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Vertebral Morphometrics and Lung Structure in Non-Avian Dinosaurs

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Supplementary Methods

Supplementary Methods 1

Extant taxa used in this analysis

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Class** | **Order** | **Family** | **Genus** | **Species** |
| Reptilia | Crocodylia | Alligatoridae | *Alligator* | *mississipiensis* |
| Reptilia | Crocodylia | Alligatoridae | *Caiman* | *crocodilus* |
| Reptilia | Crocodylia | Crocodylidae | *Crocodylus* | *americanus* |
| Reptilia | Crocodylia | Gavialidae | *Gavialis* | *gangeticus* |
| Aves | Anseriformes | Anatidae | *Anser* | *anser* |
| Aves | Sphenisciformes | Spheniscidae | *Aptenodytes* | *patagonicus* |
| Aves | Apterygiformes | Apterygidae | *Apteryx* | *hastii* |
| Aves | Accipitriformes | Accipitridae | *Aquila* | *chrysaetos* |
| Aves | Pelecaniformes | Ardeidae | *Ardea* | *cinera* |
| Aves | Pelecaniformes | Balaenicipitidae | *Balaeniceps* | *rex* |
| Aves | Strigiformes | Strigidae | *Bubo* | *bubo* |
| Aves | Bucerotiformes | Bucerotidae | *Buceros* | *rhinoceros* |
| Aves | Bucerotiformes | Bucorvidae | *Bucorvus* | *abyssinicus* |
| Aves | Cacatuoidea | Cacatuidae | *Calyptorhynchus* | *baudini* |
| Aves | Cariamiformes | Cariamidae | *Cariama* | *cristata* |
| Aves | Cuculiformes | Cuculidae | *Centropus* | *sinenesis* |
| Aves | Anseriformes | Anhimidae | *Chauna* | *chavaria* |
| Aves | Ciconiiformes | Ciconiidae | *Ciconia* | *ciconia* |
| Aves | Anseriformes | Anatidae | *Coroscoba* | *coroscoba* |
| Aves | Procellariiformes | Diomedeidae | *Diomedea* | *epomophora* |
| Aves | Casuraiformes | Dromaidae | *Dromaius* | *novellhandiae* |
| Aves | Suliformes | Fregatidae | *Fregata* | *aquila* |
| Aves | Procellariiformes | Procellaridae | *Fulmarus* | *glacialis* |
| Aves | Charadriiformes | Haematopodidae | *Haematopus* | *ostralegus* |
| Aves | Otidiformes | Otididae | *Otis* | *tarda* |
| Aves | Accipitriformes | Accipitridae | *Pandion* | *haliaetus* |
| Aves | Podargiformes | Podargidae | *Podargus* | *strigoides* |
| Aves | Piciformes | Ramphastidae | *Ramphastos* | *tucanus* |
| Aves | Rheiformes | Rheidae | *Rhea* | *americana* |
| Aves | Accipitriformes | Sagittaridae | *Sagittarius* | *serpentarius* |
| Aves | Struthioniformes | Struthionidae | *Struthio* | *camelus* |
| Aves | Muscophagiformes | Musophagidae | *Tauraco* | *persa* |
| Aves | Charadriiformes | Laridae | *Thalasseus* | *sandvicensis* |

Supplementary Methods 2

Extinct taxa used in this analysis

|  |  |  |
| --- | --- | --- |
| **Group** | **Genus** | **References and Specimen ID** |
| Ornithischia | *Ankylosaurus* | (Carpenter, 2004) |
| Sauropoda | *Camarasaurus* | AMNH 5760, 5761, (Osborn and Mook, 1921) |
| Dinosauromorpha | *Silesaurus* | (Piechowski and Dzik, 2010) |
| Ornithischia | *Huayangosaurus* | (Maidment et al., 2006) |
| Ornithischia | *Iguanodon* | (Hooley, 1925; Norman, 1980) |
| Ornithischia | *Kritosaurus* | (Lull and Wright, 1942) |
| Ornithischia | *Dryosaurus* | CM 3392, (Galton, 1981) |
| Sauropoda | *Apatosaurus* | (Gilmore, 1936) |
| Sauropoda | *Diplodocus* | (Hatcher, 1901) |
| Ornithischia | *Stegosaurus* | (Maidment et al., 2015) |
| Ornithischia | *Styracosaurus* | (Holmes et al., 2005) |
| Theropoda | *Allosaurus* | (Madsen Jr, 1976) |
| Theropoda | *Deinonychus* | YPM 5210, (Ostrom, 1969) |
| Theropoda | *Sinraptor* | (Currie and Zhao, 1993) |
| Theropoda | *Tyrannosaurus* | (Brochu, 2003) |
| Ornithischia | *Triceratops* | (Ostrom and Wellnhofer, 1986) |

Supplementary Methods 3

Landmark definitions used in the geometric morphometric analysis.

|  |  |
| --- | --- |
| Landmark | Description |
| 1 | Midline dorsal margin of the centrum |
| 2 | Lateral-most point of the centrum |
| 3 | Midline ventral margin of the centrum |
| 4 | Midline ventral margin of the neural arch |
| 5 | Midline dorsal margin of the neural arch |
| 6 | Dorsal margin of the neural spine |
| 7 | Ventromedial margin of the prezygapohyseal articular facet |
| 8 | Dorsolateral margin of the prezygapohyseal articular facet |
| 9 | Lateral contact between the neural arch and prezygapophyseal body |
| 10 | Dorsomedial edge of the diapophysis/dorsolateral edge of lumbar transverse process |
| 11 | Ventromedial edge of the parapophysis/ventrolateral edge of lumbar transverse process |

**Supplementary References**

Brochu, C.A., 2003. Osteology of Tyrannosaurus rex: insights from a nearly complete skeleton and high-resolution computed tomographic analysis of the skull. J. Vertebr. Paleontol. 22, 1–138.

Carpenter, K., 2004. Redescription of *Ankylosaurus magniventris* Brown 1908 (Ankylosauridae) from the Upper Cretaceous of the Western Interior of North America. Can. J. Earth Sci. 41, 961–986. https://doi.org/10.1139/e04-043

Currie, P.J., Zhao, X.-J., 1993. A new carnosaur (Dinosauria, Theropoda) from the Jurassic of Xinjiang, People’s Republic of China. Can. J. Earth Sci. 30, 2037–2081.

Galton, P.M., 1981. Dryosaurus, a hypsilophodontid dinosaur from the upper jurassic of north America and Africa postcranial skeleton. Paläontol. Z. 55, 271–312.

Gilmore, C.W., 1936. Osteology of Apatosaurus, with Species Reference to Specimens in the Carnegie Museum. Carnegie Institute.

Hatcher, J., 1901. Diplodocus (Marsh): its osteology, taxonomy, and probable habits, with a restoration of the skeleton. Mem. Carnegie Mus. 1, 1–64.

Holmes, R.B., Ryan, M.J., Murray, A.M., 2005. Photographic atlas of the postcranial skeleton of the type specimen of Styracosaurus albertensis with additional isolated cranial elements from Alberta = Atlas photographque du squelette postcrânien du spécimen-type de Styracosaurus albertensis avec elements crâniens isolés additionnels de l’Alberta. Canadian Museum of Nature = Musée canadien de la nature, Ottawa.

Hooley, R.W., 1925. On the skeleton of Iguanodon atherfieldensis sp. nov., from the Wealden Shales of Atherfield (Isle of Wight). Q. J. Geol. Soc. 81, 1–61.

Lull, R.S., Wright, N.E., 1942. Hadrosaurian dinosaurs of North America. Geol. Soc. Am. Spec. Pap. 40, 1–272.

Madsen Jr, J.H., 1976. Allosaurus fragilis: a revised osteology.

Maidment, S.C., Wei, G., Norman, D.B., 2006. Re-description of the postcranial skeleton of the Middle Jurassic stegosaur Huayangosaurus taibaii. J. Vertebr. Paleontol. 26, 944–956.

Maidment, S.C.R., Brassey, C., Barrett, P.M., 2015. The Postcranial Skeleton of an Exceptionally Complete Individual of the Plated Dinosaur Stegosaurus stenops (Dinosauria: Thyreophora) from the Upper Jurassic Morrison Formation of Wyoming, U.S.A. PLOS ONE 10, e0138352. https://doi.org/10.1371/journal.pone.0138352

Norman, D.B., 1980. On the ornithischian dinosaur Iguanodon bernissartensis from the Lower Cretaceous of Bernissart (Belgium). Imprimerie Hayez.

Osborn, H.F., Mook, C.C., 1921. Camarsaurus, Amphicoelias and other sauropods of Cope. Mem. Am. Mus. Nat. Hist. 3, 247–440.

Ostrom, J.H., 1969. Osteology of Deinonychus antirrhopus, an unusual theropod from the Lower Cretaceous of Montana. Peabody Museum of Natural History, Yale University.

Ostrom, J.H., Wellnhofer, P., 1986. The Munich specimen of Triceratops with a revision of the genus. Zitteliana.

Piechowski, R., Dzik, J., 2010. The axial skeleton of Silesaurus opolensis. J. Vertebr. Paleontol. 30, 1127–1141.