

A Femur of *Plotopterum* from the Early Middle Miocene of Japan (Pelecaniformes: Plotopteridae)

By

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Abstract A femur of early middle Miocene age (Hemingfordian correlative) of Honshu, Japan, that had previously been referred to the Phalacrocoracidae is here reidentified as that of a member of the Plotopteridae, an extinct family of diving birds belonging to the order Pelecaniformes. Because of the small size of the specimen it is assigned to the genus *Plotopterum*, heretofore known only from lower Miocene rocks of California, and it provides the youngest known occurrence of the family.

Introduction

Remains of the flightless penguin-like pelecaniform birds of the family Plotopteridae occur in mid-Tertiary marine deposits around the North Pacific. Those from Japan and the state of Washington are very large to gigantic species known so far only from Oligocene rocks (HASEGAWA, ISOTANI, *et al.*, 1979; OLSON and HASEGAWA, 1979; OLSON, 1980). The family was originally diagnosed from the scapular end of a coracoid, the holotype of *Plotopterum joaquinensis* HOWARD (1969), which, being within the size range of modern species of cormorants (Phalacrocoracidae), is quite the smallest species of the family. The specimen came from the early Miocene (Arikarean correlative) Pyramid Hill Local Fauna in the Pyramid Hill Sand Member of the Jewett Sands, Pyramid Hill, Kern County, California (BARNES, 1979: 7; HOWARD, 1983).

HASEGAWA, OKUMURA, and OKAZAKI (1979) described a nearly complete femur from early middle Miocene deposits in Honshu, Japan, that they referred to the "Phalacrocoracidae?, gen. et sp. indet." Upon further comparison, we have found that this specimen is not from a cormorant, however, and instead is most likely from a small member of the Plotopteridae.

Acknowledgements. We acknowledge the assistance of the Mizunami Fossil Museum, Mr. Yoshitsugu OKUMURA, Mr. Tatsuya KAEDE, and Mr. Keiichi ONO. We thank Dr. Lawrence G. BARNES and Dr. Clayton E. RAY for their comments on the manuscript. The photographs are by Mr. Victor E. KRANTZ.

Order Pelecaniformes SHARPE
Suborder Sulae SHARPE
Family Plotopteridae HOWARD, 1969
Plotopterum sp.

(Fig. 1)

Referred material: Essentially complete left femur, lacking only part of the proximo-anterior region of the head, Mizunami-shi Fossil Museum MFM 1800, collected 7 December 1976 by Tatsuya KAEDE.

Locality: Matsugase, Togari, Akeyo-cho, Mizunami-shi, Gifu Prefecture, Honshu, Japan.

Horizon: Yamanouchi Member, Akeyo Formation, Mizunami Group. This formation and the correlative Nataki Formation in Japan have yielded fossils of cetaceans and other marine mammals indicating that these deposits correlate approximately with the Hemingfordian North American Land Mammal Age, or the early "Temblor" molluscan stage (BARNES and MITCHELL, 1984; BARNES, pers. comm.). These beds are also approximately correlative with the Astoria Formation of Oregon, some 15 to 18 million years old, and are thus somewhat younger than the Pyramid Hill Sand from which the holotype of *Plotopterum joaquinensis* was derived (see correlation chart in RAY, 1977: 423).

Measurements: Length along lateral side, 70.5 mm; proximal width, 17.5; proximal depth through trochanter, 12.0; width and depth of shaft at midpoint, 7.2×6.8 ; distal width and depth, 17.5×11.5 .

Comparisons: The Japanese femur differs from that of the Phalacrocoracidae and is actually much more similar to the femur in the Anhingidae in the following features: shaft in lateral view not as heavy and decidedly straighter, head relatively larger and more inclined proximally relative to the trochanter, trochanteric ridge shorter and not as pronounced, tibiofibular crest of the lateral condyle smaller and not nearly as produced posteriorly, posterior intercondylar sulcus not as deep or as well defined. The specimen differs from the Anhingidae and resembles the femora known for some of the larger forms of Plotopteridae from Japan in having the distal end of the shaft wider and more compressed antero-posteriorly, appearing more slender in lateral or medial view, with the patellar sulcus decidedly more excavated but the popliteal fossa less so.

Remarks: We have noted previously that in several aspects of the postcranial skeleton that are not unique, the Plotopteridae much more closely resemble the Anhingidae than the Phalacrocoracidae (OLSON and HASEGAWA, 1979; OLSON, 1980). This, combined with the slight differences from the Anhingidae shown by the Japanese fossil, as well as its occurrence in a marine deposit (the modern anhingas being confined to fresh water), justify the assignment of this specimen to the Plotopteridae. The fossil is considerably larger than the femora in modern species of *Anhinga* (Fig. 1), although a larger fossil species, *Anhinga grandis* MARTIN and MENGEL (1975), is



Fig. 1. Anterior (top row) and medial (bottom row) views of left femora: A, *Plotopterum* sp., MFM 1800, from the lower middle Miocene of Japan; B, *Anhinga anhinga*, USNM 500870; C, *Anhinga rufa*, USNM 18743; D, *Phalacrocorax auritus* USNM 500865. Natural size.

known.

The fossil femur would have come from a bird approximately the size of a large modern cormorant such as *Phalacrocorax carbo*, although the proportions of the femur are quite different. Comparison with the femora and coracoids in the larger species of Plotopteridae indicates that the Japanese fossil is of a size compatible with that of the holotypical coracoid of *Plotopterum joaquinensis*. Because both specimens are much smaller than any other known plotopterid but cannot be directly compared, we tentatively refer them to the same genus, there being no basis for establishing a new taxon for the Japanese femur.

The fossil reported here represents the geologically youngest known occurrence of the Plotopteridae. All of the species of plotopterids known from Oligocene deposits are much larger, although it is probably reasonable to assume that very large size is a derived condition and that the ancestral plotopterids would have been more similar in size to *Plotopterum* and the other members of the Pelecaniformes. We have suggested that the extinction of the giant species of Plotopteridae in the Northern Hemisphere and the giant penguins in the Southern Hemisphere may be related events possibly resulting from the increasing abundance and diversity of marine mammals in the mid-Tertiary. Regardless of the cause of their disappearance, the giant plotopterids evidently do not occur in deposits as young as Miocene in age and the family persists into the Neogene only in the small forms of the genus *Plotopterum* known so far from the early and middle Miocene of California (Arikarean) and Japan (Hemingfordian). The absence of fossils of this family in the extensively sampled younger Miocene deposits of the North Pacific basin is probably a good indication that the Plotopteridae became completely extinct prior to the late middle Miocene.

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