anteroposterior diameter; ULMTD, ulna mid-shaft mediolateral diameter; WP, wing propelled.

Genus	Species	LM	HML	HMMSD	HMMTD	ULL	ULMSD	ULMTD	CMCL	CMCMTD	STERL	STERW
Halszkaraptor	*escuilliei*	-	45.7	4.51	4.97	39.3	2.78	3.66	18.5	4.85	45.6	27.2
Aechmophorus	*clarkii*	FP	115.95	4.91	5.2	104.25	4.81	4.25	50.31	2.82	55.93	41.97
Aechmophorus	*occidentalis*	FP	116.83	5.18	5.53	104.17	4.92	4.44	51.5	2.91	59.76	44.53
Anhinga	*anhinga*	FP	124.35	6.22	5.99	113.01	6.01	5.53	64.73	3.74	58.83	38.78
Aythya	*affinis*	FP	80.83	5.36	5.15	71.31	4.56	4.49	44.77	3.29	68.35	37.3
Aythya	*americana*	FP	84.72	5.58	5.28	75.16	4.74	4.58	49.57	3.54	73.12	37.53
Aythya	*australis*	FP	88.44	5.68	5.55	77.16	4.79	4.75	47.78	3.46	76.59	36.85
Aythya	*collaris*	FP	76.4	5.2	4.81	66.12	4.17	4.12	41.79	3.08	68.17	36.16
Aythya	*fuligula*	FP	77.81	4.99	4.76	68.95	4.16	4.11	41.99	2.93	66.37	36.33
Aythya	*marila*	FP	87.4	5.74	5.16	76.29	4.53	4.32	47.17	3.32	70.47	40.73
Aythya	*valisineria*	FP	94.73	6.02	5.44	83.58	4.95	4.93	51.62	3.59	80.59	42.73
Biziura	*lobata*	FP	113.46	7.04	6.3	97.01	5.56	5.37	53.31	3.09	84.48	49.89
Bucephala	*albeola*	FP	62.25	4.12	3.99	53.53	3.5	3.35	36.8	2.45	58.98	29.59
Dendrocygna	*bicolor*	FP	95.19	5.72	5.13	99.07	4.41	4.37	50.33	3.01	68.33	32.3

Gavia	*adamsii*	FP	201.11	10.44	9.89	162.04	9.83	7.93	104.57	7.16	186.9	77.21
Gavia	*arctica*	FP	141.91	7.12	6.73	113.77	6.5	5.34	75.89	4.98	140.41	55.86
Gavia	*immer*	FP	180.94	8.59	8.61	145.99	8.35	6.47	95.29	6.19	165.73	66.47
Gavia	*pacifica*	FP	149.55	7.35	7.2	120.69	7.1	5.51	79.81	5.31	148.14	56.09
Gavia	*stellata*	FP	141.84	6.68	6.57	114.88	5.95	5.53	76.61	4.18	137.42	50.08
Melanitta	*nigra*	FP	92.15	5.77	5.07	83.71	4.55	4.41	52.47	2.93	85.16	45.89
Netta	*peposaca*	FP	96.54	6.13	5.54	82.99	4.63	4.84	53.99	3.63	78.65	34.15
Oxyura	*jamaicensis*	FP	69.5	4.22	4.13	60.45	3.31	3.11	35.46	2.27	55.35	35.84
Phalacrocorax	*africanus*	FP	94.68	4.93	4.09	99.47	3.73	3.77	47.48	2.33	48.49	29.89
Phalacrocorax	*albiventer*	FP	145	7.96	6.83	152.11	6.14	6.01	65.58	3.84	93.32	63.43
Phalacrocorax	*atriceps*	FP	152.87	8.68	7.32	166.23	6.43	6.48	68.4	3.93	97.46	65.11
Phalacrocorax	*auritus*	FP	152.35	7.94	7.62	160.99	6.07	6.32	73.27	3.71	80.24	50.52
Phalacrocorax	*bouganvillii*	FP	155.48	8.2	7.3	167.69	6.23	6.28	66.16	3.79	89.26	53.78
Phalacrocorax	*brasilianus*	FP	123.85	6.72	5.95	129.68	4.81	5.25	60.86	3.12	62.31	40.8
Phalacrocorax	*capensis*	FP	121.64	6.46	5.64	129.56	4.77	4.97	57.94	2.98	66.3	42.54
Phalacrocorax	*carbo*	FP	156.17	8.76	7.63	166.39	6.12	6.47	75.28	3.98	80.45	49.78
Phalacrocorax	*coronatus*	FP	95.65	5.63	4.51	100.09	3.96	4.21	47.92	2.44	49.8	34.55
Phalacrocorax	*harrisi*	FP	93.37	6.42	5.76	76.54	4.65	4.35	39.56	2.54	75.31	57.49
Phalacrocorax	*magellanicus*	FP	121.72	7.13	5.77	127.67	5.44	5.22	58.1	3.19	69.21	54.31
Phalacrocorax	*melanoleucos*	FP	105.31	5.76	4.79	109.57	4.35	4.5	53.57	2.7	53.13	35.03
Phalacrocorax	*neglectus*	FP	134.3	7.48	6.35	141.2	5.71	5.9	59.77	3.33	75.47	53.75
Phalacrocorax	*pelagicus*	FP	117.92	7.06	5.66	125.61	5.23	5.16	57.19	3.09	66.74	49.05
Phalacrocorax	*penicillatus*	FP	142.08	8.23	6.47	149.77	5.55	5.88	62.79	3.37	83.54	55.41
Phalacrocorax	*urile*	FP	125.02	7.94	6.24	133.73	5.87	5.7	61.06	3.44	69.83	53.84
Phalacrocorax	*varius*	FP	143.64	7.52	6.67	149.35	5.48	5.76	69.14	3.29	73.94	51.19
Podiceps	*auritus*	FP	78.73	3.56	3.72	70.7	3.18	3.22	35.7	2.1	40.29	30.11
Podiceps	*grisegena*	FP	109.98	4.95	5.3	100.69	4.74	4.25	48.09	2.95	56.22	40.06
Podiceps	*major*	FP	110.71	5.16	4.86	97.53	4.78	3.99	49.7	2.64	55.45	37.76
Podiceps	*nigricollis*	FP	72.26	3.25	3.43	66.38	3.15	2.92	32.69	1.96	40.05	27.81
Podilymbus	*podiceps*	FP	74.32	3.51	3.45	68.99	3.02	2.99	32.37	1.85	34.21	27.25
Puffinus	*carneipes*	FP	111.3	4.7	5.36	112.1	4.77	4.67	58.24	3.41	55.84	32.15
Puffinus	*creatopus*	FP	113.84	4.98	5.29	113.97	4.94	4.68	60.08	3.39	56.14	34.68
Puffinus	*griseus*	FP	109.54	4.36	6.43	102.06	5.13	4.37	57.08	3.52	65.94	33.89
Puffinus	*lherminieri*	FP	67.96	3	3.44	63.2	3.01	2.66	35.93	2.16	35.36	19.81
Puffinus	*opisthomelas*	FP	83.78	3.46	4.93	76.64	4	3.29	45.49	2.69	48.51	28.32
Puffinus	*tenuirostris*	FP	98.21	4.09	6.01	93.82	4.89	4.02	50.55	3.21	57.79	31.96
Rollandia	*microptera*	FP	68.34	2.75	3.18	52.88	2.94	2.51	28.21	1.89	34.3	32.4
Rollandia	*rolland*	FP	54.4	2.51	2.45	48.64	2.27	1.9	24.75	1.54	30.72	20.48
Tachybaptus	*dominicus*	FP	48.16	2.49	2.2	46.94	2.01	2.08	21.7	1.4	23.59	18.99
Tachybaptus	*novaehollandiae*	FP	56.93	2.82	2.6	52.65	2.46	2.19	25.45	1.61	32.78	22.1
Tachybaptus	*ruficollis*	FP	57.95	2.69	2.46	53.03	2.51	2.08	25.73	1.56	30.8	23.07
Bucephala	*clangula*	FW	78.18	5.28	4.95	67.42	4.56	4.38	46.41	3.38	82.21	38.98
Cepphus	*columba*	FW	66.12	3.85	4.4	55.59	3.67	4.06	36.84	2.54	69.68	27.07
Clangula	*hyemalis*	FW	72.18	5.16	5.27	64.55	4.52	4.53	44.91	3.5	90.23	39.55

Fulmarus	*glacialis*	FW	106.19	5.21	4.75	102.24	4.39	4.27	50.92	3.16	49.45	32.47
Lophodytes	*cucullatus*	FW	65.25	4.96	4.37	54.26	3.94	3.82	39.81	2.94	69.6	32.52
Melanitta	*fusca*	FW	97.33	6.63	6.26	87.68	5.41	5.44	56.69	4.05	90.49	50.62
Melanitta	*perspicillata*	FW	81.94	5.67	5.41	74.1	4.68	4.58	47.88	3.44	78.39	43.9
Mergus	*merganser*	FW	93.94	6.21	5.95	79.08	5.58	5.42	57.18	3.76	93.85	43.29
Mergus	*serrator*	FW	75.58	4.81	4.95	63.09	4.3	4.16	43.98	2.98	80.23	36.11
Polysticta	*stelleri*	FW	72.97	5.15	5.12	65.86	4.53	4.27	47.7	3.71	78.43	39.4
Somateria	*fischeri*	FW	98.1	6.57	6.34	85.75	6.01	5.83	61.17	4.05	95.24	51.07
Somateria	*mollissima*	FW	107.06	7.59	7.53	95.01	6.46	6.43	65.36	4.56	97.33	53.05
Somateria	*spectabilis*	FW	100.41	6.92	6.79	87.92	6.12	5.93	62.06	4.37	95.01	51.08
Dendrocygna	*autumnalis*	NS	100.21	6.24	5.6	102.87	4.7	4.77	55.81	3.37	72.64	32.17
Aerodramus	*bartschi*	NS	6.68	1.96	1.1	11.09	1.04	1.1	11.7	1.17	13.49	5.79
Amazona	*ochrocephala*	NS	62.14	5.16	4.74	74.21	4.33	4.34	41.28	2.94	53.8	26.3
Anthus	*novaeseelandiae*	NS	20.79	1.95	1.65	26.3	1.49	1.48	13.82	1.3	17.06	10.46
Aphelocoma	*coerulescens*	NS	30.12	2.67	2.29	34.36	2.28	2.12	18.63	1.75	24.74	11.64
Aquila	*chrysaetos*	NS	192.97	13.65	12.13	219.17	10.54	10.62	107.23	6.47	117.11	63.17
Ardea	*alba*	NS	138.97	8.31	7.29	164.08	5.17	5.91	73.86	3.42	70.58	26.04
Aulacorhynchus	*prasinus*	NS	35.68	3.31	3.03	45.34	2.57	2.71	17.78	2.35	23.3	17.84
Auriparus	*flaviceps*	NS	13.05	1.1	0.95	15.64	0.91	0.98	8.35	0.91	10.68	6
Bombycilla	*cedrorum*	NS	19.98	2.01	1.85	25.29	1.74	1.63	14.52	1.38	19.52	11.44
Burhinus	*bistriatus*	NS	98.23	5.29	4.83	110.35	4.15	4.28	46.76	2.94	71.29	27.62
Calidris	*mauri*	NS	23.81	1.6	1.61	24.78	1.5	1.56	14.8	1.03	24.61	9.96
Callipepla	*californica*	NS	34.48	3.82	2.88	30.47	2.63	2.34	17.58	2.19	58.06	3.46
Cardinalis	*cardinalis*	NS	22.52	2.24	1.89	25.78	1.9	1.87	13.67	1.53	20.79	10.69
Cathartes	*aura*	NS	156.44	12.99	11.07	185.91	10.6	10.65	87.98	7.7	77.84	42.85
Catoptrophorus	*semipalmatus*	NS	64.55	4.42	3.99	70.18	3.6	3.88	39.26	2.42	56.72	22
Centrocercus	*urophasianus*	NS	81.24	8.1	6.25	84.59	4.9	4.85	44.56	3.58	113.14	12.14
Certhia	*americana*	NS	12.33	1.27	1.01	15.49	1.08	1.06	9.5	1.06	10.74	6.6
Charadrius	*vociferus*	NS	38.72	3.15	2.62	43.29	2.67	2.8	26.02	1.79	38.62	15.38
Chiroxiphia	*linearis*	NS	19.31	1.79	1.64	25.57	1.4	1.4	12.33	1.14	15.33	9.73
Chloephaga	*melanoptera*	NS	160.53	10.26	10.51	162.66	8.03	7.86	88.59	5.07	114.13	53.99
Chordeiles	*acutipennis*	NS	34.14	2.76	2.29	44.39	2.37	2.25	24.41	1.51	22.96	12.65
Coccothraustes	*vespertinus*	NS	23.51	2.37	2.03	28.56	2.05	1.89	17.64	1.82	24.71	12.57
Coccyzus	*americanus*	NS	29.87	2.7	2.52	28.54	2.2	2.12	15.49	1.34	21.65	12.92
Dendrocygna	*javanica*	NS	89.14	5.21	4.71	93.27	4.08	3.99	46.2	2.74	64.74	29.25
Dumetella	*carolinensis*	NS	21.96	1.97	1.67	25.33	1.63	1.58	14.13	1.3	19.43	11.04
Empidonax	*difficilis*	NS	15.03	1.46	1.21	20.5	1.16	1.13	10.49	0.92	13.25	8.15
Eremophila	*alpestris*	NS	22.23	2.05	1.78	27.22	1.75	1.6	15.01	1.43	20.31	10.02
Falco	*sparverius*	NS	44.04	3.82	3.38	49.42	3.09	2.92	28.33	2.16	22.45	15.07
Ficedula	*narcissina*	NS	17.57	1.62	1.44	21.45	1.38	1.32	12.36	1.25	16.54	9.07
Fregata	*minor*	NS	187.89	10.64	9.56	244.7	8.64	9.42	110.42	6.87	52.52	51.89
Galbula	*ruficauda*	NS	23.17	2.06	1.72	30.09	1.68	1.52	12.12	1.41	17.23	11.04
Gallinago	*gallinago*	NS	37.71	2.78	2.52	39.59	2.29	2.37	25.76	1.49	46.01	15.95
Glaucidium	*gnoma*	NS	33.43	2.41	2.3	38.8	1.88	1.82	17.75	1.26	21.13	13.29

Grus	*canadensis*	NS	188.54	12.69	10.82	210.95	8.2	8.48	94.8	5.76	121.71	33.96
Gygis	*alba*	NS	47.93	2.98	2.66	58.43	2.62	3.03	31.2	1.75	38.71	16.55
Haematopus	*palliatus*	NS	81.01	4.98	4.8	89.22	4.02	4.22	46.54	2.98	62.36	29.59
Himantopus	*mexicanus*	NS	54.04	3.39	3.04	59.78	3.03	3.12	33.36	2.16	45.36	17.99
Petrochelidon	*pyrrhonota*	NS	15.21	1.89	1.68	23.47	1.57	1.64	14.58	1.7	15.61	9.51
Histrionicus	*histrionicus*	NS	65.18	4.58	4.46	56.27	4.06	3.76	40.59	3.09	65.61	37.51
Jacana	*spinosa*	NS	39.96	3.01	2.7	44.85	2.54	2.58	24.44	1.76	37.54	12.37
Lanius	*ludovicianus*	NS	24.31	2.18	1.93	28.87	1.68	1.69	16.25	1.46	20.02	12.53
Larus	*californicus*	NS	112.59	5.89	4.94	128.47	4.5	5.26	62.81	3.05	59.22	31.66
Larus	*canus*	NS	92.63	5.21	4.46	103.82	4.17	4.77	54.86	2.94	55.07	26.81
Larus	*heermanni*	NS	103.46	5.59	4.74	117.06	4.52	4.82	60.93	2.89	56.87	29.77
Larus	*occidentalis*	NS	126.98	6.96	5.68	141.87	5.08	5.98	71.58	3.52	70.85	36.11
Laterallus	*jamaicensis*	NS	22.85	1.4	1.22	18.37	1.19	1.13	12.61	1.04	19.8	4.93
Lepidocolaptes	*affinis*	NS	23.08	2.26	2	28.26	1.85	1.92	15.96	1.59	19.38	9.19
Meleagris	*ocellata*	NS	113.83	12.21	9.53	117.42	8.79	7	61.65	5.04	169.78	8.95
Momotus	*mexicanus*	NS	35.14	2.95	2.71	41.94	2.39	2.22	17.71	1.77	21.74	15.97
Monarcha	*takatsukasae*	NS	14.56	1.3	1.09	17.6	1.06	1.07	9.49	0.91	10.66	7.05
Monasa	*morphoeus*	NS	35	2.74	2.36	43.2	2.32	1.98	17.84	1.63	22.1	14.02
Nothoprocta	*ornata*	NS	57.89	5.26	4.01	61.29	4.05	3.23	32.34	2.74	81.56	3.81
Numenius	*americanus*	NS	95.33	5.44	5.2	106.91	4.36	4.85	54.05	3.18	80.82	28.42
Oceanites	*gracilis*	NS	16.59	1.53	1.31	15.73	1.5	1.38	12.68	1.18	14.91	9.92
Oceanites	*oceanicus*	NS	22.34	1.95	1.8	19.99	1.91	1.71	15.53	1.55	18.66	12.12
Oreortyx	*pictus*	NS	38.74	3.77	2.95	37.02	3.05	2.47	22.09	2.2	63.3	4.9
Pagodroma	*nivea*	NS	67.32	3.64	3.48	63.02	3.31	3.3	33.92	2.31	37.73	23.3
Parus	*carolinensis*	NS	13.9	1.33	1.1	17.12	1.11	1.14	9.26	1.09	11.47	6.71
Passer	*domesticus*	NS	18.64	1.85	1.61	20.89	1.66	1.41	12.37	1.43	18.52	10.03
Phainopepla	*nitens*	NS	21.42	2.07	1.68	27.17	1.75	1.65	14.55	1.53	17.12	10.02
Phasianus	*colchicus*	NS	70.5	6.58	5.38	63.19	5.29	4.55	36.91	3.31	106.08	6.9
Phoeniconaias	*minor*	NS	161.37	8.88	8.48	174.26	6.04	6.14	77.59	4.07	94.65	40.2
Picoides	*pubescens*	NS	22.76	1.96	1.72	27.07	1.62	1.68	13.05	1.46	18.6	8.05
Piranga	*ludoviciana*	NS	21.12	2.07	1.78	26.45	1.75	1.62	14.74	1.46	19.92	10.69
Plegadis	*chihi*	NS	87.95	6.28	5.52	101.59	4.49	4.43	52.56	3.08	62.89	29.22
Pluvialis	*squatarola*	NS	54.72	4.94	4.48	100.53	3.93	4.02	44.57	2.8	66.6	25.82
Polioptila	*melanura*	NS	11.13	0.98	0.82	12.84	0.85	0.82	7.01	0.81	9.38	5.57
Porzana	*carolina*	NS	32.26	2.2	1.92	27.41	1.88	1.76	19.42	1.5	28.06	7.19
Psaltriparus	*minimus*	NS	10.27	0.91	0.78	11.61	0.74	0.81	6.64	0.81	8.86	5.73
Pterocnemia	*pennata*	NS	260.64	10.22	11.72	206.68	6.08	4.48	83.29	4.39	115.26	60.55
Pycnonotus	*jocosus*	NS	21.11	2.02	1.71	24	1.67	1.68	12.66	1.4	18.32	10.3
Regulus	*calendula*	NS	10.98	0.97	0.91	14.78	0.94	0.97	8.56	0.92	9.6	6.46
Rissa	*tridactyla*	NS	86.07	4.98	4.53	94.69	4.19	4.62	48.24	2.84	50.93	26.31
Sitta	*carolinensis*	NS	17.84	1.58	1.42	22.88	1.46	1.45	12.84	1.28	15.8	8.47
Stercorarius	*longicaudus*	NS	87.42	4.8	4.76	93.71	3.87	4.42	47.8	2.78	54.86	26.06
Stercorarius	*maccormicki*	NS	135.58	8.17	7.71	139.37	5.61	6.94	68.23	3.84	92.1	43.32
Stercorarius	*parasiticus*	NS	101.03	5.79	5.45	108.44	4.45	5.18	53.8	3.21	64.37	29.81
Stercorarius	*pomarinus*	NS	113.85	6.49	6.39	118.82	4.88	5.73	59.09	3.55	77.09	35.72

Sturnella	*neglecta*	NS	32.58	2.87	2.48	36.53	2.61	2.37	20.43	1.86	31.76	15.01
Sturnus	*vulgaris*	NS	27.06	2.6	2.22	31.99	2.3	2.14	20.26	1.91	27.15	12.77
Synallaxis	*albescens*	NS	16.88	1.4	1.15	17.29	1.13	1.08	9.97	1	13.63	7.74
Thamnophilus	*doliatus*	NS	20.32	1.8	1.53	22.07	1.42	1.46	10.77	1.27	15.71	10.49
Thryomanes	*bewickii*	NS	13.26	1.17	0.98	14.57	0.98	0.94	7.81	1.01	11.12	6.59
Tockus	*erythrorhynchus*	NS	45.58	3.95	3.65	64.2	3.99	3.75	25.69	3.61	30.14	15.98
Trogon	*elegans*	NS	31.6	3.23	2.85	35.55	2.32	2.11	18.13	1.83	21.93	16.71
Turnix	*suscitator*	NS	29.33	2.29	1.96	27.54	1.83	1.63	17.2	1.4	31.17	9.15
Tyto	*alba*	NS	100.23	6.34	5.81	113.96	4.5	4.63	52.48	2.87	44.71	30.25
Uraeginthus	*bengalus*	NS	13.33	1.17	0.99	14.94	0.99	0.93	8.06	1.04	12.12	6.72
Vermivora	*celata*	NS	12.8	1.19	1.01	15.96	0.94	1.01	8.94	0.91	11.29	6.31
Vireo	*gilvus*	NS	14.69	1.37	1.18	18.77	1.14	1.13	10.08	1.01	13.71	6.36
Zenaida	*macroura*	NS	32.25	3.61	2.97	36.7	2.75	2.61	23.27	2.02	46.15	15.18
Zonotrichia	*leucophrys*	NS	18.83	1.71	1.49	19.79	1.44	1.4	11.7	1.15	18.33	9.61
Anous	*stolidus*	PL	66.32	3.89	3.72	77.31	3.09	3.58	40.78	2.35	40.91	19.51
Ceryle	*alcyon*	PL	48.81	3.84	3.29	60.27	3.03	2.94	27.11	2.12	35.6	18.52
Cinclus	*mexicanus*	PL	22.68	2.15	1.85	26.96	1.84	1.8	17.45	1.6	22.9	11.98
Larus	*delawarensis*	PL	102.54	5.78	4.78	116.28	4.55	5.15	59.04	3.07	59.39	28.68
Larus	*glaucescens*	PL	135.12	7.56	6.31	149.51	5.72	6.68	76.47	3.78	75.95	39.21
Morus	*bassanus*	PL	189.82	9.84	9.83	196.92	8.27	8.46	93.14	5.77	120.42	46.67
Morus	*capensis*	PL	213.04	8.92	9.52	187.21	7.93	8.12	87.46	5.59	112.7	45.37
Pelecanus	*occidentalis*	PL	288.54	15.79	13.45	343.53	10.48	11.32	132.74	7.6	111.11	70.04
Phaethon	*aetherus*	PL	92.05	5.34	5	95.9	5.17	4.49	47.78	3.45	54.25	34.3
Phaethon	*lepturus*	PL	79.91	4.9	4.42	86.52	3.82	4.11	42	2.93	44.36	27.54
Phaethon	*rubricauda*	PL	101.23	6.26	5.8	110.45	5.24	5	51.55	3.58	66.51	33.95
Sterna	*dougallii*	PL	49.35	2.89	2.62	57.53	2.49	2.83	30.45	1.81	34.67	14.77
Sterna	*elegans*	PL	74.12	4.15	3.67	91.35	3.36	3.92	44.06	2.47	45.94	21.55
Sterna	*forsteri*	PL	55.54	3.26	2.89	65.26	2.85	3.12	34.87	2.02	36.53	17.55
Sterna	*fuscata*	PL	63.72	3.75	3.43	75.55	3.25	3.85	39.48	2.5	41.42	19.7
Sterna	*hirundo*	PL	55.4	3.3	2.98	64.19	3.02	3.41	33.42	2.06	35.05	17.75
Sterna	*maxima*	PL	94.39	5.03	4.71	117.45	4.34	4.95	56.19	3.2	58.76	26.97
Sterna	*paradisaea*	PL	49.39	3.14	2.73	58.06	2.77	3.09	30.67	1.96	32.12	16.66
Sula	*dactylatra*	PL	193	8.39	8.75	204.22	7.78	7.52	86.16	5.57	100.06	45.65
Sula	*leucogaster*	PL	160.84	7.5	7.56	175.97	6.54	6.33	73.97	4.71	72.08	39.04
Sula	*sula*	PL	162.3	6.95	7.59	181.23	6.41	6.34	73.54	4.44	68.36	38.45
Aix	*sponsa*	SS	71.64	5.37	4.97	58.72	4.07	4.11	45.91	3.19	69.81	29.92
Anas	*acuta*	SS	86	6.11	5.47	75.9	4.89	4.69	52.76	3.85	78.2	33.12
Anas	*americana*	SS	82.37	6.09	5.72	71.06	5.05	4.82	51.9	3.97	74.11	35.71
Anas	*clypeata*	SS	75.14	5.2	5.05	65.34	4.39	4.08	46.25	3.35	68.87	30.89
Anas	*crecca*	SS	59.44	4.44	4.11	52.15	3.52	3.37	37.43	2.96	60.76	25.04
Anas	*cyanoptera*	SS	66.69	4.69	4.59	56.72	3.72	3.82	40.75	3.05	63.77	25.78
Anas	*gibberifrons*	SS	70.78	4.91	4.74	62.21	4.13	4.04	43.5	3.12	66.72	27.59
Anas	*platyrhynchos*	SS	88.64	6.67	6.55	76.98	5.41	5.43	56.88	4.22	84.77	36.59
Anas	*strepera*	SS	86.61	6.5	5.94	75.05	5.41	5.18	53.78	3.93	81.03	34.78

Anser	*albifrons*	SS	153.01	10.19	9.26	146.9	7.62	7.44	86.22	5.19	112.86	49.85
Cairina	*scutulata*	SS	124.95	9.35	8.63	112.38	7.14	6.72	72.42	5.17	110.79	48.62
Branta	*bernicla*	SS	122.27	7.98	7.36	115.15	6.03	5.88	65.31	4.13	93.95	43.63
Branta	*canadensis*	SS	155.26	10.22	9.26	149.75	7.16	7.67	80.9	4.81	118.86	51.65
Chen	*caerulescens*	SS	152.2	10.03	9.29	151.37	7.24	7.13	85.19	4.99	109.61	49.15
Chen	*canagica*	SS	141.68	8.77	8.11	135.11	6.59	6.25	79.41	4.29	101.6	52.52
Chen	*rossii*	SS	127.64	8.81	8.36	126.1	6.7	6.62	71.99	4.45	88.89	43.26
Cygnus	*atratus*	SS	238.35	12.99	11.5	221.84	8.61	8.97	110.72	6.18	155.27	66.74
Cygnus	*columbianus*	SS	248.85	13.42	11.85	226.07	8.86	9.21	114.08	6.43	167.36	70.76
Malacorhynchus	*membranaceus*	SS	66.55	4.31	3.99	60.99	3.65	3.56	40.5	2.5	60.34	26.77
Nettapus	*coromandelianus*	SS	57.92	4.11	3.72	51.01	3.35	3.2	32.8	2.49	52.21	24.5
Oceanodroma	*furcata*	SS	35.64	2.3	1.99	34.38	2.21	2.08	20.71	1.58	25.33	13.78
Oceanodroma	*homochroa*	SS	31.44	1.89	1.82	30.92	1.97	1.87	17.78	1.44	20.13	11.37
Oceanodroma	*leucorhoa*	SS	34.89	1.94	2.07	34.86	2.06	1.92	18.8	1.45	20.74	11.84
Oceanodroma	*melania*	SS	41.57	2.31	2.32	41.85	2.51	2.34	23.27	1.82	23.84	13.97
Pelecanus	*erythrorhynchos*	SS	297.2	18.36	16.37	337.37	12.67	13.69	145.7	8.69	129.17	86.97
Pelecanus	*onacrotalus*	SS	343.33	20.79	17.64	397.83	14.03	15.23	159.78	9.74	147.62	98.82
Phalaropus	*fulicarius*	SS	34.97	2.27	2.01	36.01	2.01	2.13	20.87	1.24	33.04	13.54
Phalaropus	*lobatus*	SS	28.18	1.8	1.66	28.91	1.64	1.75	17.36	1.05	27.26	11.32
Phalaropus	*tricolor*	SS	34.53	2.18	1.98	36.22	1.9	2.07	21.39	1.38	32.46	12.72
Phoebastria	*nigripes*	SS	266.34	10.78	11.13	267.92	7.49	7.96	103.23	6.18	87.07	59.1
Pterodroma	*externa*	SS	100.65	4.72	4.74	103.42	4.65	4.51	51.08	3.54	48.41	27
Pterodroma	*hypoleuca*	SS	71.96	3.75	3.8	74.72	3.58	3.5	35.86	2.79	36.28	19.59
Pterodroma	*inexpectata*	SS	85.17	3.98	4.69	86.34	4.3	4.08	42.68	2.98	49.19	25.92
Tachyeres	*pteneres*	SS	127.35	9.41	8.94	97.85	7.66	7.39	66.68	5.4	121.74	65.03
Tadorna	*tadornoides*	SS	125.74	8.9	8.59	116.31	7.8	7.31	75.31	4.81	100.72	41.9
Aethia	*cristatella*	WP	53.1	3.09	3.33	45.08	3.51	2.64	29.65	2.08	74.06	19.48
Aethia	*pusilla*	WP	34.51	1.95	2.47	28.97	1.81	2.44	18.79	1.42	41.34	13.19
Alca	*torda*	WP	81.32	5.04	5.85	65.1	4.01	5.39	42.74	2.87	103.21	29.26
Alle	*alle*	WP	41	2.4	2.67	34.32	2.32	3.06	22.24	1.69	59.49	17.2
Aptenodytes	*forsteri*	WP	132.71	10.53	24.27	90.77	7.04	19.56	73.17	15.36	214.86	105.09
Aptenodytes	*patagonica*	WP	111.72	8.21	22.6	86.57	5.9	15.44	71.92	13.22	177.91	87.92
Brachyramphus	*brevirostris*	WP	50.38	3.06	3.91	40.93	2.71	3.35	27.49	2.29	74.46	20.21
Brachyramphus	*marmoratus*	WP	47.92	2.65	3.8	36.3	2.53	3.37	25.12	2.01	68.8	19.61
Cepphus	*grylle*	WP	60	3.74	4.09	51.62	3.42	3.75	33.71	2.2	86.98	26.95
Cerorhinca	*monocerata*	WP	67.24	3.74	5.12	54.9	3.64	4.8	36.04	2.74	90.46	28.27
Cyclorrhynchus	*psittacula*	WP	55.25	3.23	3.81	48.64	3.17	3.76	30.86	2.33	72.28	22.32
Eudyptes	*chrysocome*	WP	59.65	5.07	11.65	42.08	2.97	11.55	34.14	8.15	95.34	45.7
Eudyptes	*chrysolophus*	WP	72.99	6.08	15.62	55.74	6.66	11.54	46.4	11.23	125.41	59.38
Eudyptula	*minor*	WP	47.22	3.75	7.64	33.56	2.47	8.37	26.71	6.09	65.87	34.85
Fratercula	*arctica*	WP	65.49	3.22	4.46	51.86	3.15	4.33	33.98	2.64	83.15	24.02
Fratercula	*cirrhata*	WP	77.2	3.8	5.72	61.57	3.46	5.12	41.02	2.9	94.64	30.26
Fratercula	*corniculata*	WP	70.5	3.93	4.95	57.17	3.65	4.75	38.12	2.75	88.79	25.61
Pelecanoides	*urinatrix*	WP	43	2.35	2.89	33.87	2.31	2.77	24.99	1.77	33.75	16.98

Ptychoramphus	*aleuticus*	WP	45.66	2.43	3.33	39.56	2.39	3.35	25.21	2.03	58.99	18.83
Pygoscelis	*adeliae*	WP	71.04	5.42	15.08	45.74	3.88	11.4	37.85	9.08	124.93	66.48
Pygoscelis	*antarctica*	WP	73.22	6.19	15.6	48.6	3.85	13.47	42.5	10.26	126.63	60.73
Pygoscelis	*papua*	WP	80.29	6.56	17.06	54.06	4.14	14.39	45.75	10.43	144.46	69.81
Spheniscus	*demersus*	WP	62.4	4.68	10.79	45.15	3.67	12.59	37.52	8.63	84.73	44.02
Spheniscus	*humboldti*	WP	74.3	6.1	15.12	52.6	4.12	15.08	43.81	10.14	116.06	55.13
Spheniscus	*magellanicus*	WP	69.87	5.83	12.58	49.81	3.73	12.67	39.28	8.78	113.82	51.16
Spheniscus	*mendiculus*	WP	56.42	4.64	10.93	41.12	3.13	11.24	33.73	8.21	85	41.94
Synthliboramphus	*antiquus*	WP	50.87	2.73	3.93	39.05	2.64	3.47	28.01	2.07	68.7	20.42
Uria	*aalge*	WP	89.37	4.95	6.51	67.33	4.91	5.17	45.1	2.91	123.57	33.54
Uria	*lomvia*	WP	88.3	4.69	5.84	69.42	4.7	5.3	44.08	3.18	118.1	35.25