Bull. Natn. Sci. Mus., Tokyo, Ser. C, **12** (4), pp. 165–170, December 22, 1986

Recognition of the Genus *Entelodon* (Artiodactyla, Mammalia) from the Joban Coalfield, Japan, and the Age of the Iwaki Formation

By

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Abstract Reexamination of an artiodactyl molar tooth from the Joban Coalfield indicates that the tooth is a right upper second molar of *Entelodon* sp. cf. *E. orientalis*. This identification is based mainly on (1) the brachybunodont, six-cusped (rather than five-cusped as in anthracotheres) tooth, (2) each cusp is bulbous and rounded (rather than pyramidal or cresentic as in anthracotheres), (3) absence of labial cingulum, and (4) the size. The tooth had been misidentified as a late Eocene anthracothere similar to *Anthracothema*. Revised identification of the tooth as *E.* cf. *orientalis* suggests an early Oligocene (Rupelian) age for the fossil-bearing Iwaki Formation.

Introduction

Paleogene mammals have been found very rarely in Japan, and nine specimens from four localities are all the terrestrial Paleogene mammal fossils that have been reported so far. Thus, even a single specimen, if it is identifiable, has been very important for understanding of Japanese Paleogene fauna. A Paleogene artiodactyl molar was reported by TAKAI from the Iwaki Formation of Shiramizu Group at the Joban Coalfield in 1961 (Fig. 1). TAKAI (1961) identified this specimen as a left M^2 of an anthracothere similar to the genus *Anthracothema* PILGRIM. Unfortunately he gave "provisionally" a name, "*Anthracothema*" *tsuchiyai*, without any description, and the name has been used since then as if it were a valid species name (e.g., ASANO, 1962; ICHIKAWA, 1983; SAITO *et al.*, 1984).

Reexamination of the specimen revealed that the tooth is a right M^2 of a rather small species of the genus *Entelodon* as described below, which indicates an early Oligocene age. The geologic age of the Iwaki Formation has been uncertain for a long time mainly bacause of the absence of marine planktonic microfossils. This artiodactyl molar, which has been the only identified mammalian remain from the Iwaki Formation, has played an important role on the interpretation of the geologic age of the formation. The present revised identification of the specimen, therefore, requires certain revision on the interpreted age of the Iwaki Formation, as discussed below.

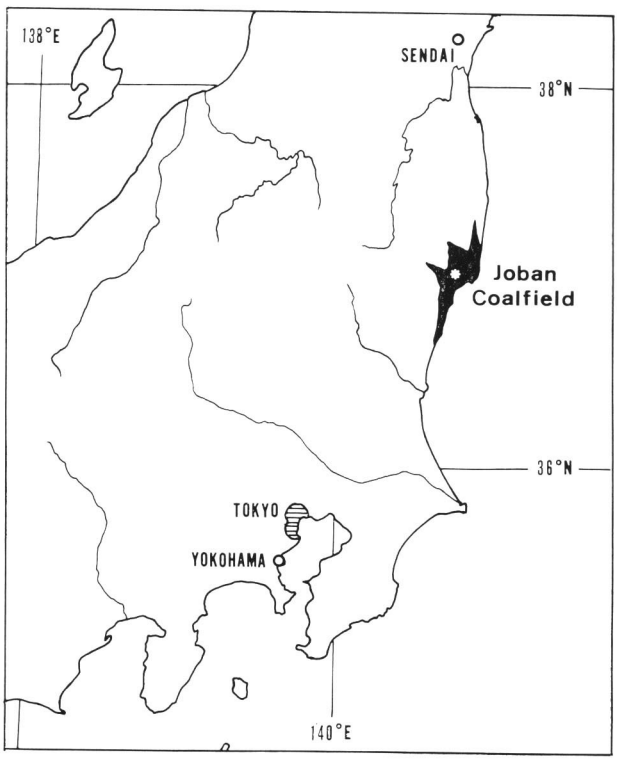

Fig. 1. Map showing the fossil locality (an asterisk) with the maximum range of the Joban Coalfield (black area).

Systematic Paleontology

Order Artiodactyla OWEN, 1848
Suborder Suiformes JAECKEL, 1911
Superfamily Entelodontoidea LYDEKKER, 1883
Family Entelodontidae LYDEKKER, 1883
Genus ***Entelodon*** AYMARD, 1846
Entelodon sp. cf. ***E. orientalis*** DASHZEVEG, 1965

(Fig. 2)

"*Anthracothema*" *tsuchiyai* TAKAI (MS), 1962, Proc. Japan Acad., 37 (5).

Material: An isolated right upper second molar, University Museum, University of Tokyo CV-6189.

Occurrence and Age: Coarse-grained sandstone bed that is stratigraphically 14 meter above the upper coal seam of the Iwaki Formation, Shiramizu Group, at Iwasaki Colliery of the Joban Coalfield, Iwaki City, Fukushima Prefecture (TAKAI, 1961) (Fig. 1). An early Oligocene age is inferred (see geologic age section below).

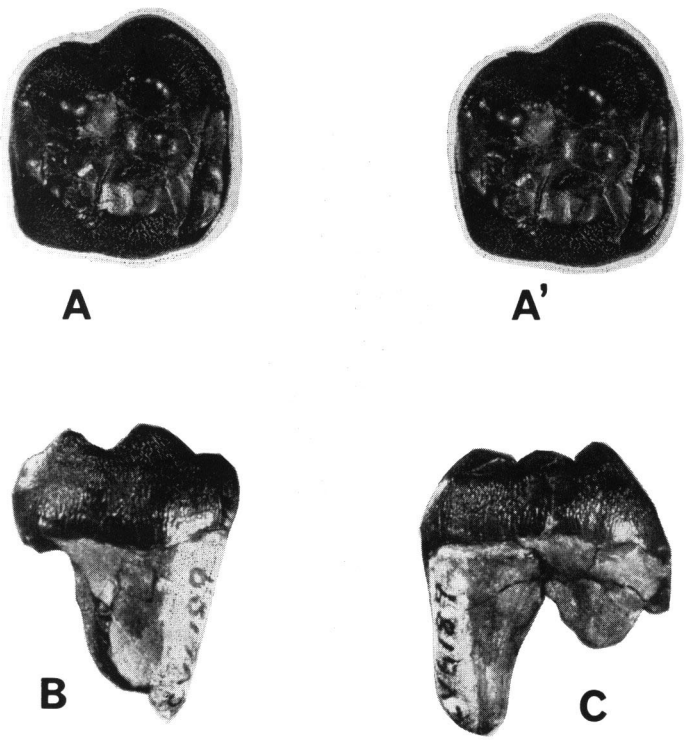

Fig. 2. *Entelodon* sp. cf. *E. orientalis* DASHZEVEG, University of Tokyo CV-6189, right M^2. A–A , stereophotographs of occlusal view; B, lingual view; C, anterior view. ×1.

Description: Brachybunodont tooth with enamel surface finely rugose. Maximum length and width are 30.7 and 34.0 mm, respectively. Occlusal outline is a rounded square with labial expansion of the anterolabial part. The crown has six cusps which are bulbous and rounded. The paracone, metacone, and protocone are three large cusps and are similar to each other in size. The paracone is located more labial relative to the metacone. The hypocone is medium-sized and is located directly posterior to the protocone. The protoconule is a medium-sized cusp, distinct from the protocone and paracone, and is located about the same distance from them. The metaconule is the smallest of the six cusps; it is located close to and is somewhat indistinct from the hypocone.

The anterior cingulum is well developed and extends from the anterolingual base of the protocone to the labial base of the paracone. The posterior cingulum is present but is less developed and much shorter than the anterior cingulum (Fig. 2A–A′). No labial and lingual cingula are present. Lingual root is well developed and is elongated anteroposteriorly, with a groove in the middle. Although two labial roots are broken off, they appear to have been well developed (Fig. 2B, C).

Comparisons: The tooth (CV-6189) is clearly an entelodont right M^2. Isolated upper molars are one of the least characteristic elements among the entelodont remains; however, individual size is reliable for generic and species identification within the family Entelodontidae. Following comparisons were made, mainly with BRUNET (1979).

The specimen (CV-6189) described above is medium-sized for an entelodont. Various genera and species known from the late Oligocene through Miocene of North America and the Miocene of Asia (except for *Entelodon ordosius* (YOUNG et CHOW)) can be readily distinguished by their much larger size, whereas the late Eocene *Eoentelodon* CHOW from China can be easily distinguished by its much smaller size (XU and CHIU, 1962).

Entelodon and *Archaeotherium* LEIDY are the two most diversified genera in the Old World and New World, respectively. They are distinguished on dental characters, mainly by the morphology and arrangement of ante-molar teeth. These two genera are nearly indistinguishable with the morphology of the isolated teeth alone (BLUNET, 1979). *Archaeotherium* has been restricted to North America as far as known, and the known species of that genus are either small (*A. mortoni* LEIDY, *A. coarctatum* (COPE)) or slightly larger (*A. scotti* SINCLAIR, *A. wanlesi* SINCLAIR) than the Japanese form described above. Thus, it is very unlikely that the Japanese form belongs to *Archaeotherium*.

Among the species of the genus *Entelodon*, *E. deguilhemi* REPELIN and *E. dirus* MATTHEW et GRANGER (M^2 not known) are much larger than the Japanese form. Although M^2 of *E. ordosius* is not known, this species is distinguished by having strong external cingulum on M^1 and somewhat larger expected size of M^2 (YOUNG and CHOW, 1956). *E. gobiensis* (TROFIMOV) is somewhat larger in size and has upper molars transversely wider (more rectangular in outline). *E. magnus* AYMARD is slightly larger in size, and the paracone of M^2 is located directly anterior to the metacone.

The Japanese specimen described above is more or less similar in size to *E. antiquus* REPELIN (although M^2 is not known), *E. major* BIRIOUKOV, and *E. orientalis*, and thus it could possibly be any of these species based on size. CV6189 is most similar to the holotype of *E. orientalis* both in size (that is nearly identical) and with the paracone located antero-external to the metacone and the base of the paracone expanded externally. It differs from the holotype in having the metaconule less developed (DASHZEVEG, 1965). Although the Japanese specimen is most similar to *E. orientalis*, the possibility that it belongs to another species can not be entirely excluded.

Discussion: The morphology of the specimen (CV-6189) as described above indicates that it is a right M^2 of an entelodont. But, it had been misidentified as a left M^2 of an anthracothere similar to the genus *Anthracothema*. Unfortunately TAKAI (1961) "provitionally" (his term) gave the name "*Anthracothema tsuchiyai*" without any description or rationale of a new species. This name does not meet the International Code of Zoological Nomenclature (RIDE *et al.*, 1985) on two articles: Art. 13-a, requirements for names published after 1930 to be available, and Art. 15, con-

ditional proposals after 1960. Thus, the name is a nomen nudum and should be abandoned.

Geologic Age of the Iwaki Formation

Geological and paleontological investigations of the Paleogene strata of the Joban Coalfield were pretty much terminated in the early 1960's coinciding with the rapid decline of coal-mining in Japan. Therefore, the most recent biostratigraphic correlation of the Joban Coalfiedld by SAITO *et al.* (1984) is essentially the same as the one by ASANO (1962) and TAKAI (1961).

The Paleogene strata at the Joban Coalfield are called the Shiramizu Group which is divided into three formations: Iwaki, Asagai, and Shirasaka in ascending order (SUGAI *et al.*, 1957). Before the work of TAKAI (1961), geologic age of the entire Shiramizu Group had been generally thought within the Oligocene, based mainly on molluscan fossils (HATAI and KAMADA, 1950; HIRAYAMA, 1955) and on fossil floras from the Iwaki Formation (TANAI, 1952), although no detailed study of the latter has been published. On the basis of TAKAI's identification of "*Anthracothema*", the Iwaki formation has been correlated with the late Eocene, Priabonian, since 1961.

The only known mammalian remain from the Iwaki Formation is now identified as *Entelodon* cf. *orientalis*, as described above. The genus *Entelodon* appeared in the early Oligocene, and rapidly evolved into several species in Asia and Europe (BRUNET, 1979). They became large forms by the late Oligocene and early Miocene. This tendency of entelodont (to increase in size) has also been demonstrated among the North American forms. *E. orientalis* is known from early Oligocene deposits of Mongolia. Even if the assignment of the M^2 described above to *E.* cf. *orientalis* proves erroneous, the specimen almost certainly belongs to one of the early Oligocene species of *Entelodon* as discussed above. Thus, the early Oligocene (Rupelian) is strongly suggested for the geologic age of the fossil-bearing deposits, the Iwaki Formation.

Acknowledgments

I am grateful to Dr. Itaru HAYAMI of the University of Tokyo for permission to study the specimen and to Drs. Richard H. TEDFORD and Lawernce J. FLYNN (now at Harvard University) of the American Museum of Natural History (USA) for permission to compare specimens in the museum collection. My thanks also go to Dr. Michel BRUNET of Universite de Poitiers (France) and Dr. FLYNN for their help in the early stage of this study, and to Dr. Everett H. LINDSAY of the University of Arizona (USA) for his reading of the manuscript. Financial support of the present study was provided in part by the Grant-in-Aid for Scientific Research (No. 58740389) from the Ministry of Education, Science and Culture of the Japanese Government.

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