Bull. Natn. Sci. Mus., Tokyo, Ser. C, 17 (1), pp. 1–9, March 22, 1991

A Diplodocid Dinosaur from the Early Cretaceous Miyako Group of Japan

By

Yoshikazu HASEGAWA[1], Makoto MANABE[2], Tetsuro HANAI[3], Tomoki KASE[4] and Tatsuo OJI[5]

[1]Geological Institute, Faculty of Education, Yokohama National University, Yokohama
[2]Division of Vertebrate Paleontology, Yale University Peabody Museum, New Haven, CT 06511 USA (address in correspondence: Department of Geology, University of Bristol, Bristol, United Kingdom)
[3]Osakagakuin University, Osaka
[4]Department of Geology, National Science Museum, Tokyo
[5]Geological Institute, Faculty of Science, University of Tokyo, Tokyo

Abstract A sauropod humerus from the Late Aptian section of the Miyako Group (Early Cretaceous), northeastern Honshu, represents the first indisputable dinosaur ever found in the Japanese Islands. The specimen is tentatively referred to the Diplodocidae (?*Mamenchisaurus* sp.), and its occurrence suggests that at least one group of sauropods other than the Inner Mongolian *Mongolosaurus haplodon* (GILMORE, 1933) inhabited the Early Cretaceous of East Asian terranes.

Introduction

The professional and amateur paleontologists of Japan have dreamed of discovering a dinosaur from Japan ever since the publication of the first report of *Nipponosaurus sachalinensis* from Sakhalin—a Japanese territory at the time— (NAGAO, 1936). In 1962, another discovery on Taka-shima island off Kyushu was made. Identified as an edmontosaurid the specimen was mentioned at a meeting of the Palaeontological Society of Japan (TAKAI, 1962). However its validity is yet to be confirmed. The first indisputable dinosaur, described here, was discovered unexpectedly in the marine stratum of northeastern Honshu, the largest island of the Japanese Islands.

Tetsuro HANAI of the University of Tokyo and Tomoki KASE of the National Science Museum, Tokyo were in Moshi, Iwaizumi-cho, Shimohei-gun, Iwate Prefecture (141°58′53″E, 39°50′01″N, Fig. 1), in the summer of 1978 for a field survey of the Early Cretaceous Miyako Group. They found a reptilian bone on the weathered surface of a conglomerate outcrop (approximately 3 m above the foot of the outcrop) just outside an inn where they were staying (Fig. 2). While uncertain about detailed nature of what they had discovered, they decided to have it investigated further.

The specimen was excavated carefully by KASE and forwarded to HASEGAWA of Yokohama National University. HASEGAWA identified the specimen as a dinosaur

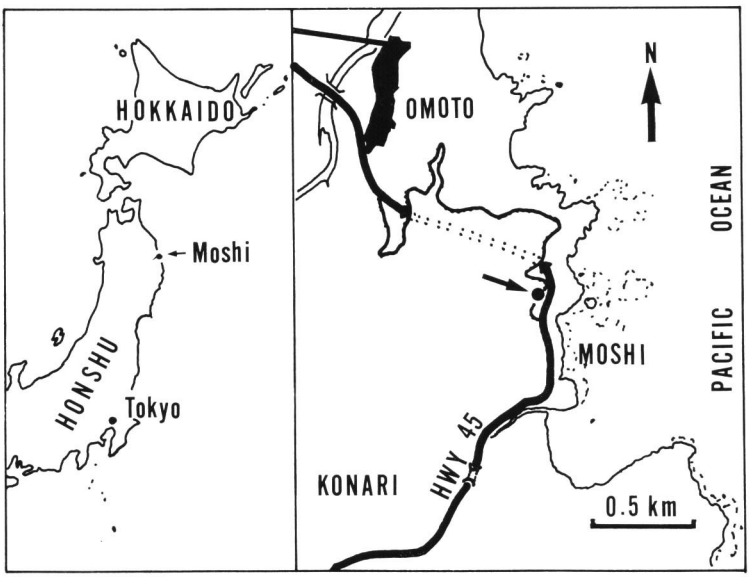

Figure 1. Map showing the locality of NSM PV17656.

limb bone, but was not prepared to identify it much further. After comparing it with specimens available from the USSR and China, he concluded that it was a sauropod humerus, most likely that of *Mamenchisaurus*, a genus previously described from the Upper Jurassic of Szechuan, China (HASEGAWA *et al.*, 1982). This study includes both a description of the specimen (NSM PV17656) and a discussion of the validity of its earlier identification.

HASEGAWA and MANABE will take the responsibility of the taxonomic assignment of the specimen and the paleontological remarks, and HANAI, KASE and OJI will bear the responsibility of descriptions on stratigraphy and occurrence of the specimen.

Abbreviation

NSM PV: Section of Vertebrate Paleontology, Department of Geology, National Science Museum, Tokyo 169, Japan.

Acknowledgments

The first and second authors are grateful to the following individuals: Z. DONG of Institute of Vertebrate Paleontology and Paleoanthropology, Academia Sinica, W. HUANG of Tianjin Natural History Museum, J. JENSEN of Brigham Young University, A. CHARIG of British Museum of Natural History, J. OSTROM, G. STORRS, C. CHANDLER, and T. HOLTZ of Yale University Peabody Museum (YPM), M. BENTON

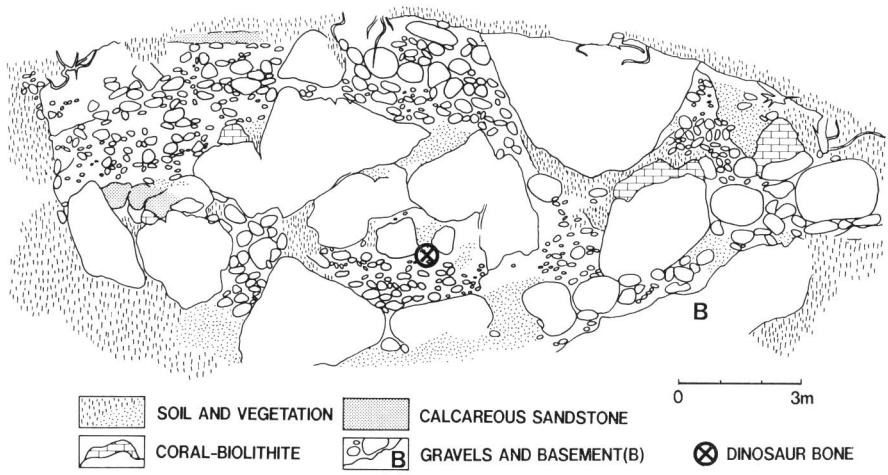

Figure 2. Sketch of the outcrop. Keys included in the figure.

of University of Bristol for their stimulating discussions; C. HOLTON and M. NORRELL of American Museum of Natural History, R. PURDY of National Museum of Natural History, A. CHARIG and A. MILNER of British Museum of Natural History, M. TURNER and C. CHANDLER of YPM for the valuable information on the specimens under their respective care; M. BENTON, J. OSTROM, C. CHANDLER, and P. DAVIS of University of Bristol for critically reading of the manuscript; T. UYENO of National Science Museum, Tokyo for his assistance in the publication of this paper; and T. HOLTZ for lifting a number of heavy sauropod humeri.

Stratigraphy

The specimen came from a formation correlated stratigraphically with the Tanohata Formation. Both formations are of the Miyako Group. The Miyako Group consists mainly of shallow marine sediments. It crops out in five small isolated areas along the Pacific coast of the Kitakami Mountains. The group in the Moshi area has a total thickness of greater than 58 m; and, it lies clino-unconformably over the Neocomian Harachiyama Formation, which consists mostly of dark green lava and pyroclastics of cpx-andesite accompanied with tuffaceous sandstone and, in places, shale. The basal member of the group in the Moshi area is the Tanohata-equivalent formation. It is composed, from the bottom to the top, of three units, conglomerate, sandstone, and silty sandtone, representing transgressive one cycle sedimentation. The basal conglomerate in which the specimen was discovered is exposed locally and abuts against the basement. It consists generally of pebbles and boulders of andesite within a matrix of calcareous bioclastic coarse-grained sandstone,

becoming finer toward the upper horizon. Soft substrate dwelling molluscs (*e. g. Trajanella*, *Nipponitrigonia*, astartids), reef building molluscs (*e.g.* pachyodont bivalves), rocky substrate dwelling molluscs (*e. g.* patellogastropod limpets), and debris of encrusting type organisms (*e. g.* corals and calcareous algae), are abundant in the sandstone of the basal unit and suggest a reef environment near a rocky shore, strongly influenced by open sea under warm climate (HANAI, OBATA and HAYAMI, 1968).

The locality is one of the road-cuts on an escarpment facing eastward along the coast of Moshi village. It is 20 m wide along the old road, where the andesitic rocks of the Harachiyama Formation are unconformably overlain by a boulder conglomerate of the Tanohata-equivalent formation.

The basement rock consists of the following: dark green andesitic rocks, probably an autobrecciated lava; brecciated blocks of cpx-andesite with various size are cemented by an poorly sorted matrix derived from the andesite. The upper surface of the unconformity is fairly flat and smooth. It dips approximately 40° southeast and is much steeper than the general dip, 20° of the overlying Miyako Group.

The boulder conglomerate, which is at least 8.5 m thick, consists of fairly packed well-rounded gravels of andesitic rock. No stratification is apparent. The gravels are exclusively composed of andesitic rock from the basement. The boulders are surrounded by round or well rounded cobbles and pebbles, and these are in turn surrounded by poorly sorted sand. The sand matrix is usually brown and badly weathered, however, in unweathered parts the sand is indurated.

In the horizon 4 to 6 m above the road, *Eohydonophora* aff. *picteti* and other hermatypic corals of approximately 10 cm in thickness occur like a patch covering the upper surface of the large boulders of 2 m in diameter. These corals are interpreted as autochthonous, because of their restricted and attached occurrence on the upper side of the boulders and observed growth direction of corals in transverse section. Such corals were isolated from each other, but occur at approximately the same horizon. The rest of the fauna is restricted, it is represented by sporadic and allochthonous occurrence of *Lopha* (*Actinostreon*) *nagaoi*, and boring shells in the corals. The bone specimen was found embedded horizontally in the weathered matrix of the conglomerate at the side of a large boulder.

The following environmental reconstruction may be possible. Although the sea level rise was relatively rapid, the sea did not invade very far landward (westward) from this area. The basement rocks formed a steep and undulating topography. Boulders rolled down from the cliff of basement rocks, and accumulated at the base of the cliff. Several boulders offered a favorable topographic condition for the growth of colonies of hermatypic corals. The bone fragment NSM PV17656 was transported and then trapped in sand matrix like a piece of a driftwood. Although the proximal and distal ends of the humerus are broken off and missing, it is not likely to have been transported over a long distance, for the bone is made of the fragile material.

The age of the group has been determined to be Late Aptian to Early Albian, based upon ammonite zonation. The Tanohata Formation is middle Late Aptian or

late Late Aptian and the lowest unit where the humerus came from most likely represents the middle Late Aptian. The lower Tanohata Formation yields *Parahoplites* spp., indicating a middle Late Aptian age, meanwhile the upper Tanohata through the overlying lower Hiraiga Formation yields *Hypacanthoplites subcornuerianus* which is closely related to *Hypacanthoplites multispinalum*. The latter is recorded from the Late Aptian of Germany, Morocco and the Caucasus (OBATA and MATSUMOTO, 1977).

Systematic Paleontology

Class Reptilia

Order Saurischia HUENE, 1932

Infraorder Sauropoda MARSH, 1878

Family Diplodocidae MARSH, 1884

Subfamily Mamenchisaurinae YOUNG and CHAO, 1972

Genus ***Mamenchisaurus*** YOUNG and CHAO, 1972

?Mamenchisaurus sp.

Material: Specimen NSM PV17656: A partial humerus, missing both proximal and distal ends.

Description

Humerus (Plate 1): The rather battered humerus includes most of the shaft but is missing both articular ends and the delto-pectoral crest. Proximally this specimen is broad, with a wide, shallow flexor surface. Distally the bone narrows and then thickens to an oval cross section. As preserved NSM PV17656 is about 53 cm long with a maximum width of 20 cm. Sauropod humeri are either massive and short as in the Diplodocidae, long and slender as in the Brachiosauridae, or somewhere between as in the Cetiosauridae. While the specimen is definitely not long enough to be a brachiosaur, it is not as short and massive as the humerus of *Apatosaurus*. The degree of tapering is very different from that of *Apatosaurus*. But as suggested in HASEGAWA *et al.* (1982), it matches that of *Mamenchisaurus hochuanensis* (YOUNG, 1958; YOUNG and CHAO, 1972) (Figure 3). The estimated original length is about 100 cm, medium size for a sauropod.

Discussion

Although the specimen described here is clearly a sauropod, its poor quality and fragmentary condition pose a severe obstacle to determining its relationship to other sauropod genera. Moreover, it is generally agreed that no satisfactory system of

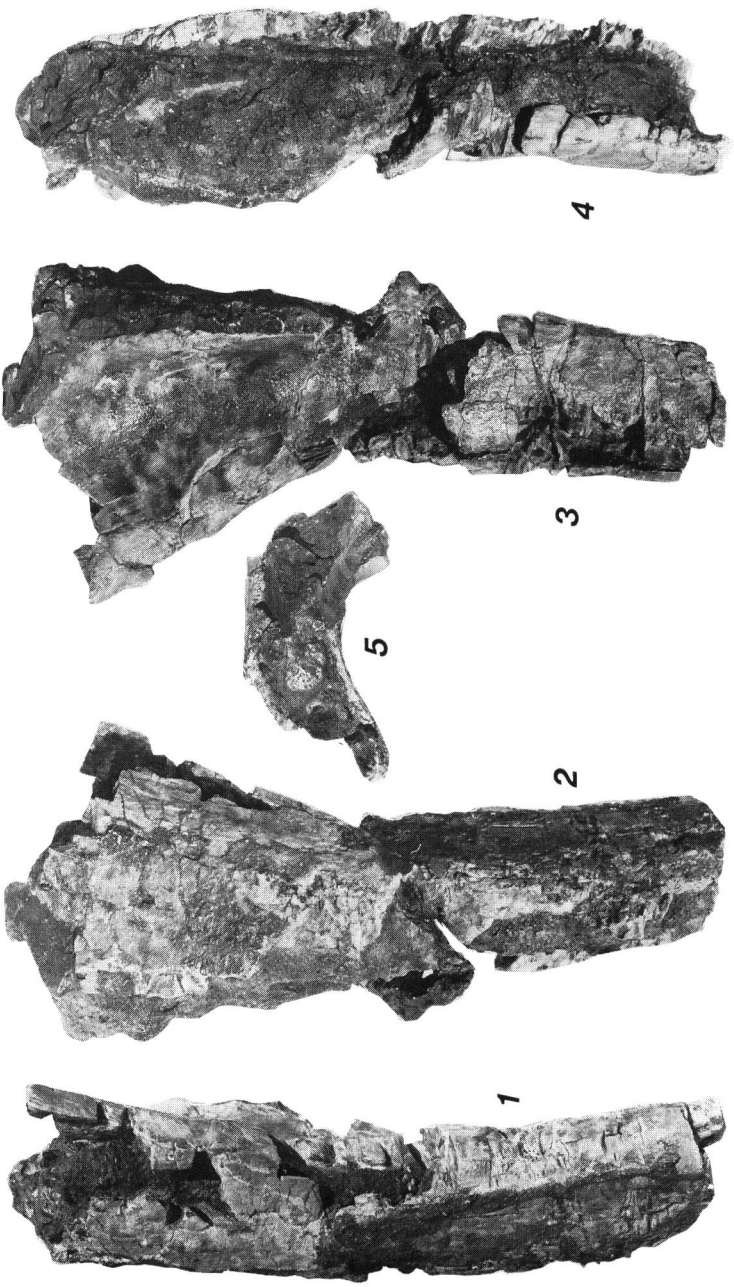

Plate 1. Left humerus of NSM PV17656 in right lateral (1), posterior (2), anterior (3), left lateral (4), and proximal (5) views. Length of the specimen = 53 cm.

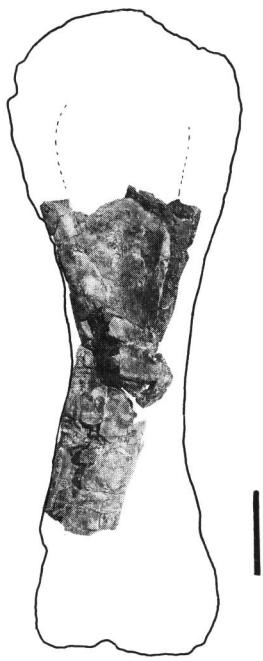

Figure 3. NSM PN17656 on the outline of *Mamenchisaurus hochuanensis* (YOUNG and CHAO, 1972). Scale=12 cm.

sauropod taxonomy has yet been devised, and that sauropod nomenclature at the generic and specific level is in great need of an extensive review and revision (*e. g.* OSTROM, 1970; COOMBS and MOLNAR, 1981; MCINTOSH, 1989, 1990). Many of the genera consist of incomplete remains. In fact, only a few genera (*e. g. Camarasaurus*, *Shunosaurus*) are known from complete skeletons.

There are only couple of studies which describe interfamilial variations in sauropod humeri: COOMBS and MOLNAR (1981) reviewed the development of the humeral heads in sauropods. Needless to say, the study cannot be applied to the NSM PV 17656. MCINTOSH (1990, fig. 16.10) has documented variations in the humeri of 28 species. The variations observed fall into the three categories: (1) the overall size, (2) the degree of tapering, and (3) the degree of the development of delto-pectoral crest. Although it may be premature at this time to use differences in humeri to distinguish between sauropod families, it would not be inaccurate to describe diplodocids as having humeri which equally taper along the internal and external edges towards the mid shaft (see MCINTOSH, 1990, p. 366, fig. 16.10).

If the specimen were complete, it would have most likely an outlime similar to that of the Diplodocidae. The missing delto-pectoral crest would have fringed the external edge, not extended inward like those of *Diplodocus* sp. (MCINTOSH, 1990, fig. 16.10o: according to MANABE's personal observation *Diplodocus* sp. shown in the

figure is not likely *Diplodocus carnegii* because it has a twist of an axis which is not seen in *Diplodocus carnegii*), *Barosaurus? africanus* (MCINTOSH, 1990, fig. 16.10q), *Dicraeosaurus hansemanni* (MCINTOSH, 1990, fig. 16.10f) and *Cetiosauriscus stewarti* (MCINTOSH, 1990, fig. 16.10s).

A large gap exists in the record of Early Cretaceous East Asian sauropods. The only other documented occurrence was *Mongolosaurus haplodon* from the On Gong Formation of Inner Mongolia (GILMORE, 1933). It is only described based upon teeth, atlas, axis, and cervical vertebra. No other Early Cretaceous sauropods have been discovered from the sauropod-rich Yangtze or Sino-Korean cratons. The existence of Early Cretaceous sauropods in East Asia is also supported recently by an undescribed diplodocid tooth from the Berriasian Itoshiro Subgroup of the Tetori Group of the northwestern Honshu.

Summary and Conclusions

The Early Cretaceous sauropod humerus from Northeastern Honshu, described herein, represents a medium-sized sauropod and similar in some respect to *Mamenchisaurus hochuanensis* from the Upper Jurassic of Szechuan, China. Although it may be premature to do so, humeral variations allow for some differentiation of taxa. We regard the present material as inadequate upon to which base a new taxon, and the specimen is here classified as *?Mamenchisaurus* sp. and considered most likely to belong to the Diplodocidae. It is traditional in Japan that a significant fossil specimen is given a "Japanese name", a nickname used by the mass-media for the general public. NSM PV17656 is named "Moshi-ryu". "Moshi", for the local name of the locality and "ryu", meaning a dragon in Japanese.

This occurrence provides evidence of Early Cretaceous sauropod evolution in East Asia where little or no record had been known to exist in the interval between the rich Late Jurassic sauropod formations (*e. g. Omeisaurus, Euhelopus, Mamenchisaurus*) to the Late Cretaceous Nemegt Formation with sauropods (*e.g. Nemegtosaurus* and *Opisthocoelicaudia*).

The specimen made both amateur and professional paleontologists in Japan aware of the existence of dinosaurs in Japan and has given them incentive to pay careful attention to any vertebrate remains from the Mesozoic strata. The influence has resulted in the discovery of more than 20 dinosaurian specimens as of the fall of 1990 from 8 different localities throughout Japan. As a result, the sauropod humerus is regarded as a landmark of the rapidly growing study of dinosaurs in the country.

References

COOMBS, W. P. J. & R. E. MOLNAR, 1981. Sauropoda (Reptilia, Saurischia) from the Cretaceous of Queensland. *Mem. Queensland Mus.*, **20**(2): 351–373.

GILMORE, C. W., 1933. Two new dinosaurian reptiles from Mongolia with notes on some fragmentary specimens. *Am. Mus. Nat. Hist. Novitates*, **679**: 1–20.

HANAI, T., I. OBATA & I. HAYAMI, 1968. Notes on the Cretaceous Miyako Group, Northeast Japan. *Mem. Nat. Sci. Mus., Tokyo*, (1): 20–28. (In Japanese with English summary)

HASEGAWA, Y., T. HANAI & T. KASE, 1982: The vertebrate fossil from the Lower Cretaceous in Moshi, Iwaizumi, Iwate, Japan. Abstracts of the Annual Meeting of the Palaeont. Soc. Japan at Chiba University.

MCINTOSH, J. S., 1989. The sauropod dinosaurs: A brief survey. *In* PADIAN, K. & J. CHURE (organized): *The Age of Dinosaurs, Short Courses in Paleontology*, (2): 85–99, Paleont. Soc. America.

———, 1990. Sauropoda. *In* WEISHAMPEL, D. B., P. DODSON & H. OSMOLSKA (eds.): *The Dinosauria*, University of California Press, Berkeley, Los Angeles, Oxford, p. 345–401.

NAGAO, T., 1936. *Nipponosaurus sachalinensis*, a new genus and species of trachodont dinosaur from Japanese Saghalien. *Jour. Fac. Sci., Hokkaido Imp. Univ.*, ser. 4, **3**(2): 185–220.

OBATA, I. & T. MATSUMOTO, 1977. Correlation of the Lower Cretaceous formations in Japan. *Sci. Rep. Dept. Geol., Kyushu Univ.*, **12**(3): 165–179. (In Japanese with English abstract)

OSTROM, J. H., 1970. Stratigraphy and paleontology of the Cloverly Formation (Lower Cretaceous) of the Bighorn Basin area, Wyoming and Montana. *Bull. Peabody Mus. Nat. Hist., Yale Univ.*, (35): 1–234.

TAKAI, F., 1962. The hadrosaurian dinosaur of Takashima, Kyushu, Japan. Annual Meeting of the Palaeont. Soc. Japan at Hiroshima Univ. (No written report).

YOUNG, C. C., 1958. New sauropods from China. *Vertebrata PalAsiatica*, **2**(1): 1–28.

——— & H. C. CHAO, 1972. *Mamenchisaurus hochuanensis. Palaeontologia Sinica*, (8): 1–32.