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New basal hadrosauroid (Dinosauria: Ornithopoda) from the Lower Cretaceous Kitadani Formation, Fukui, central Japan

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Abstract

A new basal hadrosauroid, *Koshisaurus katsuyama,* from the Lower Cretaceous Kitadani Formation in Fukui, central Japan, is reported. The new taxon is distinguished by an autapomorphy and a unique combination of maxillary, vertebral, pubic and femoral characters. A phylogenetic analysis indicates that *Koshisaurus* is positioned as a basal member of Hadrosauroidea and is more derived than the contemporaneous *Fukuisaurus*, which is a non-hadrosauroid hadrosauriform. The presence of the antorbital fossa on the maxilla and at least three subsidiary ridges on the labial side of maxillary tooth crown implies that *Koshisaurus* was among the most basal hadrosauroids. This discovery indicates a higher diversity of hadrosauroids along the eastern margin of the Asian continent in the Early Cretaceous.

Key words: Early Cretaceous, Hadrosauroidea, Kitadani Formation, Tetori group, Japan

Introduction

Recent discoveries and descriptions of styracosternan iguanodonts indicate the great diversity of this group throughout the Early Cretaceous (You & Li 2009; McDonald *et al*. 2010a, b; Wu *et al.* 2010; You *et al*. 2011; McDonald *et al*. 2012; Wu & Godefroit 2012). In Asia, the fossil record of this group is extensive. However, discoveries in Asia are largely restricted to dinosaur-rich formations in China and Mongolia. Until recently, *Fukuisaurus tetoriensis* from the Lower Cretaceous (Barremian–lower Aptian) Kitadani Formation of Japan was the only named Asian styracosternan recognized from outside of this region (Kobayashi & Azuma 2003). The recent reports of two species of styracosternans in Thailand extended their diversity and distribution into Southeast Asia in the late Early Cretaceous (Buffetaut & Suteethorn 2011; Shibata *et al*. 2011). In Japan, styracosernan iguanodont discoveries in addition to *Fukuisaurus* include a maxillary tooth from the Tatsukawa Formation (Hauterivian) in Tokushima, several well-preserved teeth from the Kuwajima Formation (Barremian) in Ishikawa (Morozumi *et al*. 1995; Manabe & Barrett 2000), and shed teeth from the "Lower Formation" (lower Albian) of the Sasayama Group in Hyogo (Saegusa & Ikeda 2014).

The Kitadani Formation, the uppermost unit of the Tetori Group, is the most productive dinosaur-bearing unit in Japan, having yielded *Fukuiraptor kitadaniensis, Fukuisaurus tetoriensis* and *Fukuititan nipponensis* (Azuma & Currie 2000; Kobayashi & Azuma 2003; Azuma & Shibata 2010). Additionally, ornithopod dentaries, which do not pertain to *Fukuisaurus*, have also been reported (Shibata & Azuma 2011). All of these dinosaurian specimens were found in one locality, the Kitadani Quarry in Katsuyama City (Fig. 1). At least four bonebeds are recognized at this locality (Fig. 2A); the definition of "bonebed" in this study follows Behrensmeyer (2007). The lowermost one, the Bonebed I (BB I), has yielded *Fukuiraptor*, *Fukuisaurus*, other dinosaur bones and teeth, and other vertebrates including crocodilians, turtles and fishes (Shibata & Goto 2008). Most of the BB I vertebrate assemblage consists of disarticulated or associated skeletons of dinosaurs and other vertebrates. Other horizons (BB II and III), which are approximately 10 m above BB I, yielded *Fukuititan* elements and a well-preserved small theropod skeleton (Shibata & Goto 2008), respectively. The iguanodontian bones described in this paper came from the fourth bone

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In all consensus trees the two Fukui taxa are not particularly closely related. In the Adams consensus tree, for example, *Koshisaurus* is positioned at the base of Hadrosauroidea. In contrast, the other Fukui iguanodontian, *Fukuisaurus,* falls out as a basal hadrosauriform and closely related to *Proa*, *Iguanodon* and *Ouranosaurus*. Consequently, our analysis corroborates that *Koshisaurus* and *Fukuisaurus* are phylogenetically distinct; *Koshisaurus* is more derived than *Fukuisaurus.* Coexistence of at least two taxa of styracosternans occurred repeatedly during the Early Cretaceous. Examples include *Barilium* and *Hypselospinus* in the Wadhurst Clay Formation of England, *Cedrorestes, Iguanocolossus* and *Hippodraco* in the Cedar Mountain Formation of Utah, *Iguanodon* and *Mantellisaurus* in the Wessex Formation of England and Sainte-Barbe Clays Formation of Belgium, *Bolong* and *Jinzhousaurus* in the Yixian Formation of China, and *Lurdusaurus* and *Ouranosaurus* in the El Rhaz Formation of Niger (Taquet 1976; Norman 1980, 1986; Taquet & Russell 1999; Wang & Xu 2001;You and Ji *et al.* 2003; McDonald *et al*. 2010b; Wu & Godefroit 2012).

Koshisaurus was one of the most primitive forms of Hadrosauroidea because it possesses an antorbital fossa and three subsidiary ridges on the maxillary teeth, similar to *Equijubus* (You *et al.* 2003). The subsidiary ridges of the maxillary teeth are also present in *Xuwulong, Jinzhousaurus* and *Altirhinus* among basal hadrosauroids, but these taxa lack the antorbital fossa on the maxilla (Norman 1998; You *et al.* 2003; Barrett *et al.* 2009).

Conclusions

A new hadrosauroid, *Koshisaurus katsuyama* from the Early Cretaceous Kitadani Formation, is a distinct new genus and species and distinguishable from the contemporaneous hadrosauriform *Fukuisaurus tetoriensis*. Due to its possession of an antorbital fossa and at least three subsidiary ridges on the crown of the maxillary teeth, *Koshisarus* is found to be one of the most primitive hadrosauroids in our phylogenetic analysis. The occurrence of numerous basal hadrosauroids in Asia suggests a diversification of this group in Asia during the Early Cretaceous period.

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References

Azuma, Y. & Currie, P.J. (2000) A new carnosaur (Dinosauria: Theropoda) from the Lower Cretaceous of Japan. *Canadian Journal of Earth Sciences*, 37, 1735–1753. http://dx.doi.org/10.1139/e00-064

Azuma, Y. & Shibata, M. (2010) *Fukuititan nipponensis,* a new titanosauriform sauropod from the Early Cretaceous Tetori Group of Fukui Prefecture, Japan. *Acta Geologica Sinica-English Edition*, 84, 454–462.

Barrett, P.M., Butler, R.J., Wang, X. & Xu, X. (2009) Cranial anatomy of the iguanodontoid ornithopod *Jinzhousaurus yangi* from the Lower Cretaceous Yixian Formation of China. *Acta Palaeontologica Polonica*, 54, 35–48. http://dx.doi.org/10.4202/app.2009.0105

Behrensmeyer, A.K. (2007) Bonebeds through time. *In*: Rogers, R., Eberth, D. & Fiorillo, A. (Eds.), *Bonebeds: Genesis, Analysis, and Paleobiological Significance*. The University of Chicago Press, Chicago and London, pp. 65–102. http://dx.doi.org/10.7208/chicago/9780226723730.003.0002

Buffetaut, E. & Suteethorn, V. (2011) A new iguanodontian dinosaur from the Khok Kruat Formation (Early Cretaceous,

Aptian) of northeastern Thailand. *Annales de Paléontologie*, 97, 51–62.
http://dx.doi.org/10.1016/j.annpal.2011.08.001

Carpenter, K. & Wilson, Y. (2008) A new species of Camptosaurus (Ornithopoda: Dinosauria) from the Morrison Formation (Upper Jurassic) of Dinosaur National Monument, Utah, and a biomechanical analysis of its forelimb. *Annals of Carnegie Museum*, 76, 227–263.
http://dx.doi.org/10.2992/0097-4463(2008)76[227:ANSOCO]2.0.CO;2

Canudo, J.I., Barco, J.L., Pereda-Suberbiola, X., Ruiz-Omeñaca, J.I., Salgado, L., Fernández-Baldor, F.T. & Gasulla, J.M. (2009) What Iberian dinosaurs reveal about the bridge said to exist between Gondwana and Laurasia in the Early Cretaceous. *Bulletin de la Société géologique de France*, 180 (1), 5–11.
http://dx.doi.org/10.2113/gssgfbull.180.1.5

Cope, E.D. (1870) Synopsis of the extinct Batrachia and Reptilia of North America, 14, 1–252.

Dollo, L. (1888) Iguanodontidae et Camptonotidae. *Comptes Rendus de Academie des Sciences, Paris*, 106, 775–777.

Francillon-Vieillot, H., Buffrénil, V. De, Castanet, J., Géraudie, J., Meunier, F., Sire, J., Zylberberg, L. & Ricqlès, A. de (1990) Microstructure and mineralization of vertebrate skeletal tissues. *In*: Carter, J.G. (Ed.), *Skeletal biomineralization: patterns, processes and evolutionary trends.* an Nostrand Reinhold, New York, pp. 471–530.

Gilmore, C.W. (1909) Osteology of the Jurassic reptile *Camptosaurus*, with a revision of the species of the genus, and descriptions of two new species. *Proceedings of the United States National Museum*, 36, 197–332.
http://dx.doi.org/10.5479/si.00963801.36-1666.197

Gilpin, D., DiCroce, T. & Carpenter, K. (2007) A possible new basal hadrosaur from the Lower Cretaceous Cedar Mountain Formation of Eastern Utah. *In:* Carpenter, K. (Ed.), *Horns and Beaks: Ceratopsian and Ornithopod Dinosaurs*. Bloomington and Indianapolis, Indiana University Press, pp. 79–89.

Godefroit, P., Li, H. & Shang, C. (2005) A new primitive hadrosauroid dinosaur from the Early Cretaceous of Inner Mongolia (PR China). *Comptes Rendus Palevol*, 4, 697–705.
http://dx.doi.org/10.1016/j.crpv.2005.07.004

Goloboff, P.A., Farris, J.S. & Nixon, K.C. (2008) TNT, a free program for phylogenetic analysis. *Cladistics*, 24, 774–786.
http://dx.doi.org/10.1111/j.1096-0031.2008.00217.x

Hai, X., Wang, D., Han, F., Sullivan, C., Ma, Q., He, Y., Hone, D.W.E., Yan, R., Du, F. & Xu, X. (2014) A New Basal Hadrosauroid Dinosaur (Dinosauria: Ornithopoda) with Transitional Features from the Late Cretaceous of Henan Province, China. *PLoS ONE*, 9 (6), e98821.
http://dx.doi.org/10.1371/journal.pone.0098821

Horner, J.R. & Currie, P.J. (1994) Embryonic and neonatal morphology and ontogeny of a new species of *Hypacrosaurus* (Ornithischia, Lambeosauridae) from Montana and Alberta. *In*: Carpenter, K. & Horner, J.H. (Eds.), *Dinosaur Eggs and Babies*. Cambridge University Press, Cambridge, pp. 313–336.

Horner, J.R., Ricqlès, A. de, Padian, K. & Scheetz, R.D. (2009) Comparative long bone histology and growth of the "hypsilophodontid" dinosaurs *Orodromeus makelai*, *Dryosaurus altus*, and *Tenontosaurus tillettii* (Ornithischia: Euornithopoda). *Journal of Vertebrate Paleontology*, 29, 734–747.
http://dx.doi.org/10.1671/039.029.0312

Isaji, S. (1993) *Nippononaia ryosekiana* (Bivalvia, Mollusca) from the Tetori Group in Central Japan. *Bulletin of the National Science Museum, Series C*, 19, 65–71.

Kobayashi, Y. & Azuma, Y. (2003) A new iguanodontian (Dinosauria: Ornithopoda) from the Lower Cretaceous Kitadani Formation of Fukui Prefecture, Japan. *Journal of Vertebrate Paleontology*, 23, 39–45.
http://dx.doi.org/10.1671/0272-4634(2003)23[166:ANIDOF]2.0.CO;2

Kubota, K. (2005) *Charophyte gyrogonites* from the Lower Cretaceous Kitadani Formation of the Tetori Group in the Takinamigawa area, Katsuyama City, Fukui Prefecture, central Japan. *Paleontological Research*, 9, 203–213.
http://dx.doi.org/10.2517/prpsj.9.203

Manabe, M. & Barrett, P. (2000) Dinosaurs. *In*: Matsuoka, H. (Ed.), Fossils of the Kuwajima "Kaseki-kabe" (Fossil-bluff). *Scientific report on a Neocomian (Early Cretaceous) fossil assemblage from the Kuwajima Formation, Tetori Group, Shiramine, Ishikawa, Japan.* Shiramine Village Board of Education, Ishikawa Prefecture, Japan, pp. 93–98.

Marsh, O. (1881) Classification of the Dinosauria. *American Journal of Science series,* 3, 81–86.

McDonald, A.T. (2012) Phylogeny of Basal Iguanodonts (Dinosauria: Ornithischia): An Update. *PLoS ONE*, 7 (5), e36745.
http://dx.doi.org/10.1371/journal.pone.0036745

McDonald, A.T., Barrett, P.M. & Chapman, S.D. (2010a) A new basal iguanodont (Dinosauria: Ornithischia) from the Wealden (Lower Cretaceous) of England. *Zootaxa*, 2569, 1–43.

McDonald, A.T., Kirkland, J.I., DeBlieux, D.D., Madsen, S.K., Cavin, J., Milner, A.R. C. & Panzarin, L. (2010b) New Basal Iguanodonts from the Cedar Mountain Formation of Utah and the Evolution of Thumb-Spiked Dinosaurs. *PLoS ONE*, 5 (11), 1–35.
http://dx.doi.org/10.1371/journal.pone.0014075

McDonald, A.T., Espilez, E., Mampel, L., Kirkland, J.I. & Alcalá, L. (2012) An unusual new basal iguanodont (Dinosauria: Ornithopoda) from the Lower Cretaceous of Teruel, Spain. *Zootaxa*, 3595, 61–76.

Morozumi, Y., Kamei, T., Tashiro, M., Kikuchi, N., Ishida, K., Azuma, Y., Hashimoto, H. & Nakao, K. (1995) A dinosaur tooth from the Lower Cretaceous Tatsukawa Formation in Tokushima Prefecture, Japan. *Bulletin of the Tokushima Prefectural*

Museum, 5, 1–9.
Norman, D.B. (1980) On the ornithischian dinosaur *Iguanodon bernissartensis* of Bernissart (Belgium). *Mémoires de l'Institut Royal des Sciences Naturelles de Belgique*, 178, 1–103.
Norman, D.B. (1986) On the anatomy of *Iguanodon atherfieldensis* (Ornithischia: Ornithopoda). *Bulletin de l'Institut Royal des Sciences Naturelles de Belgique, Sciences de la Terre*, 56, 281–372.
Norman, D.B. (1998) On Asian ornithopods (Dinosauria: Ornithischia). 3. A new species of iguanodontid dinosaur. *Zoological Journal of the Linnean Society*, 122, 291–348.
http://dx.doi.org/10.1111/j.1096-3642.1998.tb02533.x
Norman, D.B. (2002) On Asian ornithopods (Dinosauria: Ornithischia). 4. *Probactrosaurus* Rozhdestvensky, 1966. *Zoological Journal of the Linnean Society*, 136, 113–144.
http://dx.doi.org/10.1046/j.1096-3642.2002.00027.x
Norman, D.B. (2004) Basal Iguanodontia; *In*: Weishampel, D.B., Dodson, P.B. & Osmolska, H. (Eds.), *The Dinosauria (Second Edition)*. University of California Press, Berkley, pp. 413–437.
Norman, D.B. (2013) On the taxonomy and diversity of Wealden iguanodontian dinosaurs (Ornithischia: Ornithopoda). *Revue de Paléobiologie, Genève*, 32 (2), 385–404.
Norman, D.B. & Weishampel, D.B. (1990) Iguanodontidae and related ornithopods: *In*: Weishampel, D.B., Dodson, P.B. & Osmolska, H. (Eds.), *The Dinosauria.* University of California Press, Berkeley, pp. 510–533.
Owen, R. (1842) Report on British fossil reptiles, part II. *Report of the Eleventh Meeting of the British Association for the Advancement of Science*, Plymouth, London, pp. 66–204.
Paul, G.S. (2008) A revised taxonomy of the iguanodont dinosaur genera and species. *Cretaceous Research*, 29, 192–216.
http://dx.doi.org/10.1016/j.cretres.2007.04.009
Prieto-Márquez, A. (2011) Cranial and appendicular ontogeny of *Bactrosaurus johnsoni*, a hadrosauroid dinosaur from the Late Cretaceous of northern China. *Palaeontology*, 54, 773–792.
http://dx.doi.org/10.1111/j.1475-4983.2011.01053.x
Saegusa, H. & Ikeda, T. (2014) A new titanosauriform sauropod (Dinosauria: Saurischia) from the Lower Cretaceous of Hyogo, Japan. *Zootaxa,* 3848 (1), 1–66.
http://dx.doi.org/10.11646/zootaxa.3848.1.1
Seeley, H.G. (1887) On the classification of the fossil animals commonly named Dinosauria. *Proceedings of the Royal Society of London*, 43, 165–171.
http://dx.doi.org/10.1098/rspl.1887.0117
Sereno, P.C. (1986) Phylogeny of the bird-hipped dinosaurs (Order Ornithischia). *National Geographic Research*, 2, 234–256.
Sereno, P.C. (1997) The origin and evolution of dinosaurs. *Annual Review of Earth and Planetary Sciences*, 25, 435–256.
http://dx.doi.org/10.1146/annurev.earth.25.1.435
Sereno, P.C. (1998) A rationale for phylogenetic definitions, with application to the higher-level taxonomy of Dinosauria. *Neues Jahrbuch für Geologie und Paläontologie, Abhandlungen,* 210, 41–83.
Sereno, P.C. (2005) *Stem Archosauria version 1.0*. TaxonSearch. Available from: http://www.taxonsearch.org/Archive/stem-archosauria-1.0.php (accessed 25 October 2013)
Shibata, M. & Goto, M. (2008) Report of the 3rd Dinosaur Excavation Project in Katsuyama, Fukui, 2007. *Memoir of the Fukui Prefectural Dinosaur Museum*, 7, 109–116.
Shibata, M. & Azuma, Y. (2011) Iguanodontian dentaries from the Lower Cretaceous Kitadani Formation, Fukui, Central Japan. *International Hadrosaur Symposium, Abstract Volume*, Royal Tyrell Museum of Palaeontology, Drumheller, pp. 1–131.
Shibata, M., Jintasakul, P. & Azuma, Y. (2011) A new iguanodontian dinosaur from the Lower Cretaceous Khok Kruat Formation, Nakhon Ratchasima in northeastern Thailand. *Acta Geologica Sinica, English Edition*, 85, 969–976.
http://dx.doi.org/10.1111/j.1755-6724.2011.00530.x
Swofford, D.L. (2005) PAUP* Phylogenetic Analysis Using Parsimony (*and Other Methods). Version 4.0 beta 10. Sinauer Associates, Sunderland, MA, USA.
Sues, H. & Norman. D.B. (1990) Hypsilophodontidae, *Tenontosaurus*, Dryosauridae. *The Dinosauria,* pp. 498–509.
Taquet, P. (1976) Ostéologie d'*Ouranosaurus nigeriensis,* Iguanodontide du Crétacé Inférieur du Niger. *Géologie et Paléontologie du gisement de Gadoufaoua (Aptien du Niger)*, Chapitre III, pp. 57–168.
Taquet, P. & Russell, D.A. (1999) Un iguanodontidé massif de Gadoufaoua, Crétacé inférieur du Niger. *Annales de paleontologie*, 85 (1), 85–96.
http://dx.doi.org/10.1016/S0753-3969(99)80009-3
Wang, X. & Xu, X. (2001) A new iguanodontid (*Jinzhousaurus yangi* gen. et. sp. nov.) from the Yixian Formation of Western Liaoning, China. *Chinese Science Bulletin*, 46, 1669–1672.
http://dx.doi.org/10.1007/BF02900633
Weishampel, D.B., Csiki, Z., Benton, M.J., Grigorescu, D. & Codrea, V. (2010) Palaeobiogeographic relationships of the Haţeg biota—Between isolation and innovation. *Palaeogeography, Palaeoclimatology, Palaeoecology,* 293 (3), 419–437.
http://dx.doi.org/10.1016/j.palaeo.2010.03.024
Wu, W. & Godefroit, P. (2012) Anatomy and relationships of *Bolong yixianensis*, an Early Cretaceous iguanodontoid Dinosaur from Western Liaoning, China. *In*: Godefroit, P. (Ed.), *Bernissart Dinosaurs and Early Cretaceous Terrestrial Ecosystems*,

Indiana University Press, Bloomington, pp. 293–333.
Wu, W., Godefroit, P. & Hu, D. (2010) *Bolong yixianensis* gen. et sp. nov.: A new iguanodontoid dinosaur from the Yixian Formation of Western Liaoning, China. *Geology and Resources*, 19, 127–133.
Xing, H., Wang, D., Han, F., Sullivan, C. & Ma, Q. (2014) A new basal hadrosauroid dinosaur (Dinosauria: Ornithopoda) with transitional features from the Late Cretaceous of Henan Province, China. *PLoS ONE,* 9 (6), e98821. http://dx.doi.org/10.1371/journal.pone.0098821
You, H. & Li, D. (2009) A new basal hadrosauriform dinosaur (Ornithischia: Iguanodontia) from the Early Cretaceous of northwestern China. *Canadian Journal of Earth Sciences,* 46, 949–957. http://dx.doi.org/10.1139/E09-067
You, H. & Luo, Z. (2008) Dinosaurs from the Lower Cretaceous Gongpoquan Basin in Jiuquan Area, Gansu Province, China. *Acta Geologica Sinica*, 82, 139–144.
You, H., Ji, Q. & Li, D. (2005) *Lanzhousaurus magnidens* gen. et sp. nov. from Gansu Province, China: the largest-toothed herbivorous dinosaur in the world. *Geological Bulletin of China*, 24 (9), 1–27.
You, H., Li, D. & Liu, W. (2011) A new hadrosauriform dinosaur from the Early Cretaceous of Gansu Province, China. *Acta Geologica Sinica*, *English Edition*, 85, 51–57. http://dx.doi.org/10.1111/j.1755-6724.2011.00377.x
You, H., Luo, Z., Shubin, N.H., Witmer, L.M., Tang, Z. & Tang, F. (2003) The earliest-known duck-billed dinosaur from deposits of late Early Cretaceous age in northwest China and hadrosaur evolution. *Cretaceous Research*, 24, 347–355. http://dx.doi.org/10.1016/S0195-6671(03)00048-X
Zheng, W., Jin, X., Shibata, M. & Azuma, Y. (2014) An early juvenile specimen of *Bolong yixianensis* (Ornithopoda: Iguanodontia) from the Lower Cretaceous of Ningcheng County, Nei Mongol, China. *Historical Biology*, 26 (2), 236–251. http://dx.doi.org/10.1080/08912963.2013.809347