

- Deméré, T.A., McGowen, M.R., Berta, A., and Gatesy, J. (2008). Morphological and molecular evidence for a stepwise evolutionary transition from teeth to baleen in mysticete cetaceans. *Syst. Biol.* **57**, 15–37.
- Ekdale, E.G., Deméré, T.A., and Berta, A. (2015). Vascularization of the gray whale plate (Cetacea, Mysticeti, *Eschrichtius robustus*): soft tissue evidence for an alveolar source of blood to baleen. *Anat. Rec.* **298**, 691–702.
- Fitzgerald, E.M. (2006). A bizarre new toothed mysticete (Cetacea) from Australia and the early evolution of baleen whales. *Proc. R. Soc. B. Lond.* **273**, 2955–2963.
- Fitzgerald, E.M. (2010). The morphology and systematics of *Mammalodon colliveri* (Cetacea: Mysticeti), a toothed mysticete from the Oligocene of Australia. *Zool. J. Linn. Soc.* **158**, 367–476.
- Fitzgerald, E.M. (2011). Archaeocete-like jaws in a baleen whale. *Biol. Lett.* **8**, 94–96.
- Fordyce, R.E., and Marx, F.G. (2012). The pygmy right whale *Caperea marginata*: the last of the cetotheres. *Proc. R. Soc. B* **280**, 20122645.
- Fordyce, R.E., and Marx, F.G. (2016). Mysticetes baring their teeth: a new fossil whale, *Mammalodon hakataramea*, from the Southwest Pacific. *Mem. Mus. Vic* **74**, 107–116.
- Gol'din, P., Startsev, D., and Krakhmalnaya, T. (2014). The anatomy of the late Miocene baleen whale *Cetotherium riabinini* from Ukraine. *Acta Palaeontol. Pol.* **59**, 795–814.
- Ishikawa, H., Amasaki, H., Dohguchi, H., Furuya, A., and Suzuki, K. (1999). Immunohistological distributions of fibronectin, tenascin, type I, III and IV collagens, and laminin during tooth development and degeneration in fetuses of minke whale, *Balaenoptera acutorostrata*. *J. Vet. Med. Sci.* **61**, 227–232.
- Karlsen, K. (1962). Development of tooth germs and adjacent structures in the whalebone whale (*Balaenoptera physalus* (L.)). *Hval. Skrifler.* **45**, 5–56.
- Kellogg, A.R. (1968). Fossil marine mammals from the Miocene Calvert Formation of Maryland and Virginia, Part 7: A sharp-nosed cetotherium from the Miocene Calvert. *Bull. US Natl. Mus.* **247**, 163–173.
- Marx, F.G. (2010). The more the merrier? A large cladistic analysis of mysticetes, and comments on the transition from tooth to baleen. *J. Mamm. Evol.* **18**, 77–100.
- Marx, F.G., and Fordyce, R.E. (2015). Baleen boom and bust: a synthesis of mysticete phylogeny, diversity and disparity. *R. Soc. Open Sci.* **2**, 140434.
- Marx, F.G., Tsai, C.-H., and Fordyce, R.E. (2016). A new early Oligocene toothed “baleen” whale (Mysticeti: Aetiocetidae) from western North America: one of the smallest. *R. Soc. Open Sci.* **2**, 150476.
- Peredo, C.M., and Uhen, M.D. (2016). A new basal chaemysticete (Mammalia: Cetacea) from the late Oligocene Pysht Formation of Washington, USA. *Pap. Palaeo* **2**, 1–22.
- Ridewood, W.G. (1923). Observations on the skull in foetal specimens of whales of the genera *Megaptera* and *Balaenoptera*. *Philos. Trans. R. Soc. Lond. Ser. B* **211**, 209–272.
- Tsai, C.-H., and Ando, T. (2015). Niche partitioning in Oligocene toothed mysticetes. *J. Mamm. Evol.* **23**(1), 33–41.
- Tsai, C.-H., and Fordyce, R.E. (2015). The earliest gulp-feeding mysticetes (Cetacea: Mysticeti) from the Oligocene of New Zealand. *J. Mamm. Evol.* **22**(4), 535–560.
- Tsai, C.-H., and Fordyce, R.E. (2016). Archaic baleen whale from the Kokoamu Greensand: earbones distinguish a new late Oligocene mysticete (Cetacea: Mysticeti) from New Zealand. *J. R. Soc. N. Zeal.* doi:10.1080/03036758.2016.1156552.

BARNACLES

DAGMAR FERTL AND WILLIAM A. NEWMAN

“Barnacle” is the common name for over 1000 marine species of the subclass Cirripedia. Barnacles are unique among crustaceans

in being permanently attached as adults to a variety of inanimate and animate objects. Barnacles occur in polar, tropical, and temperate waters, being found from high on the shore to the depths of the ocean. The principal superorder is Thoracica, consisting of stalked (order Pedunculata) and sessile (order Sessilia) barnacles (Newman, 1996). Perhaps as many as 20 living barnacle species have some association with marine mammal species, primarily cetaceans (Ross and Newman, 1967; Newman and Ross, 1976; Hayashi et al., 2013).

Barnacles attached to marine mammals are often referred to as ectoparasites; however, in reality, they do not feed on their hosts, but use them as a moving substratum from which they can strain plankton from the passing water. As a result, “epibiotic” is often considered a more appropriate term describing the barnacle’s lifestyle. This has been described as an example of symbiosis, usually commensalism, but barnacles create drag and can cause irritations. Therefore, they are perhaps best termed “semiparasitic,” since they survive and perpetuate themselves at the host’s expense. On the other hand, some marine mammals eat barnacles and/or their larvae.

I. Life History

Barnacles were described by T. H. Huxley and Louis Agassiz as nothing more than “a little shrimp-like animal, standing on its head in a limestone house and kicking food into its mouth” (Hoover, 2006). Most barnacles are hermaphrodites (i.e., individuals possess the reproductive structures of both sexes). The life cycle usually includes six free-swimming planktonic naupliar stages that feed while progressing by molts to the cypris or cyprid stage, which searches for a place to settle. When settling, to anchor itself, the cyprid secretes cement from its antennules, from glands located in their base, and metamorphoses by molting into a juvenile, which begins to secrete adult cement and the calcareous plates that usually constitute its home.

The cyprid actively selects and explores where it will settle, and those that attach directly to cetacean skin, a chemical cue from the host tissue likely induces larval settlement (Nogata and Matsumura, 2006) and detailed studies of site selection have been made (Carrillo et al., 2015). Through an aperture between the plates, six pairs of feathery thoracic limbs (cirri) can be spread out for passive feeding in currents, or they can be swept through the water like a net to entrap planktonic organisms. The breeding season of barnacles that cling to whales is probably largely synchronous with that of the whales’ breeding season.

II. Sessile Barnacles

The Sessilia, or sessile barnacles, are stalkless, the usually well-articulated shell wall being attached directly to the substratum. Because of their superficial resemblance to acorns of oak trees, they are called acorn barnacles. Marine mammals host species of *Amphibalanus*, *Balanus*, *Cetopirus*, *Chelonibia*, *Coronula*, *Cryptoplepas*, *Platylepas*, *Tubicinella*, and *Xenobalanus*. *Xenobalanus* superficially resembles a stalked barnacle since it has developed an aberrant pseudo-stalk, but it is nonetheless a sessile barnacle (Fig. 1).

III. Stalked Barnacles

The pedunculate, or stalked, barnacles are more primitive than the sessile barnacles. The terminal sac housing the appendages is called the capitulum. It is supported by a flexible, muscular stalk or peduncle attached to the substratum. While the capitulum is usually protected by shell plates, it is naked in *Conchoderma* spp., the goose barnacles (*Lepas* spp.), and rarely, the leaf barnacles (*Pollicipes* spp.), species of which attach to whales.



Figure 1 The pseudo-stalked sessile barnacle *Xenobalanus* attached to the dorsal fin of a bottlenose dolphin (Photo by V. Thayer and K. Rittmaster, North Carolina Maritime Museum).

IV. Barnacles and Marine Mammals

Barnacles appear to settle in greatest numbers on large baleen whales, in contrast to toothed whales. Striped dolphins (*Stenella coeruleoalba*) involved in a mass mortality event in the Mediterranean had an unusual abundance of barnacles likely due to the reduced movement and/or an impaired immune function of the skin of sick individuals (Aznar et al., 2005). Orams and Schuetz (1998) demonstrated that *Xenobalanus* spp. were more prevalent on young than adult bottlenose dolphins (*Tursiops* spp.), presumably because they are less active and/or less resistant.

Cryptolepas rhachianecti, considered to be host-specific to the gray whale (*Eschrichtius robustus*), has been found on a killer whale (*Orcinus orca*) stranded in southern California and on belugas (*Delphinapterus leucas*) housed in San Diego Bay. *Xenobalanus globicipitus*, while worldwide in distribution, are almost always found on the trailing edges of the dorsal and pectoral fins and on the flukes of at least 27 cetacean species (Kane et al., 2006; Fig. 1). What may remain of their wall in the skin of the host after death superficially resembles the wall of platylepas; this likely accounts for a report (Mead and Potter, 1990) of platylepas on a bottlenose dolphin. *Tubicinella major*, which lives within a columnar shell opening at the surface of its host's skin, and usually found among callosities of southern right whale (*Eubalaena australis*), was once collected from the flank of a stranded northern bottlenose whale (*Hyperoodon ampullatus*). *Coronula* spp., the most generalized of the sessile whale barnacles, are large and generally attach to the skin of baleen whales (Scarff, 1986). *C. reginae* and *C. diadema* (Fig. 2) are commonly epizooites of humpback whales (*Megaptera novaeangliae*), attached to flukes, flippers, ventral grooves, genital slit, and the head (Clarke, 1966). *Cetopirus complanatus* closely resembles *C. reginae*, and both occur on the right whale (Scarff, 1986). Humpback males scrape each other with their barnacle-encrusted flippers (analogous to "brass knuckles") on the breeding grounds; one individual caught during whaling operations was reported to have as



Figure 2 Humpback whale with the acorn barnacle *Coronula diadema* and a few stalked barnacles *Conchoderma auritum* attached to them. Also visible are whale lice (Photo by Alisa Schulman-Janiger, off California, 2016).



Figure 3 *Conchoderma auritum* attached to the teeth of a Blainville's beaked whale (*Mesoplodon densirostris*) off Hawai'i (Photo by Alice Mackay, courtesy Cascadia Research).

much as 450kg of *Coronula* removed from it. On the other hand, various forms of grooming, including flipper-body grooming (Sakai et al., 2006), would likely remove freshly settled larvae and young juveniles; this may account for the lack of barnacles on the bodies of most small toothed whales.

Of the pelagic pedunculate barnacles, *Conchoderma auritum* and *C. virgatum* are commonly recorded from cetaceans, though *Pollicipes polymerus*, a rocky shore barnacle, was recorded on a humpback whale (Clarke, 1966). *Conchoderma* spp. require a hard surface for attachment. *C. auritum*, identified by its' rabbit ear-like appendages, may be found at a site where teeth are exposed and unprotected (Soto, 2001), such as on erupted teeth of adult male beaked and bottlenose (*Hyperoodon* spp.) whales (Fig. 3), or because of a malformation (including bone injury) in the jaw. *Conchoderma* spp. are less commonly found on baleen plates and were once collected from the penis of a stranded sperm whale (*Physeter macrocephalus*). *C. auritum* is often found attached to *Coronula* spp. (most

commonly to *C. diadema*). *C. virgatum*, although sometimes attaching directly to a cetacean, is usually epizootic on other barnacles, and then most often on *Conchoderma auritum*. *C. virgatum* has been found on the parasitic copepods *Pennella* spp. and on the cyamid amphipod, *Neocyamus physteris*, which crawls about on cetaceans and their barnacles (Clarke, 1966; Oliver and Trilles, 2000). *Lepas* spp. usually occur on floating objects, yet *L. pectinata* and *L. hillii* have been found between the teeth of some Mediterranean striped dolphins.

There are comparatively few published records of barnacles on pinnipeds, yet *L. pacifica*, *L. australis*, and *L. hillii*, as well as *C. auritum* and *C. virgatum*, are recorded from their dorsal body surface, attached to hair or even directly to the skin of various species, including both species of elephant seals (*Mirounga* spp.) (Best, 1971; Setsaas and Bester, 2006; Fig. 4).

Manatees (*Trichechus* spp.) may acquire acorn barnacles when in brackish or seawater, but when they enter fresh water the barnacles die and drop off, leaving temporary scars. The common barnacle found embedded in the skin of West Indian and West African manatees (*Trichechus manatus* and *T. senegalensis*, respectively) is *Chelonibia manati* (Cintrón De Jesús, 2001), a close relative of its congeners on turtles. Moreover, turtle barnacles *Platylepas hexastylus* and *P. decorata* have been found on the dugong (*Dugong dugon*) and West Indian manatee. The brackish water species, *Amphibalanus amphitrite*, *A. eburneus*, *A. reticulatus*, and *A. improvisus*, and the marine species, *Balanus trigonus*, attach to the *Chelonibia* spp. on the manatees, rather than to their skin.

It is not surprising that some baleen whales eat barnacle larvae (Mayo and Marx, 1990) since the experimentally estimated filtering efficiency of 95% for plankton larger than 333 µm for the right whale (Mayo et al., 2001) would include the larvae of pelagic and some coastal barnacles.

Sea otters (*Enhydra lutris*) in California and Alaska will eat the large acorn barnacles *Balanus nubilus* and *Semibalanus cariosus*. Faurot et al. (1986) reported otters feeding on *Pollicipes polymerus*, suggesting that they may be intentionally ingesting it if not simply being incidental to their take of mussels.

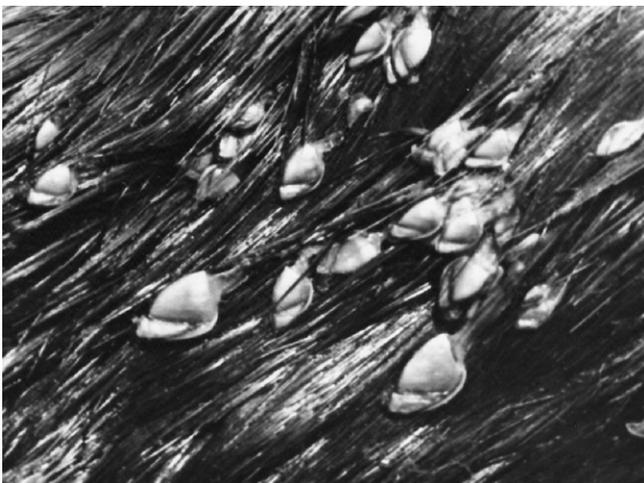


Figure 4 Goose barnacle (*Lepas australis*) attached among the hairs of a subantarctic fur seal (*Arctocephalus tropicalis*) (Photo by M. N. Bester).

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References

- Aznar, F.J., Perdiguero, D., Pérez del Olmo, A., Repullés, A., Agusti, C., and Raga, J.A. (2005). Changes in epizoic crustacean infestations during cetacean die-offs: The mass mortality of Mediterranean striped dolphins *Stenella coeruleoalba* revisited. *Dis. Aquat. Org.* **67**, 239–247.
- Best, P.B. (1971). Stalked barnacles *Conchoderma auritum* on an elephant seal: Occurrence of elephant seals on South African coast. *Zool. Afr.* **6**, 181–185.
- Carrillo, J.M., Overstreet, R.M., Raga, J.A., and Aznar, F.J. (2015). Living on the edge: Settlement patterns by the symbiotic barnacle *Xenobalanus globicipitis* on small cetaceans. *PLoS ONE* **10**, e0127367.
- Cintrón de Jesús, J. (2001). *Barnacles associated with marine vertebrates in Puerto Rico and Florida*. Master's thesis. University of Puerto Rico.
- Clarke, R. (1966). The stalked barnacle *Conchoderma*, ectoparasitic on whales. *Nor. Hvalfangst.-Tid.* **55**, 153–168.
- Faurot, E.R., Ames, J.A., and Costa, D.P. (1986). Analysis of sea otter, *Enhydra lutris*, scats collected from a California haulout site. *Mar. Mamm. Sci.* **2**, 223–227.
- Hayashi, R., Chan, B.K.K., Simon-Blecher, N., Watanabe, H., Guy-Haim, T., Yonezawa, T., Levy, Y., Shuto, T., and Achituv, Y. (2015). Phylogenetic position and evolutionary history of the turtle and whale barnacles (Cirripedia: Balanomorph: Coronuloidea). *Mol. Phylogenet. Evol.* **67**, 9–14.
- Hoover, L.P. (2006). *Hawaii's Sea Creatures*, 3rd ed. Mutual Publishing, Honolulu, Hawaii.
- Kane, E., Olson, P., and Gerrodette, T. (2006). The commensal barnacle *Xenobalanus globicipitis* Steenstrup, 1851 (Crustacea: Cirripedia) and its relationship to cetaceans of the eastern tropical Pacific. NMFS-SWFSC Administrative Report LJ-06-03.
- Mayo, C.A., and Marx, M.K. (1990). Surface foraging behavior of the North Atlantic right whale, *Eubalaena glacialis*, and associated zooplankton characteristics. *Can. J. Zool.* **68**, 2214–2220.
- Mayo, C.A., Letcher, B.H., and Scott, S. (2001). Zooplankton filtering efficiency of the baleen of a North Atlantic right whale, *Eubalaena glacialis*. *J. Cetacean Res. Manage.* (Spec. Issue 2), 225–230.
- Mead, J.G., and Potter, C.W. (1990). Natural history of bottlenose dolphins along the central Atlantic Coast of the United States. In "The Bottlenose Dolphin", (S. Leatnerwood, and R.R. Reeves, Eds), pp. 165–195. Academic Press, San Diego, CA.
- Newman, W.A. (1996). Cirripedia; suborders Thoracica and Acrothoracica. In "Traité de Zoologie Tome VII, Crustacés, Fascicule", (J. Forest, Ed.), Vol. 2 (in French), pp. 453–540. Masson, Paris.
- Newman, W.A., and Ross, A. (1976). Revision of the balanomorph barnacles; including a catalog of the species. *Mem. San Diego Soc. Nat. Hist.* **9**, 1–108.
- Nogata, Y., and Matsumura, K. (2006). Larval development and settlement of a whale barnacle. *Biol. Lett.* **2**, 92–93.
- Oliver, G., and Trilles, J-P. (2000). Crustacés parasites et epizoïtes du Cachalot, *Physeter catodon* Linnaeus, 1758 (Cetacea, Odontoceti), dans le golfe du Lion (Méditerranée occidentale). *Parasite* **7**, 311–321.
- Orams, M.B., and Schuetze, C. (1998). Seasonal and age/size-related occurrence of a barnacle (*Xenobalanus globicipitis*) on bottlenose dolphins (*Tursiops truncatus*). *Mar. Mamm. Sci.* **14**, 186–189.
- Ross, A., and Newman, W.A. (1967). Eocene Balanidae of Florida, including a new genus and species with a unique plan of "turtle-barnacle" organization. *Am. Mus. Novit.* **2288**, 1–21.
- Sakai, M., Hishii, T., Takeda, T.S., and Kohsima, S. (2006). Flipper rubbing behaviors in wild bottlenose dolphins (*Tursiops aduncus*). *Mar. Mamm. Sci.* **22**, 966–978.
- Scarff, J.E. (1986). Occurrence of the barnacles *Coronula diadema*, *C. reginae* and *Cetopirus complanatus* (Cirripedia) on right whales. *Sci. Rep. Whal. Res. Inst. Tokyo* **37**, 129–153.

Setsaas, T.H., and Bester, M.N. (2006). Goose barnacle (*Lepas australis*) infestation of the Subantarctic fur seal (*Arctocephalus tropicalis*). *Afr. Zool.* 41, 305–307.

Soto, J.M.R. (2001). First record of a rabbit-eared barnacle, *Conchoderma auritum* (Linnaeus, 1767) (Crustacea, Cirripedia), on the teeth of the La Plata dolphin, *Pontoporia blainvillei* (Gervais & D'Orbigny, 1844) (Cetacea, Platanistoidea). *Mare Magnum* 1, 172–173.

BASILOSOURIDS AND KEKENODONTIDS

MARK D. UHEN

Basilosaurids are a paraphyletic group of archaeocete cetaceans known from the late middle to early late Eocene of all continents except Antarctica. The family includes 20 species in 12 genera. They range in size from around 4 m (*Saghacetus osiris*) to around 16 m (*Basilosaurus cetoides*). Basilosaurids are the earliest fully aquatic cetaceans (Uhen, 1998) and are thought to have given rise to modern cetaceans (Barnes et al., 1985; Uhen, 1998). Kekenodontids are a small group of basal Neoceti that occur in the Oligocene and are poorly known, mostly from the Southern Hemisphere. Kekenodontidae currently includes two species in two genera.

I. Characteristics

Like all archaeocetes, basilosaurids lack telescoping of the skull like that seen in modern mysticetes or like that seen in modern odontocetes (Fig. 1; Miller, 1923). In addition, basilosaurids are diphodont (have two tooth generations: milk and adult teeth), lack polydony (11 or fewer teeth per jaw half), and retain a heterodont dentition, in which incisors, canines, premolars, and molars are easy to distinguish based on their morphologies (Kellogg, 1936; Uhen, 1998).

Basilosaurids also share a number of characteristics that distinguish them from other archaeocetes. All basilosaurids lack upper third molars, and the upper molars lack protocones, trigon basins, and lingual third roots. In addition, the cheek teeth of basilosaurids

have well-developed accessory denticles on the cheek teeth (Fig. 1). The hind limbs of basilosaurids are greatly reduced (Fig. 2; Gingerich et al., 1990; Uhen and Gingerich, 2001) and lack a bony connection to the vertebral column. Basilosaurids also lack sacral vertebrae, although vertebrae that are likely to be homologs of sacral vertebrae are identifiable (Kellogg, 1936; Uhen, 1998).

Other characteristics may be found only in basilosaurids (within archaeocetes) but are currently not known from other archaeocetes. For instance, basilosaurid forelimbs had broad, fan-shaped scapulae with the distal humerus, radius, and ulna flattened into a single plane (Fig. 2). In addition, the elbow joint motion was restricted to the same plane, and pronation and supination of the forelimb was not possible based on the articular surfaces of the distal humerus, proximal radius, and proximal ulna. Since forelimbs are poorly known in more derived protocetids, it is unclear whether these features are found only in basilosaurids, or whether they are characteristic of a larger group.

Some of the characteristics of basilosaurids can be seen in some protocetid archaeocetes, like *Georgiacetus*. Although the innominate of *Georgiacetus* is large, it does not appear to have been connected to the vertebral column. None of the vertebrae is fused into a sacrum, yielding a condition similar to that seen in basilosaurids. In addition, the cheek teeth of *Georgiacetus* have small accessory denticles, somewhat different from those in basilosaurids, but certainly larger than any of the serrations seen in other nonbasilosaurid archaeocetes.

Kekenodontidae occur from the early to late Oligocene. Kekenodontids are both heterodont and diphodont, with many cranial and dental characteristics similar to those of basilosaurids, but they have some cranial features that ally them with Neoceti. Kekenodontids also have larger diastemata between their cheek teeth when compared with basilosaurids (Clementz et al., 2014).

II. Taxonomy

Taxonomy for the family Basilosauridae is after Uhen (2013). The names “zeuglodonts” and “zeuglodons” are often colloquially used to refer to basilosaurids or archaeocetes in general. These common names are derived from the disused generic name *Zeuglodon* (discussed below), and their usage should be avoided. Gingerich and Zouhri (2015) revived some long disused taxonomic

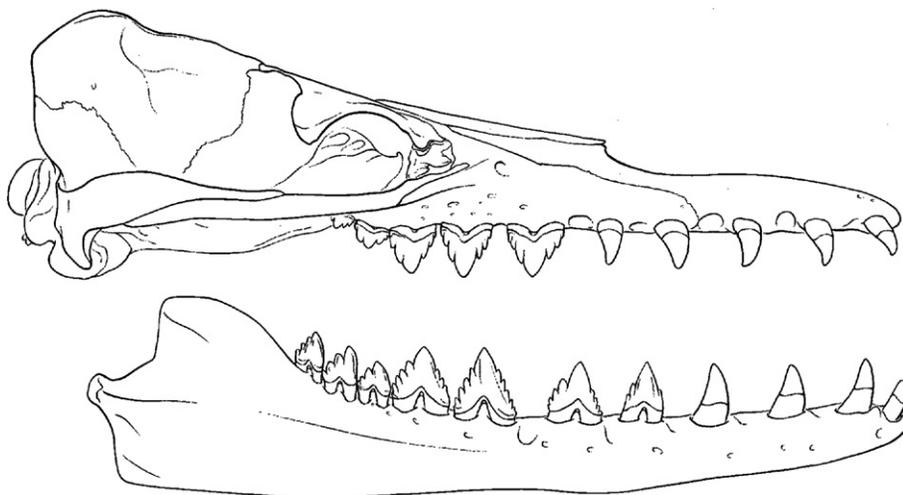


Figure 1 Skull and lower jaw of *Dorudon atrox*, lateral view. This drawing is a composite drawn from specimens of *D. atrox* at the University of Michigan Museum of Paleontology by Bonnie Miljour.

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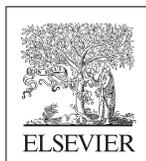
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