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The first record of an amphicyonid (Mammalia: Carnivora) from Japan, and its implication for amphicyonid paleobiogeography

NAOKI KOHNO

Department of Geology, National Science Museum, Tokyo, 3-23-1 Hyakunin-cho, Shinjuku-ku, Tokyo, 169 Japan

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Abstract. A mammalian tooth from the lower Middle Miocene Korematsu Formation (ca. 16.3-15.6 Ma) within the Bihoku Group in Shobara City, Hiroshima Prefecture, southwestern Japan, is described and identified as a right upper first molar of the amphicyonid carnivore *Ysengrinia* sp. This is the first amphicyonid to be described from Far East Asia and it provides additional evidence for the carnivoran faunal connections between Europe-Asia-North America during the Early and early Middle Miocene.

Key words: Amphicyonidae, Japan, Miocene, paleobiogeography, *Ysengrinia*

Introduction

Amphicyonidae (sensu Hunt, 1972) is an extinct carnivoran family within the Arctoidea Flower, and is thought to be the closest relative of the ursids (e.g., Wyss and Flynn, 1993) or the sister group to other arctoid carnivorans (e.g., Tedford *et al.*, 1994). Amphicyonids are now known from the latest Eocene to early Late Miocene (ca. 40-8 Ma) of Europe, Africa, Asia, and North America (Hunt, 1996). Although there have been a few reports of amphicyonids from Central and Southeast Asia (e.g., Colbert, 1939; Yan *et al.*, 1983; Ginsburg *et al.*, 1992), no amphicyonid has yet been known from Far East Asia.

In the present report, I provide the description of an amphicyonid tooth referable to the genus *Ysengrinia* Ginsburg, 1965, from the lower Middle Miocene Korematsu Formation within the Bihoku Group in Shobara City, Hiroshima Prefecture, southwestern Japan. This is the first record of an amphicyonid from Far East Asia and is the youngest record of this genus. The specimen was collected by Messrs. Takanobu Yamaoka and Masami Sugihara on the New Year's Day of 1996 and has been deposited at the Hiwa Museum of Natural History (**HMN**), Hiwa Town, Hiba-gun, Hiroshima Prefecture, Japan.

The following institutional acronyms are also used in this report: **AMNH**, Department of Vertebrate Peleontology, American Museum of Natural History, New York, U.S.A.; **MNHN**, Laboratoire de Paléontologie, Muséum National d'Histoire Naturelle, Paris, France; **UNSM**, Division of Vertebrate Paleontology, University of Nebraska State Museum, Nebraska, U.S.A.

Systematic paleontology

Order Carnivora Bowdich, 1821
Family Amphichyonidae (Trouessart, 1885) Hunt, 1972
Genus ***Ysengrinia*** Ginsburg, 1965

Ysengrinia sp.

Figure 1

Material.—HMN-F00002, right upper first molar, lacking all the roots at the base.

Locality.—A small valley, so-called "Kaisekidani" (=Shellstone Valley), located about 2.1 km east of the Bingo-Shobara Station of the Japan Railroad (JR), and about 2.3 km northeast of the Shobara Interchange of the Chugoku Expressway, Miyauchi Town, Shobara City, Hiroshima Prefecture, southwestern Japan, 34°51′31″ North latitude, and 133°02′22″ East longitude.

Formation and Age.—The specimen was found in a gray, somewhat indurated, medium-grained marine sandstone, at the "Ka2 Horizon" of Okamoto *et al.* (1990) in the lower part of the Korematsu Formation (Ueda, 1986) of the Bihoku Group. Although the upper part of the Korematsu Formation and the overlying lower part of the Itabashi Formation correspond to the NN 4 Zone (18.4-15.6 Ma: Young *et al.*, 1994) of the calcareous nannofossil zonation (Okamoto, 1992), occurrence of the bivalve genus *Hataiarca* in association with many tropical and subtropical species of molluscs and crustaceans from the entire Korematsu Formation including the "Ka2 Horizon" (e.g., Okamoto *et al.*, 1990; Karasawa, 1993) suggests an equivalency of the Korematsu Formation in whole with Neogene first climatic optimum (see

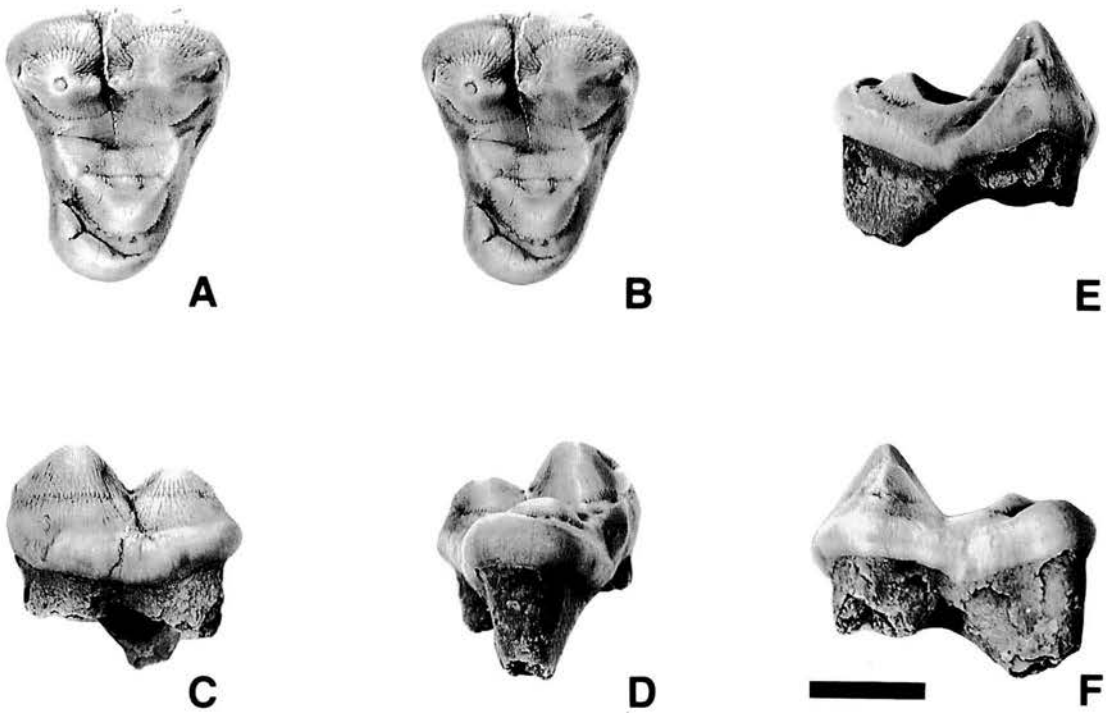

Figure 1. *Ysengrinia* sp., HMN-F00002, right M^1. A-B, occlusal view (stereograph); C, buccal view; D, lingual view; E, anterior view; F, posterior view. Scale bar equals 1 cm.

also Noda and Takahashi, 1986; Itoigawa, 1988; Ogasawara and Noda, 1996). Therefore, the best current estimate of the geologic age for the Korematsu Formation is early Middle Miocene, approximately 16.3-15.6 Ma.

Description.—The tooth is very large and consists of three principal cusps: anterobuccally located paracone, posterobuccally located metacone, and lingually located protocone. The paracone is a prominent cusp and is larger and higher than the metacone. Although smaller than the paracone, the metacone is also prominent. The two cusps are bordered buccally by a very weak bulge at the base of the crown. The enamel surface of the paracone and metacone is vertically wrinkled. A small parastyle is present beside the paracone at the anterobuccal corner of the crown. The protocone is almost like a low V-shaped ridge descending to the paraconule and metaconule, at the base of the paracone and metacone respectively around the depressed protocone basin. There is a well-developed cingulum at the posterolingual portion of the protocone, but no cingulum at anterior and posterobuccal borders of the crown, giving the form of a "pear-shaped" outline of the crown in occlusal view. This tooth has three roots corresponding to the three principal cusps, although they are broken off at each base. The anterobuccal root (for the paracone) and the posterobuccal one (for the metacone) are both round in cross section, and the medial one (for the protocone) is buccolingually elliptical and approximately twice larger in diameter than the other two at the base.

Comparisons

HMN-F00002 is characterized by its very large size, the "pear-shaped" outline in occlusal view, with well developed posterolingual cingulum, and very large paracone relative to the metacone. All these characters correspond to the characteristics of M^1s of Oligo-Miocene *Ysengrinia* species known from western Europe (Ginsburg, 1965; Savage and Russel, 1983; Viranta, 1996) and North America (Hunt, 1972; Tedford *et al*., 1987). Some other Miocene amphicyonids such as *Amphicyon* Lartet and *Pseudocyon* Lartet also have large M^1s, but they are almost equilaterally triangular in shape with cingula developed both anteriorly and posteriorly, and the paracone and metacone are almost equal in size

Table 1. Measurements of HMN-F0002 in mm.

Mesiodistal diameter of the crown	21.6
Buccolingual diameter of the crown	26.2
Height of the crown at the buccal side	12.3
Mesiodistal diameter of the anterobuccal root at the base	8.6
Buccolingual diameter of the anterobuccal root at the base	9.3
Mesiodistal diameter of the posterobuccal root at the base	7.8
Buccolingual diameter of the posterobuccal root at the base	8.3
Mesiodistal diameter of the lingual root at the base	8.8
Buccolingual diameter of the lingual root at the base	13.4

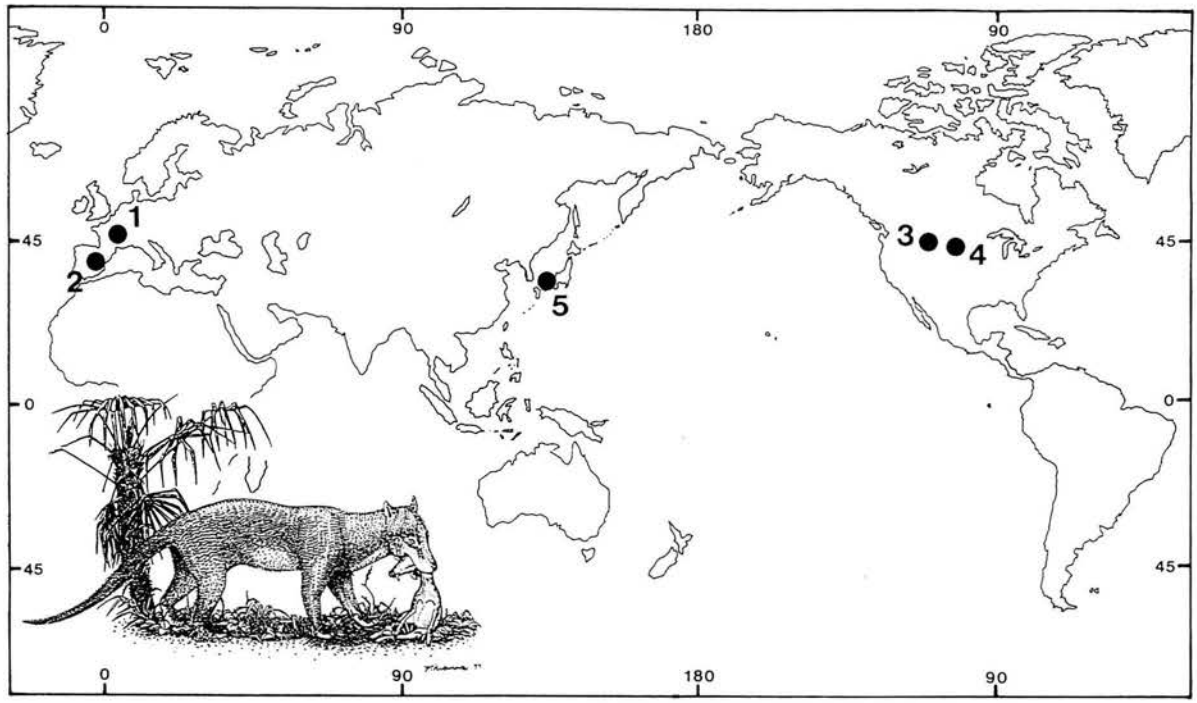

Figure 2. Distribution of *Ysengrinia*. 1, *Y. tolosana*, Late Oligocene ; *Y. gerandiana*, early Early Miocene ; *Y. depereti*, late Early Miocene, France. 2, *Y. valentiana*, late Early Miocene, Spain. 3, *Y.* sp., Early Miocene, Wyoming, U.S.A. 4, *Y.* sp., Early Miocene, Nebraska, U.S.A. 5, *Y.* sp., early Middle Miocene, Japan. Illustration is a generalized life restoration of an amphicyonid.

(Viranta, 1996). Likewise, HMN-F00002 cannot be referred to the M^1s of small pre-Miocene amphicyonids nor to the other Miocene amphicyonids that have "triangular" upper first molars.

The genus *Ysengrinia* was established by Ginsburg (1965) on the basis of the dental morphology of "*Pseudocyon*" *gerandianus* Viret, 1929, and four species have been recognized so far within the genus (Viranta, 1996). The upper first molars are known in *Y. gerandiana* (Viret, 1929) from the early Early Miocene (European Neogene Mammal Faunal Zone MN 2 of Steiniger *et al*., 1996, ca. 22.8-20.0 Ma) of France and *Y. valentiana* Belinchón and Morales, 1989, from the late Early Miocene (MN 4, ca. 18.0-17.0 Ma) of Spain. As can be seen from the illustrations of Viret (1929) and Kuss (1965) and from the descriptions of Belinchón and Morales (1989) and Viranta (1996), *Y. gerandiana* and *Y. valentiana* have large M^1 with a prominent paracone which is larger than the metacone, with a posterolingually projected cingulum, and without anterior and posterobuccal cingula. These characters produce a "pear-shaped" outline in occlusal view that is almost identical to that of HMN-F00002.

As for the North American record of *Ysengrinia*, Hunt (1972) referred two M^1s and some postcranial bones from the Early Miocene (now known from the late Late Arikareean to Early Hemingfordian of the North American Land Mammal Age, ca. 21-18 Ma ; Tedford *et al*., 1987) of Nebraska and Wyoming as a species of (?)*Ysengrinia*, since there remained some doubts regarding the status of *Ysengrinia* at that time (Hunt, 1972 : p. 31). It is, however, clear that the structure and proportion of the two M^1s (Hunt, 1972 : Fig. 10) all agree with the emended diagnoses for the M^1s of *Ysengrinia* species by Viranta (1996). Therefore, I believe that *Ysengrinia* without a question mark is warranted for the teeth described by Hunt (1972). The American *Ysengrinia* M^1s also resemble HMN-F00002 in their size and proportion, but the development of buccal and lingual cingula in the former is slightly stronger than in the latter.

Since the inter- and intra-specific variations of M^1s in the species of *Ysengrinia* are presently not well understood (see also Hunt, 1972 ; Viranta, 1996), a species-level definition based upon the morphologies of M^1s seems not to be feasible. Thus, I refer herein HMN-F00002 only to *Ysengrinia* species indeterminate until more diagnostic material is obtained.

Paleobiogeography

Ysengrinia had previously been known only from western Europe and North America during the Late Oligocene and Early Miocene (Hunt, 1972 ; Savage and Russel, 1983). HMN-F00002 from the early Middle Miocene (ca. 16.3-15.6 Ma) of Japan is, therefore, not only the first record of *Ysengrinia* from Asia but also the youngest record of this genus (Figure 2).

Judging from their oldest stratigraphic record and geographic distribution of their closest relatives, i.e., *Brachycyon* from France (Hunt, 1972) or *Pseudocyonopsis* from western Europe (Ginsburg, 1966 ; Springhorn, 1977), *Ysengrinia* is

thought to have originated in western Europe during the Late Oligocene and might have spread out rapidly from Europe into North America across the Asian Continent during the Early Miocene (Hunt, 1996). The biogeographic range extension of *Ysengrinia* into Far East Asia is, therefore, consistent with the scenario originally proposed by Hunt (1972). In addition, since only one carnivoran genus (i.e., the Miocene large-sized amphicyonid *Amphicyon*) was previously known in Europe, Asia, and North America during the Early to early Middle Miocene (Savage, 1967 ; Savage and Russel, 1983), HMN-F00002 provides new evidence that *Ysengrinia* is also one of the key elements for recognizing carnivoran faunal connections between Europe, Asia, and North America during that time. Such large amphicyonids as *Ysengrinia* and *Amphicyon* might have been the topmost predators in the terrestrial ecosystem throughout the Northern Hemisphere during the Early and early Middle Miocene.

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References

Belinchón, M. and Morales, J., 1989 : Los carnívoros del Mioceno inferior de Bunnol (Valencia, Espana). *Revista Española de Paleontología*, vol. 4, p. 3-8.

Colbert, E.H., 1939 : Carnivora of the Tung Gur Formation of Mongolia. *Bulletin of the American Museum of Natural History*, vol. 76, p. 47-81.

Ginsburg, L., 1965 : L' "*Amphicyon*" *ambiguus* des phosphorites du Quercy. *Bulletin du Muséum National d'Histoire Naturelle*, vol. 37, p. 724-730.

Ginsburg, L., 1966 : Les Amphicyons des Phosphorites du Quercy. *Annales de Paléontologie*, vol. 52, p. 23-44.

Ginsburg, L., van Minh, L., Kieu, Q., and van Thuan, D., 1992 : Premiéres découvertes de vertébrés continentaux dans le Néogène du Nord du Vietnam. *Comptes Rendus de l'Académie des Sciences, Paris, Série II*, vol. 313, p. 627-630.

Hunt, R.M. Jr., 1972 : Miocene amphicyonids (Mammalia, Carnivora) from the Agate Spring Quarries, Sioux County, Nebraska. *American Museum Novitates*, no. 2506, p. 1-39.

Hunt, R.M. Jr., 1996 : Biogeography of the Order Carnivora. *In*, Gittleman, J.L. *ed.*, *Carnivore Behavior, Ecology and Evolution*, vol. 2, p. 485-541. Chapman and Hall, London.

Itoigawa, J., 1988 : The Miocene Kadonosawa Fauna of Japan. *Saito Ho-on Kai Special Publication (Prof. Tamio Kotaka Commemorative Volume)*, p. 397-403.

Karasawa, H., 1993 : Cenozoic decapod Crustacea from southwest Japan. *Bulletin of the Mizunami Fossil Museum*, no. 20, p. 1-92.

Kuss, S.E., 1965 : Revision der europäischen Amphicyoninae (Canidae, Carnivora, Mammalia). *Sitzungsberichte der Heidelberger Akademie der Wissenschaften*, vol. 1, p. 1-169.

Noda, H. and Takahashi, H., 1986 : Distribution of *Anadara (Hataiarca) kakehataensis* and characteristics of the associated molluscan fauna in the early Middle Miocene of Japan. *Monograph of the Mizunami Fossil Museum*, no. 6, p. 49-58. (*in Japanese with English abstract*)

Ogasawara, K. and Noda, H., 1996 : Miocene *Hataiarca* (Mollusca, Bivalvia) invasion event in the Japanese Islands from a viewpoint of Indo-Pacific connection. *In*, Noda, H. and Sashida, K. *eds.*, *Professor Hisayoshi Igo Commemorative Volume on Geology and Paleontology of Japan and Southeast Asia*, p. 133-139. Gakujyutsu Tosho Insatsu Co. Ltd., Tokyo.

Okamoto, K., 1992 : Vertical sequence of molluscan assemblages from the Miocene Bihoku Group in Shobara City, southwest Japan. *Bulletin of the Mizunami Fossil Museum*, no. 19, p. 319-328. (*in Japanese with English abstract*)

Okamoto, K., Katsuhara, M., Ueno, Y. and Sumiyoshi, O., 1990 : Molluscan assemblages from the Miocene Bihoku Group in the Kaisekidani area, Miyauchi-cho, Shobara City, southwest Japan. *Bulletin of the Mizunami Fossil Museum*, no. 17, p. 35-49. (*in Japanese with English abstract*)

Savage, D.E. and Russell, D.E., 1983 : *Mammalian Paleofaunas of the World*, 432 p. Addison-Wesley Publishing Co., London.

Savage, R.J.G., 1967 : Early Miocene mammal faunas of the Tethyan region. *In*, Adams, C.G. and Ager, D.V. *eds.*, *Aspects of Tethyan Biogeography*, p. 247-282. Systematics Association Publication, London.

Springhorn, R., 1977 : Revision der Alttertiären Europäischen Amphicyonidae (Carnivora, Mammalia). *Palaeontographica Abteilung A*, bd. 158, p. 26-113.

Steininger, F.F., Berggren, W.A., Kent, D.V., Bernor, R.L., Sen, S., and Agusti, J., 1996 : Circum-Mediterranean Neogene (Miocene and Pliocene) marine-continental chronologic correlations of European mammal units. *In*, Bernor, R.L., Fahlbusch, V. and Mittmann, H.-W. *eds.*, *The Evolution of Western Eurasian Neogene Mammal Faunas*, p. 7-46. Columbia University Press, New York.

Tedford, R.H., Barnes, L.G. and Ray, C.E., 1994 : The Early Miocene littoral ursoid carnivoran *Kolponomos* : Systematics and mode of life. *Proceedings of the San Diego Society of Natural History*, no. 29, p. 11-32.

Tedford, R.H., Galusha, T., Skinner, M.F., Taylor, B.E., Fields, R.W., Macdonald, J.R., Rensberger, J.M., Webb, D. and Whistler, D.P., 1987 : Faunal succession and biochronology of the Arikareean through Hemphillian inter-

val (Late Oligocene through earliest Pliocene epochs) in North America. *In*, Woodburne, M.O. *ed.*, *Cenozoic Mammals of North America*, p. 153-210. University of California Press, Berkeley and Los Angeles.

Ueda, T., 1986 : The Miocene Bihoku Group and its molluscan assemblages in the Shobara district, Hiroshima Prefecture, west Japan. *Chikyu-Kagaku*, vol. 40, p. 437-448. (*in Japanese with English abstract*)

Viranta, S., 1996 : European Miocene Amphicyonidae : Taxonomy, systematics and ecology. *Acta Zoologica Fenica*, vol. 204, p. 1-61.

Viret, J., 1929 : Les faunes de Mammifères de l'Oligocène supérieur de la Limagne Bourbonnaise. *Annales de l'Université de Lyon, Nouvelle Série*, fasc. 47, p. 1-328.

Wyss, A.R. and Flynn, J.J., 1993 : A phylogenetic analysis and definition of the Carnivora. *In*, Szalay, F.S., Novacek, M.J. and McKenna, M.C., *eds.*, *Mammal Phylogeny*, p. 32-52. Springer-Verlag, New York.

Yan, D., Qiu, Z. and Men, Z., 1983 : Miocene stratigraphy and mammals of Shanwang, Shandong. *Vertebrata PalAsiatica*, vol. 17, p. 210-222 (*in Chinese with English summary*)

Young, J.R., Flores, J-A. and Wei, W., 1994 : A summary chart of Neogene nannofossil magnetobiostratigraphy. *Journal of Nannoplankton Research*, vol. 16, no. 1, p. 21-27.