

Origin and rapid dispersal of oceanic dolphins (Odontoceti: Cetartiodactyla) based on the oldest fossil record.

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Oceanic dolphins (Delphinidae), such as killer whales, pilot whales and bottlenose dolphins, comprise approximately 36 extant species in 17 ~19 genera, which makes them the most speciose group of cetaceans inhabiting the modern ocean. Despite their current diversity, the fossil record of delphinids is very limited, and it remains unclear how and when they first originated. Molecular clock analyses date the divergence of delphinids from other delphinoids (porpoises, belugas and narwhals) to the Early or Middle Miocene (about 23 ~14 Ma). By contrast, the so far "oldest" extinct taxon confidently referred to the group - *Eodelphinus kabatensis* from Hokkaido - is no older than Late Miocene (about 9 Ma). Thus, there is a considerable gap between the estimated time of origin as inferred from molecular data and the fossil record, respectively.

Here, we re-examine the extinct dolphin *Sinanodelphis izumidaensis* Makiyama, 1936, which is known from a relatively well-preserved skull and associated partial skeleton from the Middle Miocene Bessho Formation (approximately 13.6 ~11.8 Ma), Nagano Prefecture, central Japan. Although initially described as a delphinid, later studies classified this species as Delphinoidea *incertae sedis* because of a lack of diagnostic characters and the incomplete preparation and limited accessibility of the holotype (the latter has been designated as a Natural Monument of Nagano Prefecture). For our analysis, we studied both the holotype (via direct observation and CT scanning) and two undescribed specimens (previously reported as Delphinoidea fam., gen. et sp. indet.) that were recovered from nearly the same locality and horizon. All of the specimens are similar in terms of general skull proportions, in having numerous, small teeth, and in having markedly asymmetrical external bony nares, indicating that they likely belong to the same species.

We performed phylogenetic analysis based on 84 species (all odontocetes) and 278 morphological characters, with the archaeocetes *Georgiacetus* and *Zygorhiza* used as out-group. Our results identify *S. izumidaensis* as one of the earliest diverging members of crown Delphinidae. This placement extends the fossil record of delphinids to ca. 14 ~12 Ma, only slightly younger than - and therefore in agreement with - the youngest molecular divergence dates. A further, as yet undescribed fossil delphinid apparently also occurs in the Middle or Late Miocene (13.6 ~10.3 Ma) of California. Together, *S. izumidaensis* and the Californian material demonstrate that delphinids may have inhabited both sides of the North Pacific as little as 1 Ma after their presumed time of origin. This, in turn, may be indicated that dolphins underwent a phase of rapid geographical dispersal early during their evolutionary history.

Keywords: *Sinanodelphis izumidaensis*, Delphinidae, Middle Miocene, Bessho and Aoki Formation