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FROM THE MIOCENE OF KENYA

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A FOSSIL BEAKED WHALE (CETACEA: ZIPHIIDAE) FROM THE MIOCENE OF KENYA

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ABSTRACT—A fossil beaked whale was discovered in 1964 in late middle Miocene sediments of northern Kenya. The specimen consists of a weathered rostral fragment, found in association with a freshwater-terrestrial fauna. It is similar to the Miocene genera *Provoziphius* and *Belemnoziphius* in lacking premaxillary basining. Those genera appear to be related to such modern forms as *Mesoplodon*, whereas the remainder of the Miocene ziphiids are probably more closely related to the living *Ziphius*. *Belemnoziphius compressus* Huxley, 1865, is designated the type species of the genus *Belemnoziphius*.

INTRODUCTION

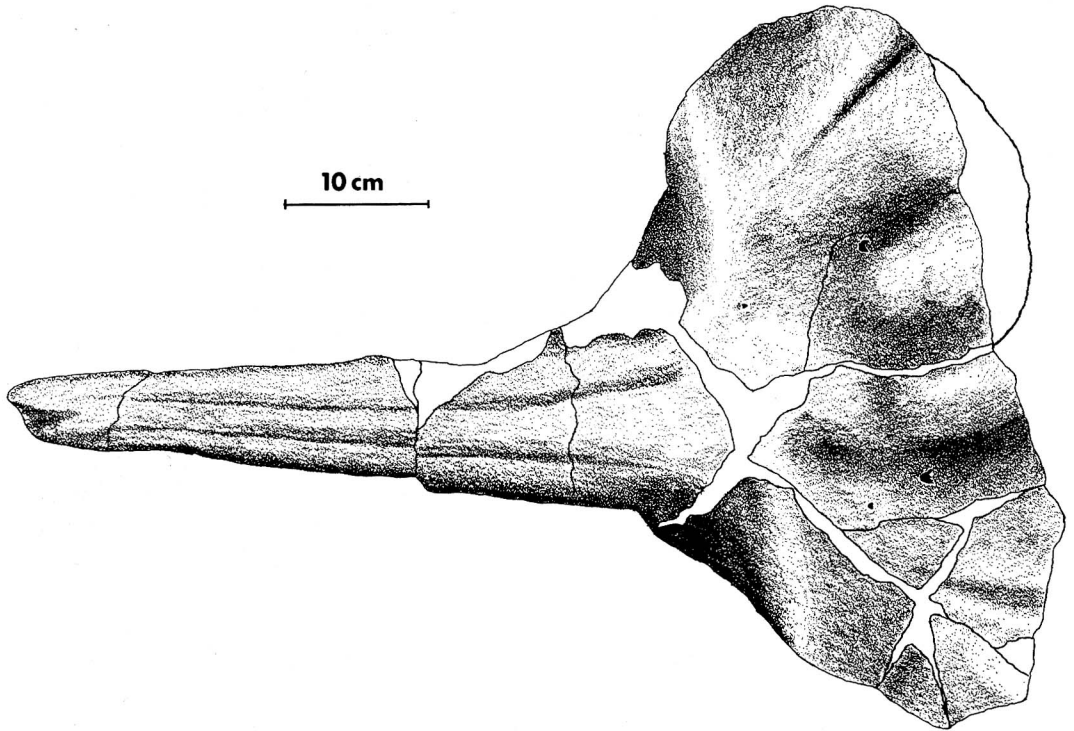
THE first cetaceans, found in the lower Eocene, are members of the suborder Archaeoceti. Archaeocetes flourished in the late Eocene, probably giving rise to the modern suborders of Cetacea during that time. The Oligocene presents a gap in the history of the Cetacea, yielding a few remnants of the archaeocetes and some poorly known and aberrant forms. Some of these are intermediate between archaeocetes and the modern cetaceans. In the Miocene, however, cetacean remains are abundant, and members of most of the living families and even a few living genera are present. Notable among these are the beaked whales, family Ziphiidae. This family is characterized by elongation of the rostrum, reduction of the dentition and elevation of the narial region. A few of the early forms assigned to this family preserve characters linking them to the more primitive squalodont cetaceans.

The specimen on which this report is based (Museum of Comparative Zoology, Harvard University, Field No. 14-64K) was recovered by the author during the summer of 1964, while on an expedition to the northern part of Kenya, under the leadership of Bryan Patterson of Harvard University, supported by National Science Foundation grant No. G. P. 1188. The specimen was obtained from the upper part of the Turkana Grit, about 20 feet below a basalt dated by K/Ar analysis at 16.7 ± 1.0 million years (Bryan Patterson, personal commun., 1969). This suggests a late middle Miocene (Burdigalian) age. Maglio (1969) presented a more extended correlation of these deposits. The locality is near Loperot, about 50 miles south-southeast of the town of Lodwar, in the Turkana District of Kenya (ap-

proximate geographic coordinates: $35^{\circ} 50' E$, $02^{\circ} 20' N$). The specimen was found in a well indurated bed of coarse sand to fine conglomerate, associated with the following fauna: bivalves, gastropods, *Protopterus*, *Polypterus*, miscellaneous other fish, *Tomistoma*, unidentified crocodile remains, trionychid, testudinid and other chelonian remains, hominoid, rodent, creodont, mastodont, gomphothere, hyracoid, suid, anthracothere, *Dorcatherium* and bovid remains (Maglio, 1969; Bryan Patterson, personal commun., 1969). D. Van Damme (personal commun., 1973) has indicated that the molluscan fauna associated with this cetacean suggests "a swampy flood plain or swamps connected with a periodically fluctuating river system."

The cetacean specimen consists of the rostrum and the ascending processes of the maxillae and premaxillae, broken from the rest of the skull just anterior to the nares. The overall length of the specimen is 82 cm, the greatest width (posteriorly) is 55 cm. The specimen contains the greater portions of the maxillae, premaxillae and vomer.

The tip of the rostrum is slightly eroded on the left side, but appears to be entire on the right side (Text-fig. 1). The premaxillae are separate at this point, forming a terminal notch as seen in the living ziphiids. One of the problems with this particular specimen is determining the relative extent of the premaxillae and vomer. On the dorsal surface the premaxillae do not appear to have met in the midline. About 5 cm posterior to the terminal notch, the dorsal surface bears a median groove and faint indications of paired grooves about 1.5 cm lateral to the median groove. The median groove could be interpreted as the junction of the premaxillae in the midline, or it could



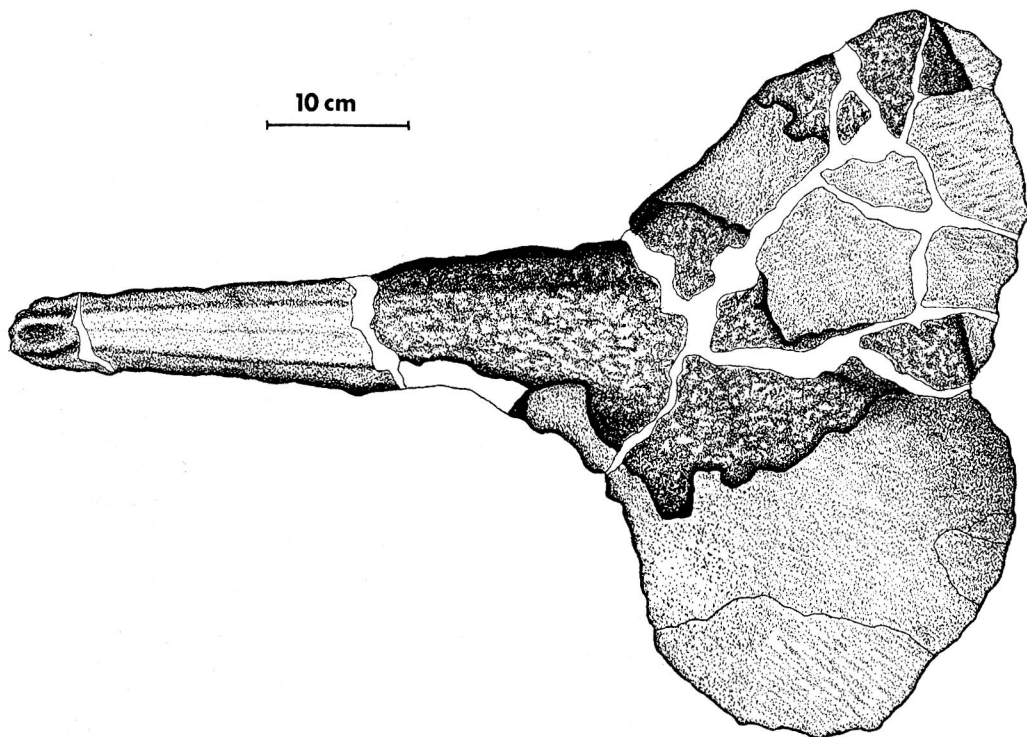
TEXT-FIG. 1—Dorsal view of ziphiid rostrum MCZ 14-64K.

be a groove in the mesorostral ossification of the vomer. The lateral grooves would then represent the junction of the vomer with the premaxillae. Posteriorly the median groove disappears and the lateral grooves become very distinct, bordering a rounded ridge about 2.5 cm wide in the midline. This is similar to the condition seen in those living species (*e.g.*, *Ziphius cavirostris*) in which the mesorostral ossification occupies the midline of the rostrum. I have interpreted the structure of the rostrum posteriorly as being similar to *Ziphius*. The ventral surface of the rostrum (Text-fig. 2) is eroded near the tip, but posteriorly there is a median groove and paired lateral alveolar grooves. There is no trace of separate alveoli, indicating that the upper dentition was reduced to the same extent as in most living ziphiids, and probably was not functional.

A thin section was ground 21 cm posterior to the tip of the rostrum in an attempt to ascertain the extent of the mesorostral ossification. However, no separation of the component bones of the rostrum could be seen. The rostrum is composed of cancellous bone, similar to that seen in most cetacean skeletal elements. The bone becomes denser and shows

clearer differentiation of osteones near the surface. So far as I am aware, there have been no histologic investigations of ziphiid rostra, but a few comparisons can be made from indirect evidence. Several authors (Fraser, 1942; Forbes, 1893; Raven, 1942) have published illustrations of ziphiid rostra showing the internal arrangement of the sutures. Flower & Lydekker (1891), however, state that the mesorostral ossification coalesces with the surrounding bones in *Ziphius* and *Mesoplodon*. Evidently the position at which the section is taken is important, as the published illustrations showing separate sutures are from sections near the base. In the present specimen, the sutures can be seen between the ascending processes of the right maxilla and premaxilla, but can be traced only a short distance onto the rostrum before they disappear (Text-fig. 3). The discrepancy between the observations of earlier authors is probably a result of the rostral elements being coalesced anteriorly, but separate posteriorly. The degree of ossification may also vary with age and sex, as Fraser (1942) has shown for the mesorostral ossification of *Ziphius*.

Some idea of the compactness of the rostral



TEXT-FIG. 2—Ventral view of ziphiid rostrum MCZ 14-64K.

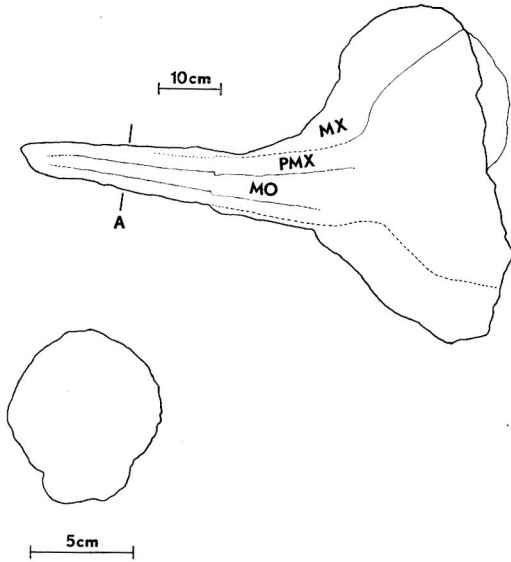
bone can be gained from references to its density. Cuvier (1823) described the original specimen of *Ziphius cavirostris* as a fossil on the basis of its density. Raven (1942) found the specific gravity of the rostrum of *Mesoplodon densirostris* to be 2.30, as compared to 1.71 for elephant ivory. In both of these cases, the bone of the rostrum must have been much more compact than in the Kenya specimen. In most of the other living ziphiids, however, the rostra are relatively light and are probably similar histologically to this specimen.

The posterior portion of the specimen, consisting of the ascending processes of the maxillae and premaxillae, appears to have been dorso-ventrally compressed during fossilization, but the extent of this is impossible to determine. The bone is heavily fractured and the rostrum is skewed to the right. The maxillary crests are prominent and lie nearly at right angles to the long axis of the specimen. Posteromedial to the maxillary crests are a pair of rounded elevations on the premaxillae, lying just anterior to the nares. Lateral to these premaxillary prominences are paired grooves which lie very near the maxillo-

premaxillary suture. These may have been produced by a thickening of the edge of the premaxilla in this area or by differential compression of the specimen. I can find no evidence of similar structures in other ziphiids. In some ziphiids there is a groove in this area which leads from one of the large foramina for the trigeminal nerve, but no signs of such a foramen can be seen in this specimen.

The ascending processes of the premaxillae lack the pronounced basining seen in some ziphiids and form a gentle depression with no definite borders. Anteriorly there is a small premaxillary foramen. A few additional small neurovascular foramina are present on the premaxillae. Aside from the strong maxillary crests, the maxillae are relatively featureless. The area around the junction of the rostrum with the ascending processes is heavily eroded on both sides, presumably because the infra-orbital foramina acted as foci for postdepositional erosion.

The ventral surface has been heavily eroded and the palatal elements and the descending processes of the maxillae are missing. The only features to be seen on this surface are radiating grooves on the posterior part of the



TEXT-FIG. 3—Above interpretation of sutures on the dorsal surface of MCZ 14-64K. MX = maxilla, PMX = premaxilla, MO = mesorostral ossification. Below, cross section of rostrum at point A.

maxillae, produced by squamous suturing to the frontals.

COMPARISONS

This specimen is readily assignable to the family *Ziphiidae* (Gray, 1865) on the basis of the reduction of dentition and prolongation of the rostrum. Many genera of fossil ziphiids are based upon characters not present in this specimen and can only be compared indirectly. *Cetorhynchus* and *Paleoziphius* are based only upon lower jaws. These genera are probably related to *Incacetus*, *Notocetus* and *Squalodelphis*, which are known from skulls possessing an unreduced dentition. These six genera constitute a group of primitive ziphiids which appear to be related to the squalodonts. The Turkana specimen differs considerably from this group in the reduction of its dentition and the filling of the mesorostral canal. In both of these features it more closely resembles some modern ziphiids.

Berardiopsis is based upon a few caudal vertebrae and is difficult to compare to any other ziphiids. *Ziphioides* is a form genus based upon teeth similar to those of the living *Berardius*. *Anoplomassa*, as True (1907) noted, probably represents a lineage separate from the other ziphiids. It is known only from a mandibular fragment and thus cannot be compared to the Turkana specimen.

This leaves a group of extinct genera which appear to be more closely related to the modern ziphiids. These are *Belemnoziphius*, *Choneziphius*, *Eboroziphius*, *Pelycorhamphus*, *Proroziphius*, and *Ziphirostrum*. These genera are known almost exclusively from rostral fragments. The postnarial region, which is so important in differentiating modern genera, is known in very few. Rudimentary alveoli are present in *Choneziphius* and *Ziphirostrum*, but a trend towards reduction of the dentition is strongly expressed in this group of genera. The Kenya specimen belongs in this group, but differs from its members in a number of characters.

In *Choneziphius*, *Eboroziphius* and *Proroziphius* the premaxillae fuse medially, enclosing a supravomerine canal, which housed the mesorostral cartilage, and which does not become filled by mesorostral ossification (Leidy, 1877). The ascending processes of the premaxillae are relatively flat in *Proroziphius*, but show pronounced basining in *Choneziphius* and *Eboroziphius*. In *Ziphirostrum* the supravomerine canal is closed over anteriorly by the premaxillae, but is open posteriorly, forming a wide mesorostral gutter (Abel, 1905). In none of these genera is the supravomerine canal filled by mesorostral ossification, as it is in the Kenya specimen.

Two genera of fossil ziphiids, *Pelycorhamphus* (Cope, 1895) and *Belemnoziphius* (Huxley, 1865) possess rostra in which the supravomerine canal was filled by ossification. The first of these was described on the basis of a weathered rostrum of unknown origin. Cope characterized it by its marked asymmetry and by a posterior expansion of the "vomer" to form a large basin anterior to the nares. It is extremely difficult to assess the relations of this genus from the confused description given by Cope. He was apparently unable to differentiate the premaxillae and the vomer, and makes no mention of the former, though it is probably the element forming the basin mentioned above. All that can be obtained from Cope's description is that the rostrum was extremely asymmetrical, that prenarial basining was prominent, and that the supravomerine canal was roofed over or filled in. The last point agrees with the Kenya specimen but the first two are markedly different and suggest that *Pelycorhamphus* is more closely related to *Choneziphius*.

Belemnoziphius (Huxley) included *Ziphius longirostris* Cuvier, *Dioplodon becanii* Gervais & Van Beneden, and *Belemnoziphius compressus*

Huxley. In addition, Huxley (1865) referred to this genus a number of species of *Ziphius* named by Owen in an unpublished manuscript. When Owen later published this work (1870), it contained a species, *Ziphius compressus* Owen, which may be based upon the same specimen as *B. compressus*, though Owen makes no mention of this. *Ziphius*, as interpreted by Owen, contained all of the ziphiid specimens from the Red Crag, including some probably belonging to distinctly separate genera (notably *Choneziphius*).

As *Belemnoziphius* contains a varied assemblage of specimens, it is best to restrict its definition to include only the characters set forth by Huxley, and to establish a type species. Since *B. compressus* Huxley was the species upon which Huxley seems to have based his concept of the genus, I designate it as the type species under the provisions of article 69(a) of the International Code of Zoological Nomenclature. The type specimen is figured by Huxley (1865, pl. 19) and may also be the specimen represented in plate 5, figure 3 (Owen, 1870). It is now possible to consider this genus both in terms of the defining characters set forth by Huxley, and in terms of the type species. The principal characters set forth by that author were:

"...the vomer occupies fully a third of the width of the upper face of the rostrum; and in the few instances in which the extremity of the rostrum is entire, it is not bifid, but sharply pointed, almost like the end of the guard of a belemnite, the vomer and the premaxillae seeming to coalesce into one solid terminal cone."

The first character is well exemplified by *B. compressus* as illustrated by Huxley, and is present in some of the species of "*Ziphius*" figured by Owen. The second character is unfortunately not preserved in the figured specimen of *B. compressus* nor in any of the figured specimens referred to this genus by Huxley.

The terminal portion of the rostrum is distinctly bifid in the Kenya specimen, mesorostral ossification having not extended this far forward. The width of the mesorostral ossification on the surface of the rostrum is difficult to estimate, but appears to be somewhat less than in *B. compressus* and the pertinent Red Crag material figured by Owen. It is about the same size as that seen in Cuvier's (1823) illustration of *Ziphius longirostris*. I attach little weight to this character, however, as it is extremely variable with respect to age, sex and degree of preservation. It is

related to age and the degree of mesorostral ossification in *Ziphius*, and is variable in adult males (e.g., Fraser, 1942, pl. 3; Mitchell & Houck, 1967, fig. 1).

The material referred to *Belemnoziphius* by Huxley differs from the Kenya specimen in having a greater development of the premaxillary basins on the premaxillae, and in the position of the premaxillary foramina. The former, where preserved in *Belemnoziphius*, are more similar to those of *Choneziphius*. The latter are placed anteriorly in the *Belemnoziphius* specimens, near the confluence of the rostrum with the ascending processes of the maxillae and premaxillae. In the Kenya specimen these foramina are placed more posteriorly and are smaller.

The Kenya specimen differs from other fossil ziphiids in a few additional characters which are less objective and more difficult to compare. The premaxillary area is striking in its simplicity and lack of relief. Part of this may be due to compression, but the majority of it appears to be real. The only major features in this area are the maxillary crests, which are somewhat reminiscent of those of *Hyperoodon*, but are oriented differently. If the sutures are properly interpreted, the ascending processes of the premaxillae are much wider than in other ziphiids. The maxillae appear thicker than in other ziphiids, certainly more so than in the modern forms.

SUMMARY AND CONCLUSIONS

The advanced ziphiids (i.e., those with a reduced dentition) show two pronounced rostral modifications which can be used to separate the genera into groups. These are: 1) mesorostral ossification of the vomer, which reaches its greatest development in the living *Mesoplodon densirostris*, in which the rostral elements are completely synostosed and the bone of the rostrum is extremely dense; 2) basining of the premaxillary portion of the premaxillae, best exemplified by the modern *Ziphius*, in which the lateral margins of the premaxillae form crests delimiting a median basin.

Choneziphius, *Eboroziphius* and *Pelycorhamphus* show premaxillary basining and probably constitute a phylogenetically separate group. Of the more primitive ziphiids, *Ziphirostrum* shows a tendency towards this condition and may be related to the ancestry of this group. The pronounced premaxillary basining of *Ziphius* suggests a relationship to this group, but differ-

TABLE 1—Summary of fossil ziphiid genera.

Genus	Locality	Material	Horizon
<i>Anoplomassa</i> Cope, 1869	"not far from Savannah, Ga."	mandible	?Upper Miocene
<i>Belemnoziphius</i> Huxley, 1865	England	rostra	?Upper Miocene
<i>Berardiopsis</i> Portis, 1886	Italy	caudal vertebrae	Middle Pliocene
<i>Cetorhynchus</i> Gervais, 1861	France	mandible	Middle Miocene
<i>Choneziphius</i> Duvernoy, 1851	Belgium, South Carolina	rostra	Upper Miocene
<i>Eboroziphius</i> Leidy, 1877	South Carolina	rostrum	Upper Miocene
<i>Incacetus</i> Colbert, 1944	Peru	skull	Miocene
<i>Notocetus</i> Moreno, 1892	Argentina	skulls	Lower Miocene
<i>Paleoziphius</i> Abel, 1905	Belgium	mandible	Upper Miocene
<i>Pelycorhamphus</i> Cope, 1895	?Maryland	rostrum	Miocene
<i>Proroziphius</i> Leidy, 1876	South Carolina	rostra	Upper Miocene
<i>Squalodelphis</i> Dal Piaz, 1917	Italy	skulls	?Lower Miocene
<i>Ziphioides</i> Probst, 1886	Germany	teeth	Middle Miocene
<i>Ziphirostrum</i> Du Bus, 1868	Belgium	skull	Upper Miocene

ences in the mode of mesorostral ossification render a direct relationship to any of the known genera unlikely.

The remaining advanced ziphiids (*Belemnoziphius* and *Proroziphius*) have relatively flat premaxillae and are less easy to characterize. Mesorostral ossification is variable and relatively few other characters are preserved, hence the relationships of these animals are more confused and uncertain. Cross sectional shape of the rostrum might serve as a useful character, but this would necessitate a restudy of the original material. The Kenya specimen belongs in this group and appears to be more closely related to some of the specimens included in *Belemnoziphius* (Huxley, 1865). The mode of mesorostral ossification of *Proroziphius* is quite different from that of the Kenya specimen. This group of ziphiids was included in *Mesoplodon* by Lydekker (1887) and Abel (1905). While many of the specimens resemble *Mesoplodon* closely, this is cer-

tainly an oversimplification. *Mesoplodon* was very likely derived from this group, and *Hyperoodon* may have its ancestry here as well.

In view of the wide distribution of living ziphiid species, and the known age and sex variation in rostra (Mitchell & Houck, 1967; Omura, 1972), paleontological studies of ziphiid systematics must take this variation into account. This is particularly relevant, considering that much of the fossil record is comprised of rostra (*cf.* Table 1). A thorough, worldwide review of these fossils is needed.

The occurrence of a ziphiid in freshwater deposits is difficult to explain. No other fossil ziphiids have been found in such deposits, and the extant members of the family inhabit the open oceans. The size of the specimen precludes the possibility of lengthy transport, hence it must have died near the site of burial. Since this represents a unique occurrence, I am inclined to suggest that this animal had

strayed into freshwater from a more normal marine habitat. Drainage in this area was probably to the east (Van Damme, personal commun., 1973), as there is no indication of a connection with the Nile prior to the Pleistocene (Walsh & Dodson, 1969). There is no information on the distance of the sea in the Miocene, but it may not have been great. The presence of a relatively large cetacean (on the order of 20 feet long) in these deposits indicates that the area was drained by a substantial river.

REFERENCES

- Abel, O. 1905. Les odontocetes du Bolderien (Miocene Superieur) d'Anvers. Mus. Roy. d'Hist. Nat. de Belg. Mém. 3:1-155.
- Colbert, E. H. 1944. A new fossil whale from the Miocene of Peru. Amer. Mus. Natur. Hist. Bull. 83(3):195-216.
- Cope, E. D. 1869. Synopsis of the extinct mammalia of the cave formations in the United States, with observations on some Myriapoda found in and near the same, and on some extinct mammals of the caves of Anguilla, W. I., and other localities. Amer. Phil. Soc. Proc. 11:171-192.
- . 1895. Fourth contribution to the marine fauna of the Miocene period of the United States. Amer. Phil. Soc. Proc. 34:135-155.
- Cuvier, G. 1823. Recherches sur les ossements fossiles. G. Dufour et E. d'Ocagne V. 5, p. 357, Pl. 27. Paris.
- Dal Piaz, G. 1917. Gli odontoceti del Miocene Bellunese; Pt. 3, *Squalodelphis fabianii*. Inst. Geol. d. Roy. Univ. di Padova Mem. 5:1-34.
- Du Bus, G. 1868. Sur differents zyphioides nouveaux du Crag d'Anvers. Acad. Roy. d. Belg. Bull., 2me ser., 35:621-630.
- Duvernoy, M. 1851. Mémoire sur les caractères ostéologiques des genres nouveaux ou des espèces nouvelles des cetacés vivants ou fossiles. Ann. d. Sci. Natur., Zool., 3me ser., 15:5-71.
- Flower, W. and R. Lydekker. 1891. An introduction to the study of mammals living and extinct. Adam & Charles Black, 793 p. London.
- Forbes, H. O. 1893. Observations on the development of the rostrum in the cetacean genus *Mesoplodon*, with remarks on some of the species. Zool. Soc. Lond. Proc. 1893:216-236.
- Fraser, F. 1942. The mesorostral ossification of *Ziphius cavirostris*. Zool. Soc. Lond. Proc. (B) 112:21-30.
- Gervais, P. 1861. Sur différentes espèces de vertebres fossiles observés pour la plupart dans le midi de la France. Acad. Sci. Lett. Montpellier Mem. 5:117-132.
- Gray, J. E. 1865. Notices of a new genus of delphinoid whales from the Cape of Good Hope, and of other cetaceans from the same seas. Zool. Soc. Lond. Proc. 1865:522-529.
- Huxley, T. H. 1865. On the cetacean fossils termed "*Ziphius*" by Cuvier, with a notice of a new species (*Belemnoziphius compressus*) from the Red Crag. Quart. J. Geol. Soc. London 20:388-396.
- Leidy, J. O. 1876. Remarks on fossils from the Ashley Phosphate Beds. Philadelphia Acad. Natur. Sci. Proc. 1876:80-81.
- . 1877. Description of vertebrate remains, chiefly from the Phosphate Beds of South Carolina. Philadelphia Acad. Natur. Sci. J., 2nd ser., 8:209-261.
- Lydekker, R. 1887. Catalogue of the fossil mammalia in the British Museum (Natural History). Pt. V, p. 68-73.
- Maglio, V. J. 1969. A shovel-tusked gomphothere from the Miocene of Kenya. Mus. Comp. Zool., Breviora no. 310, 10 p.
- Mitchell, E. and W. J. Houck. 1967. Cuvier's Beaked Whale (*Ziphius cavirostris*) stranded in northern California. Jour. Fish. Res. Bd. Canada, 24(12):2503-2513.
- Moreno, E. P. 1892. Lijeros apuntes sobre dos generos de cetaceos fosiles de la Republica Argentina. Mus. de La Plata, Rev., 3:393-400.
- Omura, H. 1972. An osteological study of the Cuvier's Beaked Whale, *Ziphius cavirostris*, in the Northwest Pacific. Sci. Rept. Whales Res. Inst., Tokyo, 24:1-34.
- Owen, R. 1870. Monograph on the British fossil cetacea from the Red Crag. Palaeontogr. Soc., 1869:1-40.
- Portis, A. 1886. Catalogo descrittivo del talassoterii rinvenuti nei terreni terziari del Piemonte e della Liguria. R. Accad. Sci. Torino Mem., ser. 2, 37:247-365.
- Probst, J. 1886. Ueber die fossilen reste von zahnwalen (cetodonten) aus der Molasse von Baltrigen. Jahresh. ver Naturk. Württemberg, 42:102-145.
- Raven, H. 1942. On the structure of *Mesoplodon densirostris*, a rare beaked whale. Amer. Mus. Natur. Hist. Bull. 80(2):23-50.
- True, F. 1907. Observations on the type specimen of the fossil cetacean *Anoplomassa forcipata* cope. Mus. Comp. Zool. Bull. 51(4):97-106.
- Walsh, J. and R. Dodson. 1969. Geology of Northern Kenya. Geol. Surv. Kenya Rept. 82, 42 p.