Supplementary Information to

**A NEW BALAENOPTERID SPECIES FROM THE SOUTHERN NORTH SEA BASIN INFORMS ABOUT PHYLOGENY AND TAXONOMY OF *BURTINOPSIS* AND *PROTORORQUALUS* (CETACEA, MYSTICETI, BALAENOPTERIDAE)**

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# COMPARATIVE DATASET

## INSTITUTIONAL ABBREVIATIONS

AMNH, American Museum of Natural History, New York, USA;
CASG, California Academy of Sciences, Department of Geology, San Francisco, California, USA;
ChM, The Charleston Museum, Charleston, USA;
CM, Condom Museum, University of Oregon, Eugene, Oregon; USA;
GNHM, Gamagori Natural History Museum, Gamagori, Japan;
GMNH, Gunma Museum of Natural History, Gunma, Japan;
KMNH, Kitakyushu Museum of Natural History and Human History, Kitakyushu, Japan;
LACM, Natural History Museum Los Angeles County, Los Angeles, California, USA
MAB, Oertijdmuseum Boxtel, Bosscheweg 80, 5283 WB Boxtel, The Netherlands;
MAUL, Museo dell'Ambiente, Università di Lecce, Lecce, Italy;
MB, Museum f¨ur Naturkunde, Humboldt–Universitat zu Berlin;
MGB, Museo Geopalaeontologico 'G. Capellini', Bologna, Italy;
MCA, Museo Geopalaeontologico 'G. Cortesi', Castell'Arquato, Italy;
MHNL, Museo de Historia Natural, Lima, Peru;
MLP, Museo de La Plata, La Plata, Argentina;
MNHL, Muséum national d'Histoire naturelle, Paris, France;
MPTAM, Ente Gestione Aree Protette Artigiane, Asti, Italy and Museo Paleontologico Territoriale dell'Astigiano e del Monferrato, Asti, Italy;
MRSN, Museo Regionale di Scienze Naturali, Torino, Italy;
MSM, Museum Sønderjylland, Department Natural History and Palaeontology, Gram, Denmark;
MSNT, Museo di Storia Naturale del Territorio, Calci, Italy;
MPST, Museo Palaeontologico, Salsomaggiore Terme, Italy;
NFL, Numata Fossil Museum, Hokkaido, Japan;
NHG, Natuurlijke Historie Genootschap, Koninklijk Zeeuwsch Genootschap; collection housed at and curated by the Zeeuws Museum, Middelburg, The Netherlands;
NMNH-P, Academician V.A. Topachevsky Paleontological Museum of the National Museum of Natural History of the National Academy of Sciences of Ukraine, Kiev, Ukraine;
NMB, NatuurMuseum Brabant, Tilburg, Holland
NMR, Natuurhistorisch Museum, Rotterdam, Holland;
NMV, Museum Victoria Palaeontology Collection, Melbourne, Australia;
NSMT, National Science Museum, Tokyo, Japan;
OU, Otago University, Dunedin, New Zealand;
PIN, A.A. Borisyak Paleontological Institute, Russian Academy of Sciences, Moscow, Russia;
RBINS, Royal Belgian Institute of Natural Sciences, Brussels, Belgium;
RMNH, Naturalis Biodiversity Center, Leiden, Holland;
SDNHM, San Diego Natural History Museum, San Diego, California, USA;
SKKC, Suginami Kagaku Kyoiku Center, Tokyo;
SMSN, Staatliches Museum für Naturkunde, Stuttgart, Germany;
UCMP, Museum of Paleontology, University of California, Berkeley, California, USA;
UM, University of Michigan Museum of Paleontology, Ann Arbor, Michigan, USA;
USNM, United States National Museum of Natural History, Smithsonian Institution, Washington, DC, USA;
UWBM, Burke Museum of Natural History and Culture, University ofWashington, Seattle,WA, USA;
ZMA, Instituut voor Systematiek en Populatiebiologie/Zoölogisch Museum, Amsterdam, Holland (the zoological and paleontological collections of ZMA recently moved to NBC).

## SPECIMENS USED IN THE COMPARATIVE ANALYSIS

The specimens listed below were examined by one or all the authors. In some cases, it was not possible to directly examine the specimens; in those cases, the relevant literature is provided in the list below. The list includes 8 undescribed taxa that are included in a phylogenetic analysis for the first time in this paper. These taxa are from Italy (MPTAM 207.13307 and UT PU13842/5), Belgium (RBINS M. 2231, M. 2315, NMR 7096, MAB002286) and Peru (MHNL 1610 and 1613). All these new taxa are balaenopterids and their publications are in progress. Relative ages of the species listed below are from the Cetacea section of the Paleobiology Database mostly compiled by Mark Uhen and, for undescribed taxa, from the cited literature.

**1. Protocetidae**
We compiled the matrix by using the following taxa:
*(i) Protocetus atavus*: SMNS 11084 (holotype); middle Eocene.
*(ii) Georgiacetus vogtlensis*: Hulbert *et al*. (1996), Hulbert (1998); middle Eocene.
*(iii) Maiacetus inuus*: Gingerich et al. (2009); middle Eocene.
*(iv) Gaviacetus razai*: Luo & Gingerich (1998); middle Eocene.

**2. *Basilosaurus cetoides***
USNM 4674, 6087 as described by Kellogg (1936); Uhen (1998); late Eocene.

**3. *Cynthiacetus peruvianus***
MNHN.F.PRU10 (holotype) as described in Martinez-Caceres & Muizon (2017); late Eocene-to-early Oligocene.

***4. Dorudon atrox***
UM 101215, 101222, 100139, 93220 as described by Uhen (2004); late Eocene.

**5. *Zygorhiza kochii***
USNM 4748, 16638, 449538; Kellogg (1936), Uhen (1998); late Eocene.

**6. *Aetiocetus weltoni***
UCMP 122900 (holotype) as described in Barnes *et al.* (1994), Deméré & Berta (2008); late Oligocene.

***7.* Mammalodontidae**
We compiled the matrix by using the following taxa:
*(i) Mammalodon colliveri* NMV P199986 (holotype) as described in Fitzgerald (2010); late Oligocene.
*(ii) Janjucetus hunderi*; NMV P216929 (holotype) as described in Fitzgerald (2006); late Oligocene.

***8. Fucaia buelli***
UWBM 84024 (holotype) as described in Marx et al. (2015); early Oligocene.

***9. Waharowa ruwhenua***
OU 22044 (holotype) as described in Boessenecker & Fordyce (2015); late Oligocene.

***10. Yamatocetus canaliculatus***
KMNH VP 000,017 (holotype) as described in Okazaki (2012); late Oligocene.

**11. *Micromysticetus rothauseni***
ChM PV4844 (holotype), Sanders & Barnes (2002a); late Oligocene.

**12.** ***Eomysticetus whitmorei***
ChM PV4253 (holotype), Sanders & Barnes (2002b); late Oligocene.

**13.** ***Horopeta umarere***
OU21982 (holotype) as described in Tsai & Fordyce (2015); late Oligocene.

**14.** ***Sitsqwayk cornishorum***
UWBM 82916 (holotype) as described in Peredo & Uhen (2016); late Oligocene.

**15.** ***Morenocetus parvus***
MLP 5–11 (holotype) as described in Buono et al. (2018): early Miocene.

**16.** ***Caperea marginata***
AMNH AMO 36692; RBINS 1536; Baker (1985), Beddard (1901); Recent.

**17.** ***Miocaperea pulchra***
SMNS 46978 (holotype); Bisconti (2012); late Miocene.

**18.** ***Balaena mysticetus***
USNM 257513; RMNH.MAM 1680, 3997, 2563, 2001; Bisconti (2003), Burns *et al.* (1993), Reeves & Leatherwood (1985); Recent.

**19.** ***Balaenula astensis***
MSNT MC CF 35 (holotype); Bisconti (2000); early Pliocene.

**20.** ***Balaenella brachyrhynus***
Natuurmuseum Brabaant (Tilburg), specimen 42001 (holotype); Bisconti (2005); early Pliocene.

**21.** ***Eubalaena glacialis***
AMNH 42752, 256803, 90241; MSNT 264; USNM 267612, 3339990, 23077, 301637; Bisconti (2003), Cummings (1985a), True (1904); Recent.

**22.** ***Tiucetus rosae***
MNHN.F. PPI261 (holotype) as described by Marx et al. (2017); middle-to-late Miocene.

**23.** ***Pelocetus calvertensis***
USNM 11976 (holotype); Kellogg (1965); middle Miocene.

**24.** ***'Aglaocetus' patulus***
USNM 13472; Kellogg (1968c); middle Miocene.

**25.** ***Uranocetus gramensis***
MSM p 813 (holotype) as described by Steeman (2009); middle-to-late Miocene.

**26.** ***Isanacetus laticephalus***
MFM 28501 (holotype) as described by Kimura & Ozawa (2002); early Miocene.

**27.** ***Joumocetus shimizui***
GMNH-PV-2401 (holotype) as described by Kimura & Hasegawa (2010); late Miocene.

**28.** ***Parietobalaena palmeri***
AMNH 128885; USNM 10677, 16570, 24883, 10909; Kellogg (1968d); middle Miocene.

**29.** ***Parietobalaena campiniana***
RBINS M.399-R.4018 (holotype); Bisconti *et al.* (2013); middle Miocene.

**30.** ***Diorocetus hiatus***
USNM 16783 (holotype), 205990; Kellogg (1968b); middle Miocene.

**31. USNM 187416**; middle Miocene.

**32.** ***Herpetocetus morrowi***
UCMP 129450 (holotype), SDNHM 65781, SDNHM 130390, SDNHM 34155, as described by El Adli et al. (2014); late Pliocene.

**33.** ***Piscobalaena nana***
MNHN SAS 892, 1616-1618, 1623, 1624, PPI 259, PPI 260 as described by Bouetel & De Muizon (2006); late Miocene-to-early Pliocene.

**34.** ***Cetotherium rathkei***
PIN 1840/1 (type) as described by Pilleri (1986) and Gol'Din (2014); middle Miocene.

**35.** ***Cetotherium riabinini***
NMNH-P 668/1 (holotype) as described by Gol'Din et al. (2014); late Miocene.

**36.** ***Mixocetus elysius***
LACM 3882 (holotype) as described by Kellogg (1934b); late Miocene.

**37.** ***Metopocetus hunteri***
NMR 9991-07729; Marx et al. (2015); late Miocene.

**38.** ***Metopocetus durinasus***
USNM 60460 (holotype); Kellogg (1968a); late Miocene.

**39.** ***Herentalia nigra***
RMNH RGM.791781; Bisconti (2015); late Miocene.

**40.** ***Cophocetus oregonensis***
CM UO 305 (holotype) as described by Packard & Kellogg (1934); early Miocene.

***41. Aglaocetus moreni***
MLP 5-14 (holotype) as described byKellogg (1934a); early Miocene.

***42. Thinocetus arthritus***
USNM 23794 (holotype) as described by Kellogg (1969a); late Miocene.

***43. Halicetus ignotus***
USNM 23636 (holotype) as described Kellogg (1969b); late Miocene.

**44.** ***Eschrichtius robustus***
AMNH 181374, 34260, 1750 ('*Eschrichtius cephalum*'), A; NMB 42001; USNM 364969, 364580, 571931, 364969, 364977, 364970, 364973, 504305; RMNH.MAM St20350, St13130, 630. Andrews (1914).

**45.** ***Eschrichtioides gastaldii***
MGPT 13802 (holotype); Bisconti (2008); early Pliocene.

**45.** ***Archaeschrichtius ruggieroi***
MAUL 230/1; Bisconti & Varola (2006); late Miocene.

**46.** ***Titanocetus sammarinensis***
MGB 9073 1CMC172 (1-6) (holotype); Bisconti (2006); middle Miocene.

**47.** ***'Balaenoptera' ryani***
CASG 1733 (holotype); Hannah & McLellan (1924); late Miocene.

**48.** ***Archaebalaenoptera castriarquati***
holotype (inventory of the Soprintendenza per i Beni Archeologici dell'Emilia Romagna item No. 240536; MCA): Bisconti (2007a); late Pliocene.

**49.** ***Protororqualus cuvieri***
Specimen lost; data as described byBisconti (2007b); late Pliocene.

**50.** ***'Balaenoptera' cortesi* var. *portisi***
PU13803 (holotype); Sacco (1890); Portis (1884); early Pliocene.

**51.** ***Plesiobalaenoptera quarantellii***
holotype (inventory of the Soprintendenza per i Beni Archeologici dell'Emilia Romagna item No. 240505; MPST); Bisconti (2010); late Miocene.

**52.** ***Parabalaenoptera baulinensis***
CASG 66660 (holotype) as described by Zeigler *et al*. (1997); late Miocene.

**53.** ***Fragilicetus velponi***
NMR 999100007727; Bisconti & Bosselaers (2016); early Pliocene.

**54. UT PU13842/5**
Caretto (1970); early Pliocene.

**55.** ***Miobalaenoptera numataensis***
NFL 18 (holotpe) as described by Tanaka & Watanabe (2019); late Miocene.

**56. Shimajiri-kujira**
No given number; only specimen described by Kimura et al. (2015); late Miocene.

**57. Maesawa-cho**
No given number; only specimen described by Oishi (1984); early Pliocene.

**58.** ***'Megaptera' hubachi***
MB Ma 28570; Dathe (1983); Bisconti (2011); middle Pliocene.

**59.** ***Megaptera novaeangliae***
AMNH 24679; MSNT 263; USNM 269982, 486175 (1-2), 13656/16252, 21492; RMNH ZMA.MAM 14964, 14953 (1-2), 14952 (1-2), 14965, 14966, 14967; Winn & Reichley (1985); Recent.

**60.** ***Diunatans luctoretemergo***
NHG 22279 holotype; Bosselaers & Post (2010); early Pliocene.

**61.** ***'Balaenoptera' siberi***
No given number; only specimen described by Pilleri (1989); late Miocene.

**62.** ***'Balaenoptera' bertae***
UCMP 219078 (holotype) as described by Boessenecker (2013); early-to-late Pliocene.

**63.** ***'Megaptera' miocaena***
USNM 10300 (holotype) as described by Kellogg (1925); Late Miocene.

**64.** ***Balaenoptera omurai***
NSMT-M32505 as described byWada et al. (2003); Yamada et al. (2008); Recent.

**65.** ***Balaenoptera acutorostrata***
AMNH 181411, 35680; RBINS 1537; MSNT 260, 261; RMNH ZMA.MAM 12873; Stewart & Leatherwood (1985), True (1904); Recent.

**66.** ***Balaenoptera bonaerensis***
SKKC 71]2793, 71]2883, AY69B, AY69A as described by Omura (1975); Recent.

**67.** ***Balaenoptera physalus***
AMNH 35026, 256796; MSNT 251, 252, 253, 258, 255, 257; RMNH ZMA.MAM 14950 (1-2), 14927 (1-2), 14935 (1-2), 23353, 14947; Gambell (1985*a*); Recent.

**68.** ***Balaenoptera musculus***
AMNH 234949, 256797, 256798; MSNT 250; ZMA 23356, 23354, 23355, 14946, 14942, 14961; Yochem & Leatherwood (1985), True (1904); Recent.

**69.** ***Balaenoptera edeni***
USNM 504692, 236680 (1-3); Cummings (1985b); Recent.

**70.** ***Balaenoptera brydei***
NBC Reg. 4003; NRMH.MAM 17712; Yamada et al. (2008); Recent.

**71.** ***Balaenoptera borealis***
USNM 504699, 504698, 504701, 504244, 486174; Gambell (1985b); Recent.

**72.** ***Nehalaennia devossi***
NMR 14035; Bisconti et al. (2019); late Miocene.

**73. MPTAM 207.13307**
Bisconti et al. (in prep. a); early Pliocene.

**74. NMR 7096**
Bisconti & Bosselaers (in prep. a); late Pliocene.

**75. RBINS M. 2231**
Bisconti & Bosselaers (in prep. b); early Pliocene.

**76. *Protororqualus wilfriedneesi***
Bisconti & Bosselaers (this work); early Pliocene.

**77. *Archaebalaenoptera liesselensis***
Bisconti et al. (2020); Late Miocene.

**78. SAM55001**
Govender et al. (2017); late Miocene.

**79. *Incakujira anillodefuego***
GNHM Fs-098-12 (holotype) as described by Marx & Kohno (2016); late Miocene.

**80. MHNL 1610**
Bisconti et al. (in prep. c); late Miocene.

**81. MHNL 1613**
Bisconti et al. (in prep. d); early Pliocene.

## OUTLINES OF UNDESCRIBED SPECIMENS

**MPTA 207-13307**
This specimen represents a new genus and species of Balaenopteridae whose description is now complete. It includes an incomplete skull with periotic still in articulation and part of the postcrania. The estimated age is earliest Piacenzian.

**NMR 999100007096**
This specimen includes skull, periotic and part of the postcrania. Its morphology suggests a close relationship to 'Balaenoptera' portisi. In the remainder of the paper and in the illustrations it is called NMR 7096. The estimated age is early Piacenzian.

**RBINS M. 2231**
This specimen includes skull, periotics, dentaries and part of the postcrania. It is closely related to *'Balaenoptera' sibbaldina* of which it represents the first reasonably complete skeleton. The specimen is briefly presented in Bisconti & Bosselaers (2014) and a full description is currently in progress. The specimen is currently held by RBINS. The estimated age is Early Pliocene.

**MHNL 1613**
The specimen includes a large skull with periotics still in articulation. It represents a new balaenopterid genus characterized by wide exposure of parietal at the cranial vertex. A description is currently close to be finished. The estimated age is Late Miocene.

**MHNL 1610**
The specimen includes a partially prepared skull with fragments of dentary. Its morphology suggests close relationships with *Archaebalaenoptera castriarquati* of which it could be an additional species. A description is currently in progress. The estimated age is Late Miocene.

# TAXONOMIC REVISION OF *BURTINOPSIS*

The taxonomic revision of *Burtinopsis* was performed based on the specimens described and illustrated by *Van Beneden (1882)* that are included in the RBINS Van Beneden type collection. The specimens are listed in the Materials section of this paper. General observations about Van Beneden's taxonomic methods have been presented by *Deméré et al. (2005), Steeman (2010), Bosselaers & Post (2010)* and *Bisconti et al. (2013)*. The new taxonomic assessments of the materials examined in this revision are presented in Supplementary Table S1. The specimens are illustrated in Supplementary Figs S1-to-S54.

**Systematic Paleontology**
Mammalia *Linnaeus, 1758*
Artiodactyla *Owen, 1848*
Cetacea *Brisson, 1762*
Pelagiceti *Uhen, 2008*
Neoceti *Fordyce & Muizon, 2001*
Mysticeti *Cope, 1891*
Chaeomysticeti *Mitchell, 1989*
Balaenomorpha *Geisler & Sanders, 2003*

Balaenomorpha gen. et sp. indet.

**Descriptions and taxonomic decisions.** We assigned the specimens M 691, 692, 698 and 709 to Chaeomysticeti indet. because they lack the diagnostic characters to support their inclusions in established mysticete taxa.

**M 643.** This specimen includes an atlas (C1) lacking the right transverse process and part of the neural arch (Supplementary Fig. S1). The remaining transverse process is squared and delicate. The articular surfaces for the occipital condyles are relatively wide and deep. The neural foramen is dorsoventrally elongated. As this atlas is not fused to the other cervical vertebrae, it is possible to exclude that it belonged to Balaenoidea. As the general shape is different from Eomysticetidae, it is possible to assign it to Balaenomorpha gen. et sp. indet.

**M 689.** The specimen consists of a single, complete atlas (C1) of a small-sized mysticete (Supplementary Fig. S12; Supplementary Table S3). The atlas shows moderately wide articular facets for the occipital condyles, complete neural arch and transverse processes protruding from the centrum for a short distance. The neural arch has a reduced dorsal tubercle and is external surface is continuous with the dorsal surface of the transverse process. A blunt tubercle is located between the base of the neural arch and the transverse process and mark the position of the alar foramen. The spinal foramen is triangular with ventral apex. Therefore, lacking diagnostic characters, the specimen M 689 is assigned to Balaenomorpha gen. et sp. indet.

**M 691.** This specimen includes a small caudal vertebra (Supplementary Fig. S13; Supplementary Table S3) characterized by flat anterior and posterior epiphyses, concave laterodorsal and lateroventral surfaces of the centrum, reduced transverse process that resembles a narrow anteroposterior crest bearing an arterial foramen at its emergence, long and transversely perforated attachment sites for the hemal arches forming the borders of an elliptical ventral fossa. The spinal foramen is reduced to a short and low tube. It is not possible to obtain diagnostic characters from this vertebra that is thus assigned to Balaenomorpha gen. et sp. indet.

**M 692.** The specimen includes a posterior caudal vertebra (Suplementary Fig. S14; Supplementary Table S3) characterized by convex anterior epiphysis and concave posterior epiphysis and circular outline of the centrum in anterior view. Two foramina are observed in the ventral surface of the vertebra that are located very close each other. There are neither neural arch nor transverse processes as usually observed in vertebrae that are part of the posterior-most portion of the caudal section of the vertebral column. It is not possible to obtain diagnostic characters from this vertebra that is thus assigned to Balaenomorpha gen. et sp. indet.

**M 694.** Partial left ulna (Supplementary Fig. S16) with missing most of the distal end. The anterior border is 259 mm in length; the posterior border (including the olecranon) is 336 mm in length. The articular facet for the humerus is 58 mm in anteroposterior diameter and the anteroposterior diameter of the diaphysys at mid-length is 71 mm with a transverse diameter of 38.75 mm. Convex anterior border and uniformly concave posterior border. Well developed olecranon with triangular and pointed superior apex and blade-like posterior border. Inferior border of olecranon continuous with the posterior border of the ulna. The diaphysys is elongated and straight with an elliptical transverse outline at mid-length. This ulna lacks evident diagnostic characters and cannot be assigned to any known mysticete taxon. We assign it to Balaenomorpha gen. et sp. indet.

**M 695.** The specimen represents a robust left radius (Supplementary Fig. S17). The anterior border is convex, the posterior border is flat-to-slightly concave. The proximal and distal epiphyses are both missing suggesting a young age for this individual. The length of the radius is 401 mm, its anteroposterior diameter at mid-length is 96 mm and the maximum transverse diameter at mid-length is 36.97 mm. The maximum anteroposterior diameter at the proximal end is 90 mm and at the distal end is 129 mm. The distal epiphysys is anteroposteriorly expanded. The diaphysis is straight and shows an elliptical cross section at mid-length. There are no diagnostic characters in this radius and for this reason we assign it to Balaenomorpha gen. et sp. indet.

**M 698.** The specimen consists of a skull fragment including both occipital condyles, the lateral and ventral borders of the foramen magnum and the basioccipital (Supplementary Fig. S28). The occipital condyles are transversely narrow and border a squared foramen magnum. The maximum height of the condyles is 120 mm on the left and 119 mm on the right and their maximum diameter is respectively 25 and 55 mm. The transverse diameter of both condyles and the foramen magnum is 170 mm. Part of the articular surface of the condyle is located below the level of the ventral border of the foramen magnum. The maximum transverse diameter of the foramen magnum is 63 mm. In dorsal view, the basioccipital is transversely concave and its lateral borders are paralleled by paraxial crests. It is not possible to obtain diagnostic characters from this portion that is thus assigned to Balaenomorpha gen. et sp. indet.

**M 704.** The specimen includes a partial atlas with neural arch broken (Supplementary Fig. S33). The articular facets for the occipital condyles are very concave dorsoventrally. The neural canal is elliptical with straight sides. The short, delicate and squared transverse process is located dorsally. The posterior face is dorsoventrally flat but transversely convex. There are no diagnostic characters in this atlas and for this reason, we assign it to Balaenomorpha gen. et sp. indet.

**M 707.** The specimen represents a right humerus of an adult individual (Supplementary Fig. S36) that is 204 mm in length and 85 mm in maximum anteroposterior diameter at mid-length. The total anteroposterior diameter at the proximal epiphysys is 138 mm and at the distal epiphysis is 104 mm. The head of the humerus is hemispherical with articular surface mostly faced superiorly and with slight posterior development. The tuberculum majus (*sensu Benke, 1993*) is dorsoventrally elongated and shows a dorsally-projecting, triangular crest that is the main feature of this specimen. The tuberculum majus abruptly terminates close to the mid-length of the humerus. A clear groove separates the tuberculum majus from the head of the humerus. At the distal end, the articular facet for the radius is straight in lateral view and is 59 mm in anteroposterior diameter; the articular facet for the ulna is concave in lateral view and is 37 mm in anteroposterior diameter. A facet for the olecranon process of the ulna is present distally along the posterior border of the humerus. Even being very peculiar, this humerus does not preserve clear diagnostic characters and it is impossible to assign it to a known mysticete taxon. For this reason, we assign it to Balaenomorpha gen. et sp. Indet.

**M 708.** This specimen consists of a proximal fragment of a ulna characterized by a wide and protruding olecranon process (Supplementary Fig. S37). The ulna lacks the distal half of the diaphysys and the whole distal epiphysys. The total length of the fragment is 184 mm and its maximum transverse width is 32.28 mm. At the proximal end, the total anteroposterior diameter is 126 mm including the articular facet for the humerus that is 55.44 mm in anteroposterior length. The articular facet for the humerus is inclined anteriorly. The anterior border is straight, the posterior border is convex and continuous with the olecranon process. The olecranon is short in proximodistal length but long in anteroposterior length and shows a posteriorly convex posterior border. The very peculiar morphology of this bone prevents its assignment to any of the known mysticete taxa and, lacking further diagnostic characters, it is not possible to create a taxon to include it. For these reasons we assign it to Balaenomorpha gen. et sp. indet.

**M 709.** This specimen is represented by a complete radius (Supplementary Fig. S38). The bone shows a wide and round proximal face and an elliptical and transversely compressed distal face. The distal epiphysis is lacking. The posterior border is distally concave and proximally convex; the anterior border is concave at mid-length and concave in proximity to the proximal and distal epiphyses. The maximum length of the radius is 316 mm; its maximum anteroposterior width at the proximal end is 80 mm and 106 mm at the distal end; the maximum anteroposterior diameter at mid-length is 85 mm and the maximum transverse diameter taken proximally is 39 mm. It is not possible to obtain diagnostic characters from this radius that is thus assigned to Balaenomorpha gen. et sp. indet.

**M 800.** The specimen M 800a-o consists of a partial vertebral column including six cervical (C2-C7), six thoracic (?T indet. #1-6), two lumbar (?L indet. #1-2) and one caudal (?Cd indet.) vertebra (Supplementary Figs S39-S52; Supplementary Table S3). The centrum of the axis (M 800a) is transversely elongated and dorsoventrally low. The articular facet for the atlas is transversely wide and anteriorly concave; the dens is largely eroded and is located between the ventral portions of the articular facets for the atlas. The facets are fused ventrally. The spinal foramen is wide and has a pointed ventral border in posterior view. The specimen M 800b corresponds to a subsequent cervical vertebra; the anterior epiphysis is convex and the posterior is flat. In anterior view, the outline of the centrum is approximately pentagonal with ventral and median vertex corresponding to a median tuberosity developed along the ventral face of the vertebra. The dorsal transverse process is broken after its emergence from the dorsolateral edge of the centrum; the ventral transverse process is reduced to a tubercle. The specimen M 800c is another cervical vertebra with flat anterior and posterior epiphyses of the centrum. In anterior view, the outline of the centrum is pentagonal like that described for M 800b. All the transverse processes are broken. The specimen M 800d consists in a cervical vertebra with pentagonal outline of the centrum in anterior view and ventral tuberosity along the sagittal axis of the ventral surface of the body. The anterior epiphysis of the centrum is flat and the posterior is concave. A tuberosity protrudes anteriorly from the ventrolateral corner of the body that corresponds to the ventral transverse process. The specimen M 800e is a cervical vertebra with sagittal keel and rounded outline of the centrum in anterior view; it bears robust ventrolateral tubercles and wide spinal foramen. The anterior epiphysis of the centrum is flat and the posterior is concave. The specimen M 800f is another cervical vertebra with ventral tuberosity along the sagittal axis of the centrum, ventrolateral tuberosity corresponding to the ventral transverse process and wide spinal foramen. The specimen M 800g is represented by a thoracic vertebra with strong anterolateral tubercles protruding from the ventrolateral corner. The ventral surface is worn; the neural canal is wide with convex floor. The posterior articular face is flat and the anterior articular facet is slightly concave. The transverse processes are broken and only their bases are preserved. The outline of the body in anterio view is oval with an evident dorsoventral compression. The specimen M 800h is represented by an anterior thoracic vertebra with oval outline characterized by an evident dorsoventral compression. A tuberosity from the ventrolateral corner of the body is present. The anterior and posterior articular faces of the body are flat. The neural canal is wide. The specimen M 800i is represented by an anterior thoracic vertebra with triangular outline of the body in anterior view. The dorsal border of the body is almost flat and the lateral borders of the body converge ventrally. The neural canal is wide; the transverse processes are broken at their bases. There is a lateral tuberosity protruding from the dorsolateral corner of the body. Anterior and posterior articular faces of the body are flat. The specimen M 800j is represented by a thoracic vertebra with oval outline of the body in anterior view. There is a marked dorsoventral compression in the body. Strong tuberosities protrude from the dorsolateral border of the body. Both the anterior and posterior articular faces of the body are flat. The neural canal is wide and shows a flat floor. The specimen M 800l consists in a thoracic vertebra with sagittal crest along the ventral surface. The transverse processes (broken at their bases) are located at the dorsolateral edge of the vertebra supporting the hypothesis that this is a thoracic vertebra. The outline of the body in anterior view is almost triangular being the dorsal edge flat and the lateral borders converging ventrally towards the anteroposterior axis of the vertebral body. The neural canal is surmounted by a long neural arch that shows flat lateral surfaces. The metapophyses are only slightly developed. The neural canal is triangular and is 36 mm in height; the floor of the neural canal is anteroposteriorly relieved. The anterior and posterior articular faces of the body are flat. The specimen M 800m consists in an anterior lumbar vertebra with a slightly developed ventral keel. The transverse processes (broken at their bases) are located at the middle of the height of the lateral surface of the body. The posterior articular face of the body is flat and shows an evident polpous nucleus. The anterior articular face is flat. The dorsal edge of the anterior articular face shows an incisures along the median axis. Neural canal transversely narrow with relieved floor. The specimen M 800n is a lumbar vertebra with an evident ventral keel. The transverse processes are broken at their bases and are located at the middle of the height of the body. Both the anterior and posterior articular faces of the body are flat-to-slightly concave. The neural canal is transversely narrow with relieved floor. Nutritive foramina are observed on both sides of the ventral keel. The specimen M 800o is represented by a large caudal vertebra with hexagonal outline of the anterior articular face. Attachment sites for the chevrons are well evident on both the anterior and posterior portions of the ventral surface of the vertebra. The short transverse processes are not perforated at their bases. The neural arch is laterally flat and the neural spine is broken. The neural canal is very narrow and is 23 mm in height. Both the anterior and posterior articular faces of the body are concave. There are no diagnostic characters in these vertebrae and for this reason we assign the specimen M 800 to Balaenomorpha gen. et sp. indet.

Thalassotherii *Bisconti, Lambert, Bosselaers, 2013*

Thalassotherii gen. et sp. indet.

**Descriptions and taxonomic decisions.** Specimens M 682, 689, 696, 705, 706 and 800 are assigned to this category.

**M 682.** This specimen includes three separate cervical vertebrae (C2, ?C6, ?C7). The axis (C2: M 682a) is characterized by a robust centrum (Supplementary Figs S3, S4, S5; Supplementary Table S3); the neural arch and most of the transverse processes are broken off. The anterior articular facet for the atlas is dorsoventrally flat and slightly concave transversely. A protruding process (dens) is located between the ventral portions of the articular facets. The ventral border of the spinal foramen is round. The only ventral transverse process projects ventrally and laterally and terminates at a distance of *c.* 70 mm from the body; its distal extremity projects dorsally and medially and forms the ventrolateral border of what was a complete foramen transversarium. The posterior epiphysis has a concave dorsal border and convex ventral border; the centrum is dorsoventrally compressed. The specimen M 682b represents a posterior cervical vertebra (?C6). In posterior view, the outline of the centrum is oval; the neural arch is missing; the dorsal transverse process is elongated and narrow and protrudes laterally from the dorsolateral border of the vertebral body; its distal end is truncated suggesting that there was not a complete foramen transversarium. The ventral transverse process is reduced to a tubercle. The lateral surface of the centrum is concave and a ventral keel is present. The specimen M 682c represents another posterior cervical vertebra (?C7). In this vertebra, both the epiphyses are flat-to-slightly convex and elliptical in outline; the dorsal transverse process is long and projects laterally from the dorsolateral edge of the vertebral body; the distal end of the process is globular but there is no evidence of a complete foramen transversarium. The neural arch is missing. The ventral transverse processes are reduced to tubercles. These three cervical vertebrae are free and this prevents us to assign them to Balaenoidea. As there are no additional diagnostic characters, we assign the specimens M 682a-c to Thalassotherii gen. et sp. indet.

**M 683.** This specimen includes the posterior portion of a skull (Supplementary Fig. S6) and the anterior-most portion of the left dentary (Supplementary Fig. S7). The skull includes occipital condyles, foramen magnum and basioccipital. The occipital condyles are very convex along both the transverse and the dorsoventral axes and appear very well developed below the foramen magnum. The basioccipital crests are low and weak. One of the occipital condyles shows the presence of a deep and round foramen. The jugular notch is posteriorly perforated by a bilateral foramen. The dorsoventral heights of the occipital condyles are *c.* 110 mm (right side) and *c.* 120 mm (left side), the transverse diameters are 55 mm on both sides. The transverse diameter of the foramen magnum is 105 mm. The maximum anteroposterior length of the fragment is 105 mm. The mandibular fragment includes the anterior-most portion of a left dentary with rounded ventral border and long groove for the mental ligament (200 mm in length). The whole fratment is 440 mm in length and 87 (at anterior end) and 84 (at posterior end) mm in height. The alveolar groove is evident and shows the presence of gingival foramina. The lateral bowing is scarce and there is no dorsoventral arch. The medial surface is convex and the lateral surface is highly convex. While the skull fragment does not bear diagnostic characters, the lack of anterior torsion and the overall shape of the mandible fragment exclude that the specimen belongs to Balaenoidea. We, thus, assign it to Thalassotherii gen. et sp. indet.

**M 693.** Elongated left humerus (Supplementary Fig. S15) with hemispherical articular head and short tuberculum majus. The length is 230 mm, the maximum width at mid-length is 82 mm and at distal end is 106 mm. The articular head is 70 mm in height and 72.59 mm in maximum transverse width. The maximum diameter at the proximal end is 120 mm. The anterior and posterior borders of the diaphysys are concave giving the humerus a slender figure. The articular facet for the radius is elongated and has a maximum anteroposterior diameter of 68 mm. The articular facet for the ulna is short being only 42 mm in anteroposterior diameter. There is no tuberculum deltoideum humeri (*sensu Benke, 1993*) and the epicondylus ulnaris is not present. There are not diagnostic characters in this humerus. The peculiar elongation prevents us to assign it to Balaenopteroidea and Balaenoidea. It is likely that this humerus belong to a basal thalassotherian but, presently, it is not possible to make clear statements about this. For this reason, we assign it to Thalassotherii gen. et sp. indet.

**M 696.** The specimens M 696a-k consists of a partial vertebral column including C1, ?C5, ?C6, ?C7, 4 T indet., ?L indet., 2 ?Cd indet. (Supplementary Figs S18-S26; Supplementary Table S3). The complete atlas (M 696a: C1) shows a narrow and triangular neural canal with ventrally positioned apex; the articular facets for the occipital condyles are wider than those observed in the specimen M 689 resembling those of basal thalassotherian taxa such as *Diorocetus* or *Pelocetus (Kellogg, 1965, 1968)* but differs from them in having a shorter and stockier transverse process overhanged by a protruding tubercle that marks the position of the alar foramen. The complete neural arch is low and the dorsal tubercle is crest-like. The specimen M 696b (?C5) shows flat dorsal and ventral borders of the centrum; the neural arch is largely missing; the vertebral surface of the neural arch is flat and wide. The lateral border of the vertebral body is rounded in anterior view. A long diapophysis projects laterally from the dorsolateral border of the vertebral body; there is only an eroded surface in the place of the parapophysis. The anterior and posterior epiphyses are flat. The specimen M 696c consists of a partial cervical vertebra (?C6) with flat anterior and posterior epiphyses; the neural arch and the diapophyses are largely missing; the transverse diameter of the spinal foramen is wide. The parapophyses are reduced to protruding tubercles. Several nutritive foramina are scattered along the vertebral surface but the vertebral epiphyses are fused to the body suggesting an adult age of the individual. The specimen M 696d includes a partial cervical vertebra (?C7) characterized by a round outline of the centrum in anterior view; the diapophyses are reduced to protruding tubercles and the vertebral epiphyses are flat. The neural arch is missing as far as the parapophyses which are broken. The dorsal border of the centrum is dorsally concave. The specimen M 696e represents a thoracic vertebra of

indeterminate position (?T indet. #1) showing flat epiphyses, straight dorsal border of the vertebral body, wide spinal foramen, transverse processes broken at their bases. The specimen M 696f is an indeterminate thoracic vertebra (?T indet. #2); the centrum is dorsoventrally compressed and bears an unusual ventral keel; the transverse processes are broken but their bases protrude from the dorsolateral corner of the centrum. The specimen M 696g consists of another indeterminate thoracic vertebra (?T indet. #3) with the same characters described in M 696f. The specimen M 696h consists of an indeterminate thoracic vertebra (?T indet. #4) with flat epiphyses; a ventral keel is present along the longitudinal axis of the vertebra; neural arch and transverse processes are broken; the bases of the transverse processes protrude from the dorsolateral corner of the centrum; the transverse diameter of the spinal foramen is wide. The specimen M 696i consists of an indeterminate lumbar vertebra (?L indet.) with flat anterior and posterior epiphyses; a ventral keel is present along the longitudinal axis of the centrum. The lateral surfaces of the centrum are uniformly concave dorsally and ventrally to the emergence of the transverse process that is located approximately at the middle of its height. The specimen M 696j is a posterior caudal vertebra (?Cd indet. #1) with uniformly rounded outline of the centrum in anterior view; the anterior and posterior epiphyses are flat; the transverse processes are reduced to longitudinal bony laminae located at the middle of the centrum height; the attachment sites for the haemal arches are reduced to short processes. The neural arch is missing; the transverse diameter of the spinal foramen is small. The specimen M 696k consists of a caudal vertebra with hexagonal outline of the centrum in anterior view. The epiphyses are slightly convex and the neural canal is highly compressed transversely. The transverse processes are reduced to subtle, longitudinal laminae perforated at their bases that are located at the middle of the height of the vertebral body. A foramen is located within the ventral surface of the spinal foramen. The attachment sites for the chevron are anteriorly high and posteriorly low; the ventral fossa bordered by the attachment processes for the haemal arch shows a foramen.
The cervical vertebrae M 696a-d are free thus excluding that this partial skeleton belongs into Balaenoidea. The ventral keel in the thoracic vertebrae is an unusual character but is observed in a Pliocene balaenopterid from northern Italy (EGAPA-MPTAM 207.13307) briefly discussed in *Bisconti et al. (2019)* and currently under description by one of us (MB and co-workers). Unfortunately, there are no other diagnostic characters allowing the assignment of this fossil to an established thalassotherian taxon and, for this reason, we assign it to Thalassotherii gen. et sp. indet.

**M 697.** The specimen includes the axis and five additional vertebrae (Supplementary Fig. S27; Supplementary Table S3). The axis (M 697a) lacks the neural arch and the dorsal apophyses. The articular facets for the occipital condyles are externally convex and are ventrally separated by a deep and wide concavity. The ventral apophyses project laterally and ventrally and terminate only a few cm from the lateral side of the vertebra. The posterior surface of the vertebral body is concave and oval in outline. The specimen M 696b is a cervical vertebra with all the apophyses broken at their bases. The anterior face of the body is concave and the posterior face is convex. The body is squared in posterior view. The specimen M 697c is represented by a vertebral body with a hexagonal outline in posterior view. The apophyses are broken at their bases. The neural arch is broken at its base. A rounded median keen is observed along the ventral surface of the vertebral body. The specimen M697d has an elliptical outline of the body in posterior view. All the apophyses are broken and only their bases are present. The anterior surface of the body is convex and the posterior face is flat. There is a rounded ventral keel. The specimen M 697e shows an oval outline of the vertebral body in posterior view. The anterior face is convex and the posterior face is flat. The ventral apophyses are absent. The neural arch is represented only by its base. The specimen M 697f is represented by a caudal vertebra without neural arch. The vertebra shows attach sites for the chevron that have the shape of paraxially-developed anteroposterior crests surrounding an elliptical fossa including two foramens. The fossa is 72 mm in length and 30 mm in width. The transverse processes are reduced to longitudinal crests slightly protruding from the vertebral body. Anterior and posterior faces of the vertebral body are flat-to-convex and the whole body is anteroposteriorly compressed. There are no diagnostic characters in this partial vertebral column. The cervical vertebrae included in this specimen are separated and this excludes an assignment to Balaenoidea, therefore, we assign this specimen to Thalassotherii gen. et sp. indet.

**M 705.** The specimen consists in a partial axis (C2) characterized by a protruding dens, a neural canal pointed ventrally and widening dorsally, robust ventral transverse processes, highly concave posterior epiphysis with straight dorsal border and rounded ventral border (Supplementary Fig. S34; Supplementary Table S3). The neural arch is broken but an alar foramen is located in the preserved portion of the neural arch pedicle. Given that this is a free vertebra that does not preserve any useful diagnostic character, it cannot be assigned to Balaenoidea; therefore, we assign it to Thalassotherii gen. et sp. indet.

**M 706.** The specimen is a partial scapula with most of the dorsal portion missing and broken coracoid and acromial processes (Supplementary Fig. S35). The acetabulum is elliptical and shallow and measures 85 mm in anteroposterior diameter and 62 in transverse diameter. The maximum length of the scapula is 175 mm and the maximum height is 130 mm. The caudal border shows a marked posterior projection suggesting that it does not belong to Balaenoidea. Unfortunately, lacking further diagnostic characters, this scapula is assigned to Thalassotherii gen. et sp. indet.

Balaenopteridae *Gray, 1864*

Balaenopteridae gen. et sp. indet.

**M 657.** The specimen includes a partial dentary with balaenopterid characteristics (Supplementary Fig. S2). In particular, the articular condyle is oriented posteriorly and the angular process is dorsoventrally reduced in lateral view. As in other fossil balaenopterids, the angular process is dorsoventrally expanded in medial view and is separated from the condyle by a deep groove. There are no additional diagnostic characters in this specimen and for this reason we assign it to Balaenopteridae gen. et sp. indet.

**M684.** The specimen includes a partial dentary with balaenopterid characteristics (Supplementary Fig. S8; Supplementary Table S2). In particular, there is no dorsoventral arc, the dentary is laterally bowed in a continuous manner, the medial surface is almost flat for most of the length of the ramus. The external curvature is slightly attenuated posteriorly to the coronoid process. The coronoid crest is long and transversely acute. The mandibular canal is dorsally closed; many gingival foramina open from it. The groove for the mental ligament is located at the middle of the height of the anterior fragment. The external curvature and the proportions of this dentary suggest affinity to Balaenopteridae but it is not possible to safely assign this specimen to a known taxon. For this reason, we assign it to Balaenopteridae gen. et sp. indet.

**M 685.** The specimen includes the posterior portion of the left mandibular ramus including condyle and angular process (Supplementary Fig. S9; Supplementary Table S2). The articular surface of the condyle is faced posteriorly as in living and fossil established balaenopterid species. The articular condyle is posteriorly flat and its dorsal border protrudes dorsally. The angular process is scarcely developed and protrudes ventrally showing a round posteroventral corner. This peculiar character is not observed in other fossil and living balaenopterid whales and suggests that the specimen could represent a species new to science. However, the lack of additional evidence (in particular, about the anatomy of the skull and earbones) prevents us to establish a new taxon for this specimen. Interestingly, the angular process is separated from the condyle by an obliquely-oriented groove forming the ventral border of the articular surface of the condyle. The angular process is strongly developed in the medial side of the dentary where the pterygoid fovea proceeds anteriorly below the condyle. Based on these observations and assessments, we assign this specimen to Balaenopteridae gen. et sp. indet.

**M 686.** Left tympanic bulla with most of lateral wall missing (Supplementary Fig. S10; Supplementary Table S1). The main ridge is very marked, the anterolateral expansion present but mostly missing. The involucral protrusion is very marked giving the medial border of the specimen a sinuous outline in dorsal view. In medial view, a strong depression is observed in front of the involucral protrusion. Due to this depression, the Eustachian opening is very low differing from the typical bullae of *Protororqualus wilfriedneesi*. This bulla shows balaenopterid affinities but given its incompleteness and due to lack of further evidence, it is not possible to assign it to known balaenopterid taxa or create a new taxon. For this reason, we assign it to Balaenopteridae gen. et sp. indet.

**M 687.** Left tympanic bulla with reduced anterolateral expansion (Supplementary Fig. S11; Supplementary Table S1). The sigmoid process is missing. The conical process project dorsally and the involucral protrusion is very marked giving the medial border of the bulla a concave aspect in dorsal view. The Eustachian outlet is low. The main ridge is evident. This bulla resembles *Protororqualus wilfriedneesi* in the scarce protrusion of the anterolateral expansion but differs from it in the lower Eustachian opening thus preventing a safe assignment to this species. It is not to be excluded that it belonged to a more primitive *Protororqualus* species but the lack of additional evidence prevents us to make a clear taxonomic statement in this sense. For this reason, this specimen is assigned to Balaenopteridae gen. et sp. indet.

**M699.** The specimen M 699 consists in a single posterior process of the left periotic and in a fragment of the left posterolateral portion of the skull (Supplementary Fig. S29). The maximum width of the fragment is 188 mm and the maximum height is 160 mm. The posterior process is elongated in ventral view and shows a squared distal end. It is 113.1 mm in length, 51.81 mm in width at mid-length, and 23.72 mm in maximum height. Proximally, it has a shallow and wide concavity for the facial nerve and very small anterior and posterior flanges. The skull includes part of the left exoccipital and of the left squamosal in articulation. In posterior view, the lateral border of the exoccipital is largely broken; medially, the position of the epiphysis of the left occipital condyle is evident but the epiphysis itself is missing suggesting a young age for this individual. This interpretation is also confirmed by the scarcely rough texture of the posterior process of the periotic. In ventral view, the elongated external acoustic meatus borders the posterior border of the postglenoid process that is broken and missing; the exoccipital is well evident and robust. In anterolateral view, the falciform process projects anteroventrally and the parietal-squamosal suture is anteriorly concave. A V-shaped squamosal cleft is present. The thin posterior process of the periotic without the structural characteristics of non-balaenopterid thalassotherians and the V-shape of the squamosal cleft suggests affinity to Balaenopteridae. For these reasons, we assign the specimen to Balaenopteridae gen. et sp. indet.

**M 700.** Part of the right tympanic bulla (Supplementary Fig. S30; Supplementary Table S1) lacking most of the lateral wall including conical and sigmoid processes. The Eustachian opening is very low and the anterolateral expansion is just discernible. The main ridge is present and the involucral protrusion is very marked giving the medial edge of the bulla a sinuous and concave outline in dorsal view. The scarce development of the anterolateral expansion suggests that the specimen belongs to a primitive balaenopterid taxon but the lack of further evidence prevents the assignment of the specimen to a given taxon or the establishment of a new taxon. For these reasons we assign this specimen to Balaenopteridae gen. et sp. indet.

**M 701.** Part of the right tympanic bulla (Supplementary Fig. S31; Supplementary Table S1) lacking part of the lateral wall including the sigmoi and the conical processes. The anterolateral expansion is reduced and the Eustachian opening is very low resembling specimen M 700. A strong depression is observed anteriorly to the involucral protrusion in medial view. The main ridge is well developed. In many respects, this bulla resembles specimen M 700 even being more complete. Our taxonomic conclusions are the same: the specimen could belong to a primitive balaenopterid taxon characterized by a slight anterolateral expansion in the tympanic bulla (resembling, in that character, *Protororqualus wilfriedneesi*) but the low Eustachian opening prevents the assignment to *Protororqualus*. We thus assign this specimen to Balaenopteridae gen. et sp. indet.

**M 703.** This specimen includes the posterior portion of the left mandibular ramus (Supplementary Fig. S32; Supplementary Table S2). The articular condyle faces posteriorly and the angular process is laterally reduced thus making an assignment of the specimen to Balaenopteridae possible. The angular process is separated from the mandibular condyle by a posteriorly and medially deep pterygoid groove. The angular process is well developed along the medial side of the dentary. Unfortunately, the lack of additional diagnostic characters prevent the assignment of the specimen to a known genus and also the creation of a new taxon. For this reason we assign it to Balaenopteridae gen. et sp. indet.

*Protororqualus wilfriedneesi* Bisconti, Bosselaers (this work)

**M 688.** See associated paper (Fig. 2A-D; Supplementary Table S1).

**M. 702.** See associated paper (Fig. 2E-H; Supplementary Table S1).

# TAPHONOMY

**Description of the bite marks**

The bite marks start as fine, very shallow lines about 1 cm from the edge of the bones. They gradually become deeper and wider to become about 1 mm wide and 1 mm deep at or near the edge (Supplementary Figs S55-S57). In some cases, at the edges, somewhat bigger fragments of the bone have broken off. All the edges and most of the surface of the shark-bitten bones are bio-eroded. All the scars are straight lines and almost all of them are perpendicular to the edges of the bone.
Five bones display fine parallel lines, (almost) perpendicular to the edges of the bones and are described below.

(1) a) Anterior supraoccipital: left border posterolaterally: about 15 parallel bite marks over a length of 34 mm. The marks are about 1.3 mm wide and shallow (less than 1 mm). The spacing between the marks is about 2 mm. All the marks on this bone are (almost) perpendicular to the border (Fig. 3C).
b) Right border posterolaterally: about 12 similar bite marks.
c) At the posterior border there are also bite marks, but these are more difficult to see due to the bio-erosion of the bone; possibly about 18 marks.

(2) a) Ascending process of the maxilla, near the posterior-most dorsal infraorbital foramen: about 14 bite-marks over 4 cm, on the sharp dorsal edge of the bone (Supplementary Figs S56 and S57). They are about 8 mm long and the biggest ones are about 1 mm wide and 1 mm deep. These marks are also perpendicular to the edge of the bone. Next to it, more posteriorly, in an oval depression, some 5 marks over 8 mm; these are much finer and about 5 mm long. These marks are more inclined and more criss-crossed than ones on the adjacent sharp edge.
b) The (separate) most posterior part of the ascending maxilla also has shark-bites, but these are difficult to spot due to the erosion of the bone. They are situated at both extremities, on the rather rounded dorsal edge of the bone.

(3) There are numerous bite-marks on the external (lateral) side of the ulna also (Fig. S55). Most of them are situated at or near the ventral border, but also in the middle of the dorsal border and all over the external surface there are marks. Most of them are very faint and hard to spot, even in grazing light. The scars on the centre of the bone are criss-crossed.

(4) The clearest bite-marks are on an isolated piece of rather thick cortical bone; probably a lateral fragment of the squamosal. At the edges of the bone there are lots of marks. They are about 6 mm long and very fine (Supplementary Fig. S55)

(5) On another isolated bone fragment, possibly a fragment of the right anteromedial frontal (near the pterygoid), there are bite-marks too. They are situated at and near the (?dorsal) border. They are rather criss-crossed and hard to discern, due to the eroded condition of the bone. All together there are about 15 marks. On the ?ventral part of the bone is a shell fragment, fixed to it with sediment, of an aff. *Glottidia ?dumortieri* (Brachiopoda, Lingulidae).

These findings further indicate that at least part of the fracturing, scattering and erosion of the skull bones took place prior to fossilisation.

# SUPPLEMENTARY TABLES

**Supplementary Table S1**
Measurements of *Burtinopsis*: tympanic bullae
*Measurements (in mm) of the tympanic bullae previously assigned to* Burtinopsis*.*

| Specimen | Length[1] | Width 1[1] | Width 2[1] | Width 3[1] | Width 4[1] | Depth[1] |
|---|---|---|---|---|---|---|
| M686 | 81.59 | 34.95 | 41.38 | | | 11.56 |
| M687 | 83.33 | 38.75 | 32.77 | 45.51 | 48.25[2] | 19.31 |
| M688 | 94.36 | 41.06 | 50.08 | 48.15 | 49.6[2] | 31.5 |
| M700 | 71.04 | 37.31 | 36.39 | 38.25[2] | 37.81[2] | 14.74 |
| M701 | 77.61 | 31.08 | 36.32 | 40.95 | 40.37 | 20.04 |
| M702 | 80.38 | 35.8 | 40.16 | 44.94 | 45.84[2] | 26.16 |

[1]Caption: Depth, tympanic cavity depth; Length, total anteroposterior length of bulla; Width 1, anterior width; Width 2, posterior width; Width 3, width of bulla across conical process; Width 4, width of bulla across sigmoid process.
[2]As imperfectly preserved in the specimen.

**Supplementary Table S2**
Measurements of M684
*Measurements (in mm) of the specimen M684 representing a dentary previously assigned to* Burtinopsis.

| character | M 684 |
|---|---|
| Linear length | 1705 |
| Length along the external curvature | 1780 |
| Height of dentary at coronoid process | 140 |
| Height of dentary at the anterior end | 90 |
| Height of dentary 700 mm from the anterior end | 101 |
| Height of dentary 1000 mm from the anterior end | 128 |

**Supplementary Table S3**

Measurements of *Burtinopsis*: vertebrae

*Vertebral measurements (in mm) of specimens previously assigned to Burtinopsis held by RBINS.*

| Specimen | Part | Anatomy[1] | Vertebral body | | | Maximum height | Maximum width | Width of neural channel |
|---|---|---|---|---|---|---|---|---|
| | | | height | length | width | | | |
| M682 | a | C2 | 99 | 63 | 129 | 251 | 112 | |
| | b | ?C7 | 119 | 47 | 98 | 365 | 125 | 75 |
| | c | ?T1 | 135 | 58 | 132 | 380 | 115 | 75 |
| M689 | | C1 | 176 | | | | 302 | 69 |
| M691 | | ?Cd9 | 97 | 86 | 100 | 105 | 117 | |
| M692 | | Cd? | 51 | 39 | 63 | 64 | 65 | |
| M696 | a | C1 | 122 | | 183 | 167 | 256 | 78 |
| | b | C7 | 91 | 40 | 128 | 105 | 198 | 84[3] |
| | c | ?T1 | 93 | 46 | 131 | 114 | 178 | 90[3] |
| | d | ?T2 | 93 | 54 | 141 | 115 | 167 | 80[3] |
| | e | ?T3 | 86 | 68 | 137 | 120 | 158 | 80 |
| | f | ?T4 | 80 | 74 | 135 | 112 | 158[3] | 76[3] |
| | g | ?T5 | 91 | 84 | 139 | | | |
| | h | ?T7 | 96 | 94 | 132 | | | |
| | i | ?L3 | 112 | 120 | 134 | 122 | 139 | 27 |
| | j | ?Cd2 | 132 | 149 | 143 | 150 | | 19 |
| | k | ?Cd? | 127 | 129 | 140 | | | 25 |
| M697 | a | C2 | 87 | 46/71[2] | 195 | 129 | 246 | |
| | b | ?C3 | 94 | 31 | 120 | 123 | 144 | 80 |
| | c | ?C4 | 99 | 34 | 120 | | 131 | 82 |
| | d | ?C5 | 95 | 38 | 114 | 120 | 145 | 90 |
| | e | ?C6 | 97 | 38 | 118 | 125 | 145 | 90 |
| | f | Cd? | 119 | 91 | 107 | 129 | | |
| M704 | | C1 | | 48.25 | | | 250 | 42 |
| M705 | | C2 | 89 | 121 | 59.16 | 127 | 200 | 65 |
| M800 | a | C2 | | | 200 | 114 | 260[3]/322[4] | 55 |
| | b | ?C6 | 115[3] | 34 | 132[3] | *c.* 120 | 152 | 86[4] |
| | c | C? | 172[3] | 44 | 124[3] | 125 | 148[3] | 118[4] |
| | d | C? | 109[3] | 42 | 150[3] | 127 | 142[3] | 90[4] |
| | e | C? | 127 | 45 | 140 | 135 | 161 | 95 |
| | f | ?C7 | 127 | 54 | 145 | 140 | 222 | 96 |
| | g | T? | 120[3] | 60 | 145 | 135[3] | 200 | 101 |
| | h | T? | 119 | 72 | 160 | 138 | 200 | 110[3] |
| | i | T? | 116 | 89 | 145[3] | 139 | 190 | 90 |
| | j | T? | 122 | 97 | 140 | 140 | 182 | 78 |
| | k | T? | 123 | 104 | 149 | 147 | 177 | 72 |
| | l | T? | 121 | 112 | 140[3] | 179 | 180 | 60 |
| | m | L? | 135 | 140 | 154[3] | 145 | 204 | 42 |
| | n | L? | 144 | 158 | 172 | 209 | 209 | 40 |
| | o | Cd? | 164 | 174 | 190 | 204 | 205 | 23 |

[1]Anatomical abbreviations: C, cervical vertebra; Cd, caudal vertebra; T, thoracic vertebra; L, lumbar vertebra.
[2]Length without dens/length with dens.
[3]As incompletely preserved in the specimen.
[4]Reconstructed.

**Supplementary Table S4**
Mollusc species at the discovery site
Mollusc species found in close proximity of the holotype skeleton of *Protororoquaus wilfriedneesi*.

| | Taxon | Authors | Formation/Horizon | Age |
|---|---|---|---|---|
| 1 | *Pecten grandis* | Sowerby, 1828 | Kattendijk formation | Early Pliocene |
| 2 | *Digitariopsis* (*Astarte*) *obliquata obliquata* | (Sowerby, 1817) | Luchtbal and Oorderen Sands | Late Early till Late Pliocene |
| 3 | *Laeveastarte arijanseni* | (Marquet, 2005) | Kattendijk and Luchtbal Sands | Early Pliocene till earliest Late Pliocene |
| 4 | *Laeveastarte omalii omalii* | (De la Jonkaire, 1823) | Kattendijk and Luchtbal Sands | Early Pliocene till earliest Late Pliocene |
| 5 | *Cardites squamulosa ampla* | (Chavan & Coatman, 1943) | Kattendijk formation | Early Pliocene |
| 6 | *Pygocardia rustica tumida* | (Nyst, 1836) | Kattendijk and ?Luchtbal Sands | Early Pliocene (? till earliest Late Pliocene) |
| 7 | *Glossus humanus* | (Linnaeus, 1758) | Pliocene till recent, but considered trace fossil for the Kattendijk Sands | Early Pliocene – recent, but typical for the Kattendijk deposits |

**Supplementary Table S5**
Measurements of the holotype skull of *Protororqualus wilfriedneesi*
*Measurements (in mm) of the Protororqualus wilfriedneesi (holotype skull; specimen RBINS M2315).*

| Character | Measurement |
|---|---|
| Maxilla: maximum length (left side) | 220[1] |
| Maxilla: maximum width (left side) | 37.46 |
| Vomer: maximum length | 179[1] |
| Vomer: maximum width (anteriorly) | 54.81 |
| Vomer: maximum width (posteriorly) | 61.11 |
| Squamosal: maximum length of zygomatic process | 179 |
| Supraoccipital: length | 310 |
| Supraoccipital: maximum width at maximum external curvature | 175 |
| Supraoccipital: maximum width across the posterior apices of the temporal crests (lambdoid crests) | 257 |
| Frontal: maximum transverse diameter of supraorbital process | 110 |
| Frontal: maximum anteroposterior diameter of supraorbital process | 67[1] |
| Exoccipital: maximum width | 270[1] |
| Alisphenoid: maximum length (right side) | 57 |
| Alisphenoid: maximum width (right side) | 50 |
| Hiatus cranicus: maximum length | 58.28 |
| Hiatus cranicus: maximum width | 45.28 |
| External acoustic meatus: maximum anteroposterior diameter (distally) | 45.09 |
| External acoustic meatus: maximum anteroposterior diameter (medially) | 22.7 |

[1]As imperfectly preserved in the specimen.

**Supplementary Table S6**

Measurements of the periotics of *Protororqualus wilfriedneesi* (holotype)

*Measurements (in mm) of the right periotic of the holotype of Protororqualus wilfriedneesi (RBINS M2315).*

| Character | Measurement |
|---|---|
| Anterior process: length | 42.07 |
| Anterior process: width at base | 52.51 |
| Pars cochlearis: anteroposterior diameter | 35.7 |
| Pars cochlearis: transverse diameter | 42.2 |
| Complete internal acoustic meatus (TSF[1]+FS[1]): dorsoventral diameter | 7.17 |
| Complete internal acoustic meatus (TSF[1]+FS[1]+EFC[1]): anteroposterior diameter | 15.06 |
| Internal acoustic meatus (excluding EFC[1]): dorsoventral diameter | 7.17 |
| Internal acoustic meatus (excluding EFC[1]): anteroposterior diameter | 7.31 |
| Endocranial opening of the facial canal: dorsoventral diameter | 6.3 |
| Endocranial opening of the facial canal: anteroposterior diameter | 2.74 |
| Oval window: dorsoventral diameter | 4.73 |
| Round window: dorsoventral diameter | 2.48 |
| Round window: anteroposterior diameter | 5 |

[1]Caption: EFC, endocranial opening of facial canal; FO, Foramen singulare; TSF, tractus spiralis foraminosus.

**Supplementary Table S7**

Measurements of tympanic bullae of *Protororqualus wilfriedneesi* (holotype)

*Measurements (in mm) of the tympanic bullae of the holotype of Protororqualus wilfriedneesi.*

| Character | Measurement | |
|---|---|---|
| | Right tympanic bulla | Left tympanic bulla |
| Length | 80.09 | 79.67 |
| Anterior width | 38.66 | 36.98 |
| Posterior width | 35.46 | 33.51 |
| Width at conical process | 36.14 | 40.13 |
| Width at sigmoid process | 37.87 | 48.69 |
| Height at conical process | 58.05 | 48.21 |
| Depth of tympanic bulla | 27.07 | 31.54 |

**Supplementary Table S8**

Measurements of referred periotics

*Measurements (in mm) of periotics referred to* Protororqualus wilfriedneesi*.*

| specimen | TL[1] | WLP[1] | MAH[1] | PLC[1] | PL[1] | PW[1] |
|---|---|---|---|---|---|---|
| T12 | 80.3 | 60.7 | 42.0 | 53.5 | c. 45.0 | c. 32.0 |
| M23172 | 85.7 | 62.7 | 36.0 | c. 55.0 | c. 45.0 | c. 31.5 |
| M23182 | 82.5 | c. 70 | c. 34.0 | c. 55.0 | c. 47.0 | c. 32.0 |
| M23192 | 85.7 | c. 64 | c. 39.0 | c. 53.0 | c. 42.0 | c. 29.0 |
| NHG23430[2] | 82.3 | 69.2 | 43.0 | | *c.* 36.0 | 32.4 |

[1]Caption: MAH, maximum height; PL, promontorium length without caudal process; PLC, promontorium length including the caudal process; PW, promontorium width; TL, total length; WLP, width at lateral prominence.

**Supplementary Table S9**

Measurements of tympanic bullae of referred specimens

*Linear measurements (in mm) of the tympanic bullae of the specimens referred to* Protororqualus wilfriedneesi*. All the specimens are held by RBINS.*

| specimen | APL[1] | WPP[1] | WEO[1] | LAP[1] | HIB[1] | CSPP[1] |
|---|---|---|---|---|---|---|
| T1 | 81.8 | 39.0 | 25.0 | *c.* 15.0 | 24.2 | 4.5 |
| T2 | 80.3 | 38.8 | 26.0 | 16.5 | 24.2 | |
| M2320 | 81+ | 43.4 | 25.0 | *c.* 14.5 | 30.5 | 5.7 |
| M2321 | 81.5 | 35.5 | 20.0 | 15.3 | 28.2 | 3.2 |
| M2322 | 83.6 | 45.0 | *c.* 22.0 | 14.0 | 30.3 | |
| M2323 | 80.8 | 36.0 | 21.1 | 14.1 | 27.6 | |

[1]Caption: APL, anteroposterior length; CSPP, cross section of posterior pedicle; HIB, height at involucral bulge; LAP, length of anterior lip; WEO, width at Eustachian opening; WPP, width at posterior pedicle.

**Supplementary Table S10**
Geographic occurrences and ages of the taxa
*Stratigraphic and geographic data for the taxa used in the analyses.*

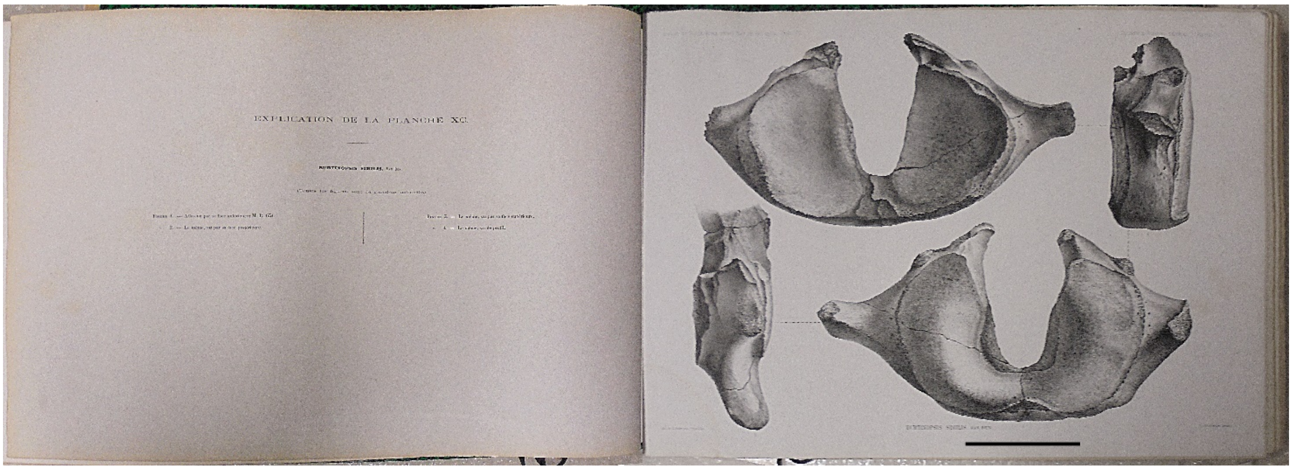
| Taxon name | Estimated stratigraphic range | | Areas of occurrence | References |
|---|---|---|---|---|
| *Protocetus atavus* | 48.6 | 40 | Mediterranean | Paleobiology Database |
| *Georgiacetus vogtlensis* | 40.4 | 37.2 | North Atlantic | Paleobiology Database |
| *Gaviacetus razai* | 48.6 | 40.4 | Indian | Paleobiology Database |
| *Maiacetus inuus* | 48.6 | 40.4 | Indian | Paleobiology Database |
| *Basilosaurus cetoides* | 37.2 | 33.9 | Mediterranean North Atlantic | Paleobiology Database |
| *Cynthiacetus peruvianus* | 37.2 | 33.9 | South Pacific | Paleobiology Database |
| *Dorudon atrox* | 37.2 | 33.9 | Mediterranean, North Atlantic | Paleobiology Database |
| *Zygorhiza kochii* | 37.2 | 33.9 | North Atlantic | Paleobiology Database |
| *Mammalodon colliveri* | 28.4 | 23.03 | South Pacific | Paleobiology Database |
| *Janjucetus hunderi* | 23.9 | 27 | South Pacific | Fitzgerald (2006) |
| *Fucaia buelli* | 33.9 | 31 | North Pacific | Marx et al. (2015) |
| *Aetiocetus weltoni* | 28.4 | 23.3 | North Pacific | Paleobiology Database |
| *Waharoa ruwhenua* | 27.3 | 20.43 | South Pacific | Boessenecker & Fordyce (2015) |
| *Yamatocetus canaliculatus* | 28.4 | 23.3 | North Pacific | Paleobiology Database |
| *Eomysticetus whitmorei* | 28.4 | 23.3 | North Atlantic | Paleobiology Database |
| *Micromysticetus rothauseni* | 33.9 | 28.4 | North Atlantic | Paleobiology Database |
| *Horopeta umarere* | 27.3 | 25.2 | South Pacific | Tsai & Fordyce (2015) |
| *Sitsqwayk cornishorum* | 28.4 | 23.03 | North Pacific | Peredo & Uhen (2016) |
| *Morenocetus parvus* | 20.03 | 15.97 | South Atlantic | Buono et al. (2018) |
| *Miocaperea pulchra* | 11.608 | 7.246 | South Pacific | Bisconti (2012) |
| *Caperea marginata* | 0.012 | 0.0 | South Pacific | Paleobiology Database |
| *Balaenella brachyrhynus* | 5.3 | 5.0 | North Sea | Bisconti (2005) |
| *Balaena mysticetus* | 0.012 | 0.0 | North Atlantic, North Pacific | Paleobiology Database |
| *Eubalaena glacialis* | 0.012 | 0.0 | North Atlantic | Paleobiology Database |
| *Balaenula astensis* | 3.4 | 3.2 | Mediterranean | Bisconti (2000) |
| *Titanocetus sammarinensis* | 15.97 | 13.81 | Mediterranean | Bisconti (2006) |
| *Tiucetus rosae* | 13.65 | 7.246 | South Pacific | Paleobiology Database |
| *Metopocetus hunteri* | 11.608 | 7.246 | North Sea | Paleobiology Database |
| *Cophocetus oregonensis* | 20.43 | 15.97 | North Pacific | Paleobiology Database |
| *Aglaocetus moreni* | 20.43 | 15.97 | South Atlantic | Paleobiology Database |
| *Mixocetus elysius* | 11.608 | 7.246 | North Pacific | Paleobiology Database |
| *Uranocetus gramensis* | 11.608 | 7.246 | North Sea | Paleobiology Database |
| *Isanacetus laticephalus* | 20.43 | 15.97 | North Pacific | Kimura and Ozawa (2002) |
| *Metopocetus durinasus* | 15.97 | 13.65 | North Atlantic | Paleobiology Database |
| *Diorocetus hiatus* | 15.97 | 13.65 | North Atlantic | Paleobiology Database |
| *Atlanticetus patulus* | 15.97 | 13.65 | North Atlantic | Paleobiology Database |
| *Parietobalaena palmeri* | 15.97 | 13.65 | North Atlantic | Paleobiology Database |

| | | | | |
|---|---|---|---|---|
| *Pelocetus calvertensis* | 15.97 | 13.65 | North Atlantic | Paleobiology Database |
| *Joumocetus shimizui* | 11.608 | 7.246 | North Pacific | Kimura and Hasegawa (2010) |
| *Parietobalaena campiniana* | 15.0 | 13.2 | North Sea | Bisconti et al. (2013) |
| USNM 187416 | 17.0 | 15.0 | North Atlantic | Gottfried et al. (1994) |
| *Piscobalaena nana* | 11.608 | 4.0 | South Pacific | Paleobiology Database |
| *Herpetocetus morrowi* | 3.6 | 2.6 | North Pacific | Paleobiology Database |
| *Cetotherium riabinini* | 11.6 | 7.246 | Paratethys | Paleobiology Database |
| *Cetotherium rathkei* | 13.65 | 7.246 | Mediterranean (Paratethys) | Paleobiology Database |
| *Thinocetus arthritus* | 13.65 | 11.608 | North Atlantic | Paleobiology Database |
| *Halicetus ignotus* | 13.65 | 11.608 | North Atlantic | Paleobiology Database |
| *Herentalia nigra* | 11.608 | 7.246 | North Sea | Paleobiology Database |
| *Archaeschrichtius ruggieroi* | 11.0 | 7.5 | Mediterranean | Bisconti & Varola (2006) |
| *Eschrichtioides gastaldii* | 5.0 | 3.0 | Mediterranean | Bisconti (2008) |
| *Eschrichtius robustus* | 0.1 | 0.0 | North Sea, North Atlantic, North Pacific | Paleobiology Database |
| *'Balaenoptera' ryani* | 11.608 | 7.246 | North Pacific | Paleobiology Database |
| RBINS M. 2231 | 5.0 | 5.0 | North Sea | Bisconti & Bosselaers in prep. a |
| MPTA 207.13307 | 3.6 | 3.2 | Mediterranean | Bisconti et al. in prep. |
| *Archaebalaenoptera castriarquati* | 3.8 | 2.558 | Mediterranean | Bisconti (2007a); Freschi & Cau (2015) |
| *Protororqualus cuvieri* | 3.1 | 3.0 | Mediterranean | Bisconti (2007b); Freschi & Cau (2015) |
| *'Balaenoptera' cortesii* var. *portisi* | 3.6 | 2.588 | Mediterranean, North Atlantic, North Pacific | Deméré et al. (2005) |
| SAM PQL-55001 | 5.3 | 5.0 | South Atlantic | Govender et al. (2016) |
| *Plesiobalaenoptera quarantellii* | 11.608 | 7.246 | Mediterranean | Bisconti (2010) |
| *'Balaenoptera' bertae* | 3.35 | 2.5 | North Pacific | Boessenecker (2013) |
| *Parabalaenoptea baulinensis* | 7.246 | 5.332 | North Pacific | Zeigler et al. (1997) |
| *Fragilicetus velponi* | 5.332 | 5.0 | North Sea; South Atlantic | Bisconti and Bosselaers (2016); Govender (2019) |
| *'Megaptera' hubachi* | 5.332 | 3.6 | South Pacific | Bisconti (2011) |
| *Diunatans luctoretemergo* | 5.3 | 2.558 | North Sea | Bosselaers & Post (2010) |
| *'Balaenoptera' siberi* | 7.246 | 5.332 | South Pacific | Paleobiology Database |
| MHNL 1610 | 8.0 | 7.0 | South Pacific | Bisconti et al. (in prep. a) |
| MHNL 1613 | 7.5 | 7.3 | South Pacific | Bisconti et al. (in prep. b) |
| UT PU13842/5 | 3.4 | 3.2 | Mediterranean | Caretto (1970) |
| *Archaebalaenoptera liesselensis* | 8.2 | 7.5 | North Sea | Bisconti et al. (in prep. c) |
| RBINS 2315 | 3.71 | 2.74 | North Sea | Bisconti & Bosselaers (in prep. b) |
| NMR 7096 | 3.7 | 2.7 | North Sea | Bisconti & Bosselaers (in prep. c) |
| *Incakujira anillodefuego* | 7.5 | 7.3 | South Pacific | Marx & Kohno (2016) |
| *Megaptera novaeangliae* | 0.781 | 0.0 | North Atlantic, North Pacific, South Atlantic, South Pacific, Indian Ocean | Paleobiology Database; |

| | | | | |
|---|---|---|---|---|
| *'Balaenoptera' bertae* | 5.332 | 2.558 | North Pacific | Boessenecker (2013) |
| *Miobalaenoptera numataensis* | 6.8 | 6.5 | North Pacific | Tanaka & Watanabe (2019) |
| *'Megaptera' miocaena* | 11.608 | 7.246 | North Pacific | Paleobiology Database |
| Maesawa-Cho | 5.3 | 5.0 | North Pacific | Oishi et al. (1985) |
| Shimajirikujira | 9.0 | 8.0 | North Pacific | Kimura et al. (2015) |
| *Balaenoptera borealis* | 2.6 | 0.0 | North Atlantic, North Pacific, South Atlantic, South Pacific, Indian Ocean | Paleobiology Database |
| *Balaenoptera edeni* | 0.012 | 0.0 | North Atlantic, North Pacific, South Atlantic, South Pacific, Indian Ocean | Paleobiology Database |
| *Balaenoptera musculus* | 1.806 | 0.0 | North Atlantic, North Pacific, South Atlantic, South Pacific, Indian Ocean | Paleobiology Database |
| *Balaenoptera omurai* | 0.012 | 0.0 | North Pacific | Paleobiology Database |
| *Balaenoptera brydei* | 0.012 | 0.0 | North Pacific | Wada et al. (2007) |
| *Balaenoptera physalus* | 1.3 | 0.0 | North Atlantic, North Pacific, South Atlantic, South Pacific, Indian Ocean, Mediterranean | Paleobiology Database |
| *Balaenoptera acutorostrata* | 3.6 | 0.0 | North Atlantic, North Pacific, Mediterranean, Indian Ocean | Paleobiology Database |
| *Balaenoptera bonaerensis* | 0.012 | 0.0 | South Atlantic, South Pacific | Paleobiology Database |

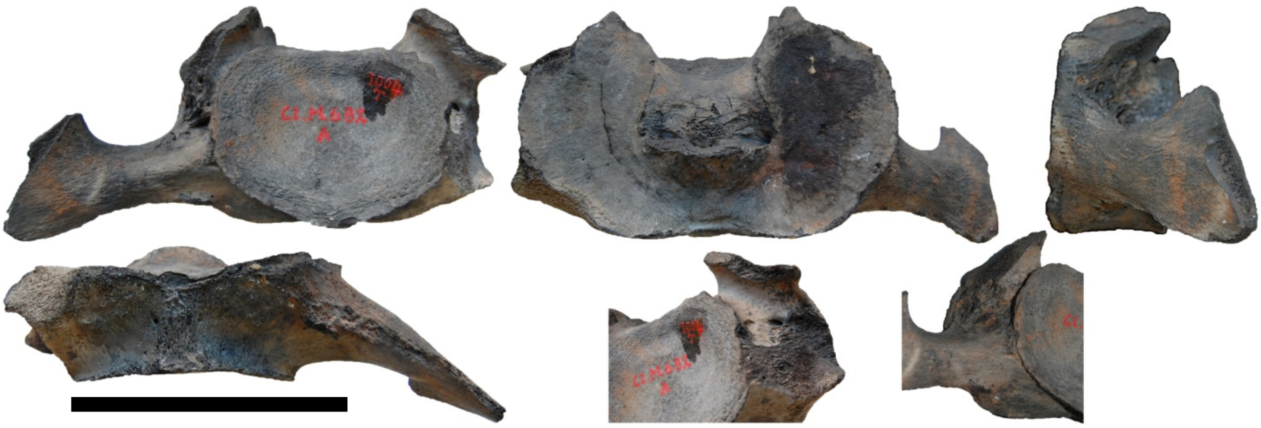
FO, first occurrence; LO, last occurrence. Data in Ma.

# SUPPLEMENTARY ILLUSTRATIONS




**Supplementary Fig. S1**
*Burtinopsis similis*: specimen “Reg” 634
*Photographic representation of the 90th plate of Van Beneden’s (1882) atlas representing the specimen “R”643 (C1). Upper row, left to right: anterior and right lateral views. Lower row, left to right, dorsal and posterior views. Scale bar equals: 10 cm. Scale bar added digitally. The specimen is currently missing and it is not in the General catalog of Fossil Vertebrates (M-numbers). Therefore, it was probably missing already when this catalog was established, sometime between 1948-1964.*

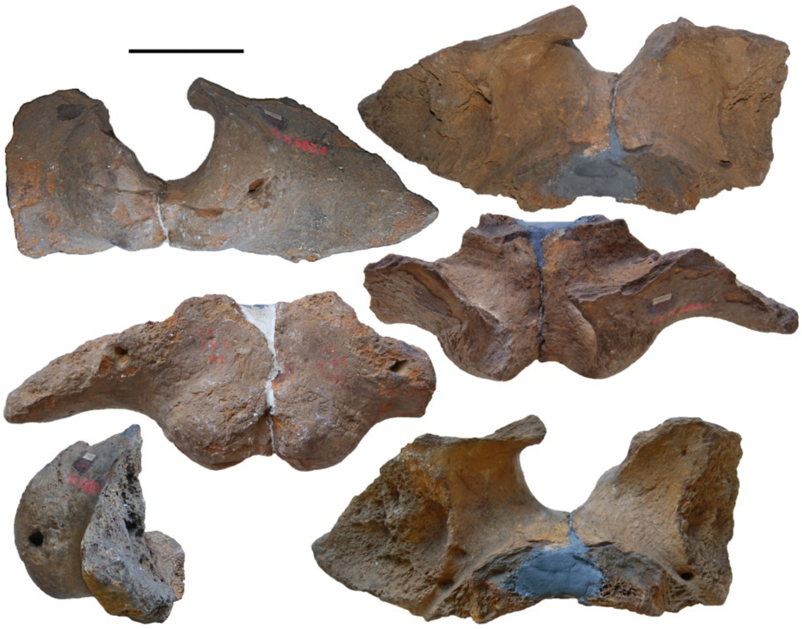
**Supplementary Fig. S2**
*Burtinopsis similis*: specimen M657
*Photographic representation of the specimen M 657. Top to down: ventral, medial , posterior, lateral, dorsal views. Scale bar equals 10 cm.*



**Supplementary Fig. S3**
*Burtinopsis similis*: specimen M682a
*Photographic representation of specimen M682a (axis). Upper row from left to right: posterior view, anterior view, left lateral view. Lower row from left to right: ventral view, posterolateral view, anterolateral view). Scale bar equals 20 cm.*

**Supplementary Fig. S4**
*Burtinopsis similis*: specimen M682b
*Photographic representation of specimen M682b. Column on the left: right lateral view; detail of the metapophysis and of the transverse process of the left side in anterodorsal view. Right column, up-to-down: anterior view; posterior view; posterolateral view. Scale bar equals 10 cm.*

**Supplementary Fig. S5**
*Burtinopsis similis*: specimen M682c
*Photographic representation of specimen M682c. Column on the left: posterior view; anterior view; posterodorsal view; ventral view. Column on the right: three views of the left side of the vertebra. Scale bar equals 10 cm.*



**Supplementary Fig. S6**
*Burtinopsis similis*: specimen M683a
*Photographic representation of specimen M683a. Column on the left: posterior view; ventral view; right lateral view. Column on the right: anterodorsal view, dorsal view, anterior view. Scale bar equals 10 cm.*

**Supplementary Fig. S7**
*Burtinopsis similis*: specimen M683b
*Photographic representation of specimen M683b. Anterior portion of a left dentary. Upper: medial view; middle: dorsal view; lower: lateral view. On the right side of the figure, the posterior cross-section of the specimen is shown. Scale bar equals 10 cm.*

**Supplementary Fig. S8**
*Burtinopsis similis*: specimen M684b
*Photographic representation of specimen M684. Right dentary. From up to down: dorsomedial view; dorsolateral view; dorsal view; detail of the posterior end in dorsal view; detail of the anterior end in medial view; detail of the posterior end in ventral view. Scale bar equals 10 cm.*

**Supplementary Fig. S9**
*Burtinopsis similis*: specimen M685
*Photographic representation of specimen M685. Condyle of a left dentary. Left: lateral view; middle: posterior view; right: medial view. Scale bar equals 10 cm.*

**Supplementary Fig. S10**
*Burtinopsis similis*: specimen M686
*Photographic representation of specimen M686. Left tympanic bulla. Up to down: dorsal view; medial view; lateral view; ventral view; anterior (left) and posterior (right) views. Scale bar equals 5 cm.*

**Supplementary Fig. S11**
*Burtinopsis similis*: specimen M687
*Photographic representation of specimen M687. Left tympanic bulla. Up to down: dorsal view; medial view; lateral view; anterior (right) and posterior (left) views. Scale bar equals 5 cm.*

**Supplementary Fig. S12**
*Burtinopsis similis*: specimen M689
*Photographic representation of specimen M689. Atlas. Up to down: anterior view, posterior view, right lateral view, anterolateral vies of the right side. Scale bar equals 10 cm.*

**Supplementary Fig. S13**
*Burtinopsis similis*: specimen M691
*Photographic representation of specimen M691. Caudal vertebra. Upper row, left to right: anterior view, right lateral view (dorsal is down). Middle row, left to right: ventral and ventrolateral views. Lower row, left to right: dorsal and posterior views. Scale bar equals 10 cm.*

**Supplementary Fig. S14**
*Burtinopsis similis*: specimen M692
*Photographic representation of specimen M692. Caudal vertebra. Upper row, left to right: right lateral, anterior, posterior views. Lower image: ventral view. Scale bar equals 10 cm.*

**Supplementary Fig. S15**
*Burtinopsis similis*: specimen M693
*Photographic representation of specimen M693. Humerus. Upper row, left to right: posterolateral and posterior views. Middle row, left to right: medial and anteromedial views. Lower row, left to right: lateral, proximal and distal views. Scale bar equals 10 cm.*

**Supplementary Fig. S16**
*Burtinopsis similis*: specimen M694
*Photographic representation of specimen M694. Ulna. Up to down: lateral, medial, posterior, anterior views. Small images represent proximal (left) and distal (right) views. Scale bar equals 10 cm.*

**Supplementary Fig. S17**
*Burtinopsis similis*: specimen M695
*Photographic representation of specimen M695. Radius. Up to down: lateral, posterior, medial, anterior views. Left column, up to down: proximal and distal views. Scale bar equals 10 cm.*

**Supplementary Fig. S18**
*Burtinopsis minutus*: specimen M696a
*Photographic representation of specimen M696a. Upper row from left to right: left side, right side, anterior view. Lower row from left to right: anterior view, dorsal view (upper image) and vengral view (lower image). Scale bar equals 20 cm.*


**Supplementary Fig. S19**
*Burtinopsis minutus:* specimen M696b
*Photographic representation of specimen M696b. Upper row from left to right: anterior, posterior and right lateral views. Lower row, from left to right: ventral and dorsal views. Scale bar equals 20 cm.*

**Supplementary Fig. S20**
*Burtinopsis minutus:* specimen M696c
*Photographic representation of specimen M696c. Upper row, from left to right: ventral and dorsal views. Lower row, from left to right: right lateral, anterior, posterior and left lateral views. Scale bar equals 20 cm.*

**Supplementary Fig. S21**
*Burtinopsis minutus:* specimen M696d
*Photographic representation of specimen M696d. Upper row, from left to right: right lateral, anterior, posterior, left lateral view. Lower row, from left to right: ventral and dorsal views. Scale bar equals 20 cm.*

**Supplementary Fig. S22**
*Burtinopsis minutus:* specimen M696e
*Photographic representation of specimen M696e. Upper row, from left to right: right lateral, posterior, anterior, left lateral views. Lower row, from left to right: ventral and dorsal views (anterior part is down). Scale bar equals 20 cm.*

**Supplementary Fig. S23**
*Burtinopsis minutus:* specimen M696f
*Photographic representation of specimen M696f. Upper row, from left to right: left lateral, anterior, posterior right lateral views. Lower row, from left to right: dorsal and ventral views (anterior is up). Scale bar equals 20 cm.*

**Supplementary Fig. S24**
*Burtinopsis minutus:* specimen M696g
*Photographic representation of specimen M696g. Upper row, from left to right: left lateral, anterior, posterior, right lateral views. Lower row, from left ot right: ventral and dorsal views (anterior is up). Scale bar equals 20 cm.*

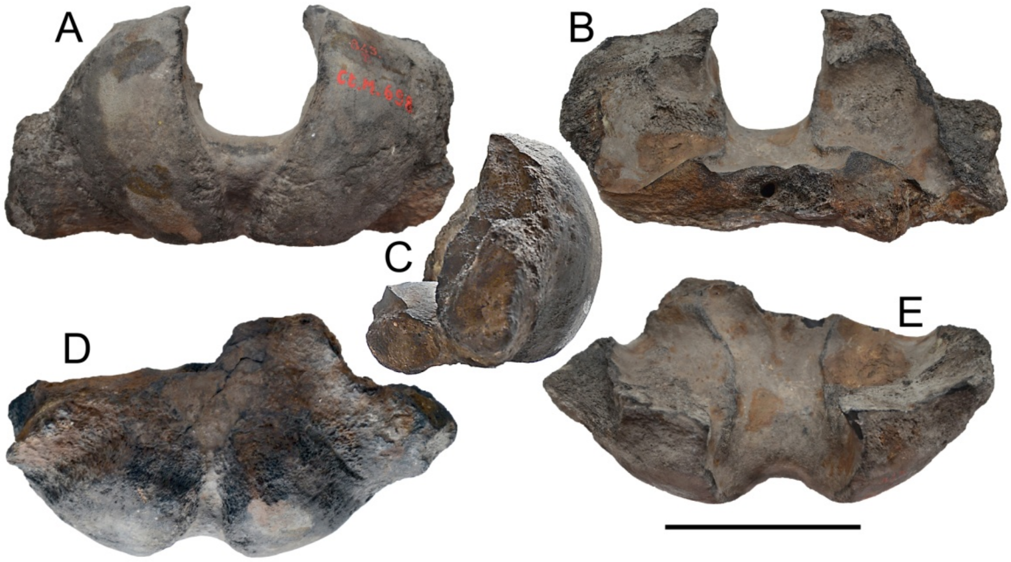
**Supplementary Fig. S25**
*Burtinopsis minutus:* specimen M696h
*Photographic representation of specimen M696h. Upper row, from left to right: left lateral, anterior, posterior, right lateral views. Lower row, from left to right: dorsal and ventral views (anterior is up). Scale bar equals 20 cm.*


**Supplementary Fig. S26**
*Burtinopsis minutus:* specimen M696k
*Photographic representation of specimen M696k. Left, posterior view. Center, right lateral view. Right, anterior view. Scale bar equals 10 cm.*

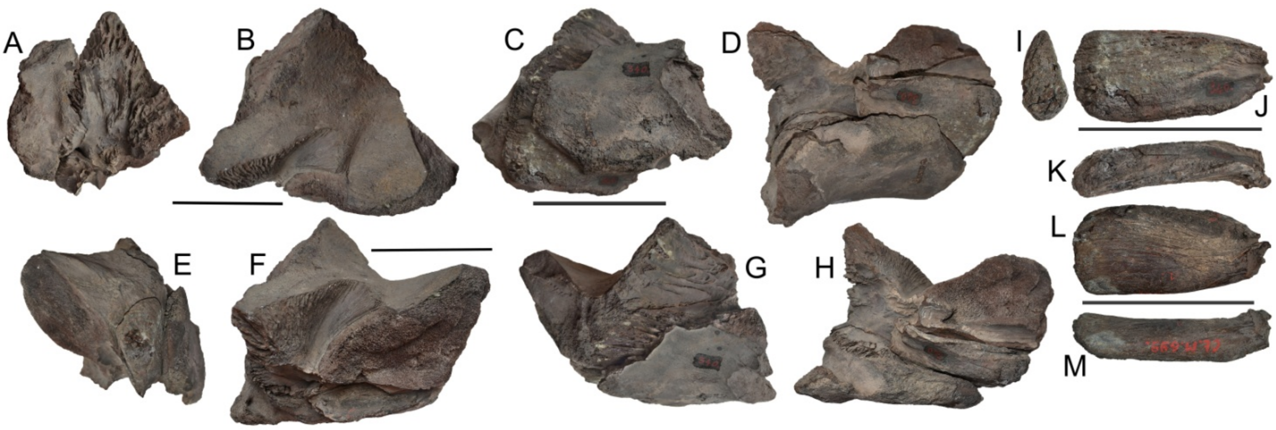

**Supplementary Fig. S27**

*Burtinopsis minutus:* specimen M697a-f

*Photographic representation of specimens M697a-f. Scale bars equal 10 cm. A, M697a (from top to down: anterior, ventral, posterior and dorsal views). B, M697b (clockwise path: right lateral, anterior, dorsal, posterior, left lateral view). C, M697c (top left, anterior view; top right, right lateral view; then, dorsal, posterior and ventral views). D, M697d (left column, top to down: left lateral and right lateral views; right column, top to down: anterior, dorsal, posterior, ventral views). E, M697e (left column, top to down: anterior, dorsal, posterior, ventral views; right column: right lateral view). F, M697f (upper row, left to right: anterior and left lateral views; middle row, left to right: dorsal and ventral views; lower row, posterior view).*




**Supplementary Fig. S28**
*Burtinopsis minutus:* specimen M698
*Photographic representation of specimen M698. A, posterior view. B, anterior (endocranial) view. C, left lateral view. D, ventral view. E, dorsal (endocranial) view. Scale bar equals 10 cm.*



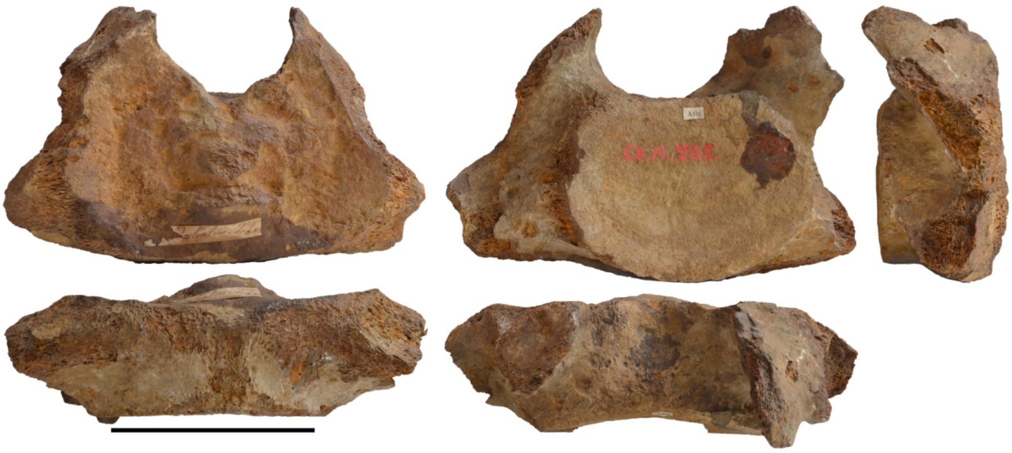

**Supplementary Fig. S29**
*Burtinopsis minutus:* specimen M699
*Photographic representation of specimen M699. A, medial view. B, anterolateral view. C, posterior view. D, posteroventral view. E, left lateral view. F, medial view. G, dorsal view. H, ventral view. I, lateral view of posterior process of periotic (ppp). J, ppp in ventral view. K, ppp in anteroventral view. L, ppp in dorsal view. M, ppp in anterior view. Scale bars equal 10 cm in A-H and 5 cm in I-M.*

**Supplementary Fig. S30**
*Burtinopsis minutus:* specimen M700
*Photographic representation of specimen M700. Top: medial view. Middle: dorsal view. Down: ventral view. Entire bulla is 71.04 mm in length.*

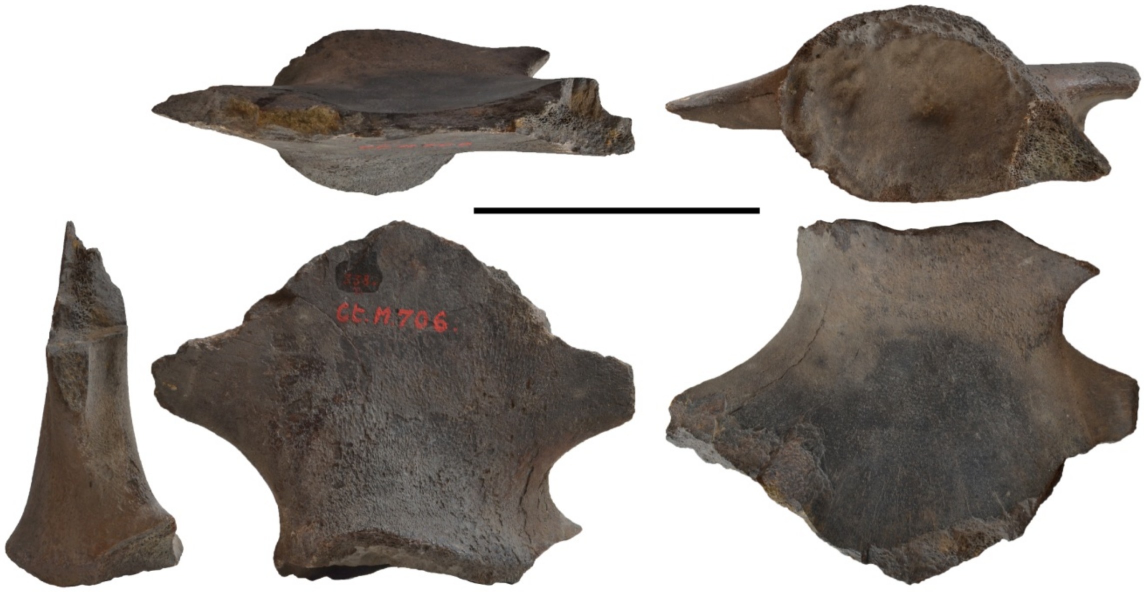

**Supplementary Fig. S31**
*Burtinopsis minutus:* specimen M701
*Photographic representation of specimen M701. Upper row, left to right: ventral and medial views. Lower row, left to right: lateral and dorsal views. Scale bar equals 5 cm.*

**Supplementary Fig. S32**
*Burtinopsis minutus:* specimen M703
*Photographic representation of specimen M703. Upper row, left to right: dorsal and ventral views. Center, posterior view of articular condyle and angular process. Lower row, left to right: medial and lateral views. Scale bar equals 10 cm.*

**Supplementary Fig. S33**
*Burtinopsis minutus:* specimen M704
*Photographic representation of specimen M704. Left column, top to down: dorsal, anterior, posterior and ventral views. Separate image represents the left lateral view. Scale bar equals 5 cm.*



**Supplementary Fig. S34**
*Burtinopsis minutus:* specimen M705
*Photographic representation of specimen M705.Upper row, left to right: anterior, posterior, right lateral views. Lower row, left to right: ventral and dorsal views. Scale bar equals 5 cm.*



**Supplementary Fig. S35**
*Burtinopsis minutus:* specimen M706
*Photographic representation of specimen M706. Upper row, left to right: dorsal and ventral (acetabulum) views. Lower row, left to right: anterior, lateral (anterior on the right), medial view (anterior on the right) Scale bar equals 10 cm.*

**Supplementary Fig. S36**
*Burtinopsis minutus:* specimen M707
*Photographic representation of specimen M707. Left to right: lateral, medial, anterior, posterior views. Extreme left, top: distal epiphysys (articular facets for radius and ulna); down: proximal epiphysys (articular head of humerus). Scale bar equals 10 cm.*


**Supplementary Fig. S37**
*Burtinopsis minutus:* specimen M708
*Photographic representation of specimen M708. Top, posterior view. Middle row, left to right: medial and lateral views. Lower row, left to right: anterior, anterodistal and posterodistal views. Scale bar equals 5 cm.*

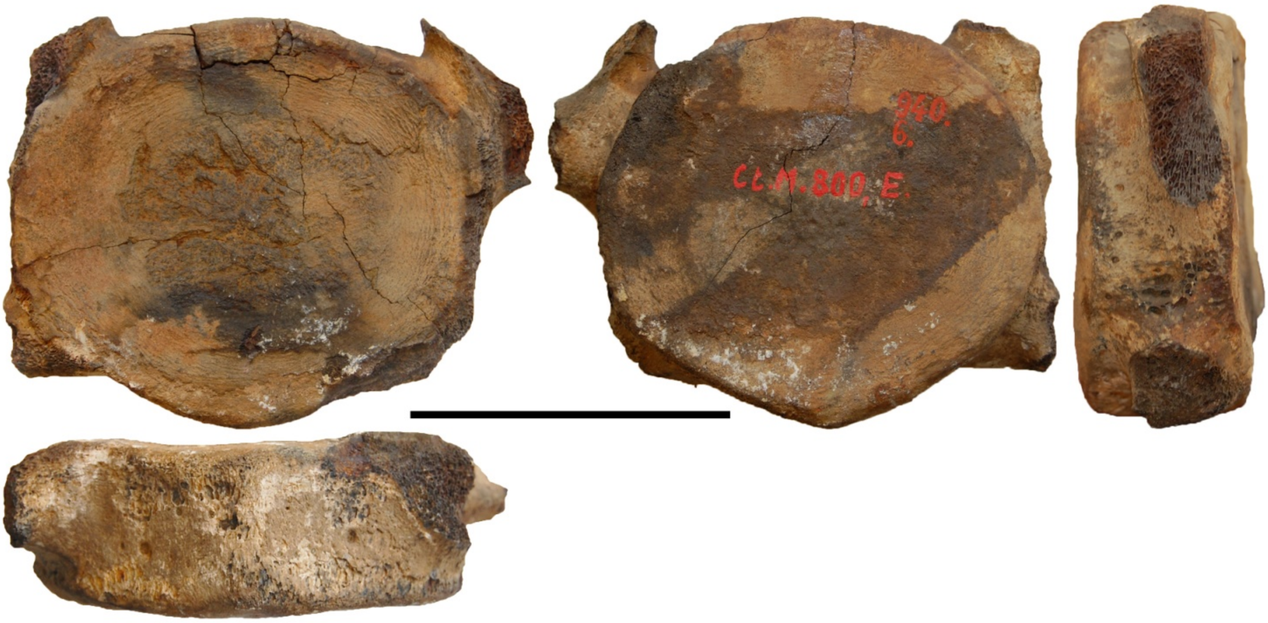
**Supplementary Fig. S38**
*Burtinopsis minutus:* specimen M709
*Photographic representation of specimen M709. Upper row, left to right: anterior, posterior, medial, lateral views. Lower row, left to right: proximal and distal epiphyses. Scale bars equal 5 cm.*

**Supplementary Fig. S39**
*Burtinopsis minutus:* specimen M800a
*Photographic representation of specimen M800a. Left column, top to down: anterior, posterior and posteroventral views. Right column: dorsal view. Scale bars equal 10 cm.*

**Supplementary Fig. S40**
*Burtinopsis minutus:* specimen M800b
*Photographic representation of specimen M800b. Upper row, left to right: anterior, posterior, medial, lateral views. Lower row, left to right: right lateral and ventral views. Scale bars equal 10 cm.*

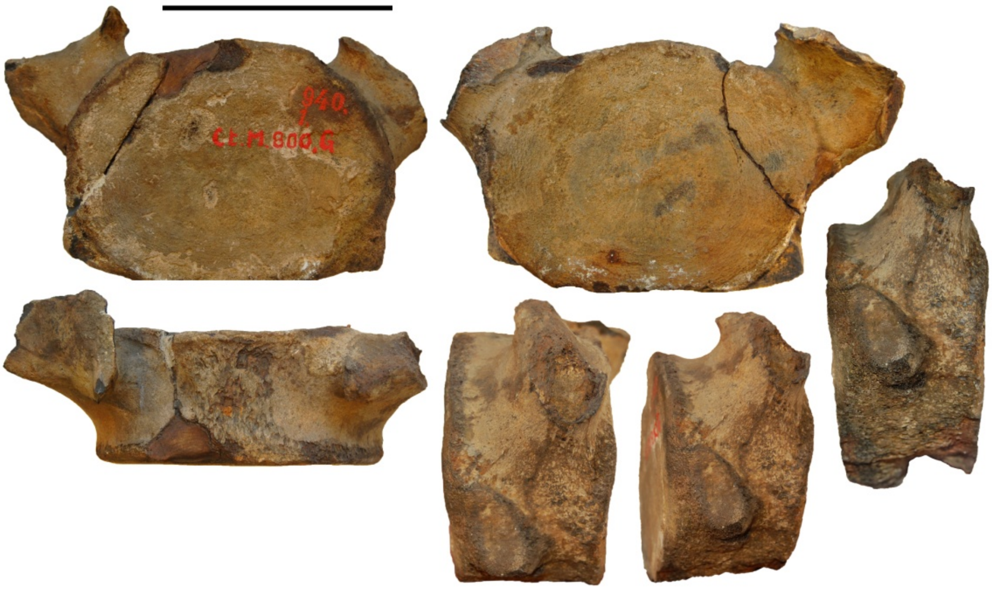
**Supplementary Fig. S41**
*Burtinopsis minutus:* specimen M800c
*Photographic representation of specimen M800c. Upper row: ventral view. Lower row, left to right: posterior, anterior and dorsal views. Scale bars equal 10 cm.*

**Supplementary Fig. S42**
*Burtinopsis minutus:* specimen M800d
*Photographic representation of specimen M800d. Left to right: posterior, dorsal and anterior views. Scale bars equal 10 cm.*

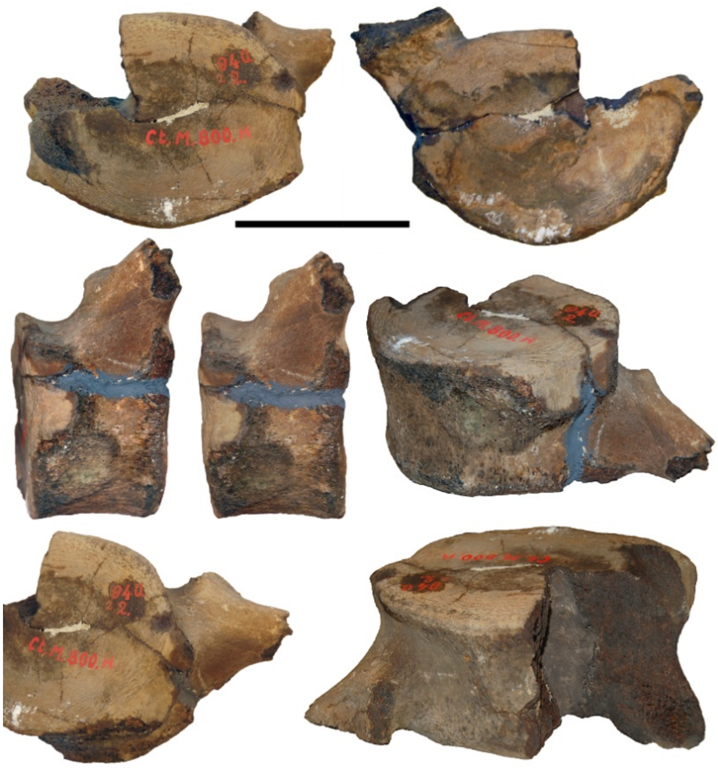



**Supplementary Fig. S43**
*Burtinopsis minutus:* specimen M800e
*Photographic representation of specimen M800e. Upper row: anterior, posterior and right lateral views. Lower row: ventral view. Scale bars equal 10 cm.*

**Supplementary Fig. S44**
*Burtinopsis minutus:* specimen M800f
*Photographic representation of specimen M800f. Left column, top to down: anterior and ventral views. Center: left lateral view. Right column: posterior and posteroventral views. Scale bar equals 10 cm.*



**Supplementary Fig. S45**
*Burtinopsis minutus:* specimen M800g
*Photographic representation of specimen M800g. Upper row, left to right: posterior and anterior views. Lower row, left to right: dorsal, left lateral, left ventrolateral, left ventrolateral views. Scale bar equals 10 cm.*

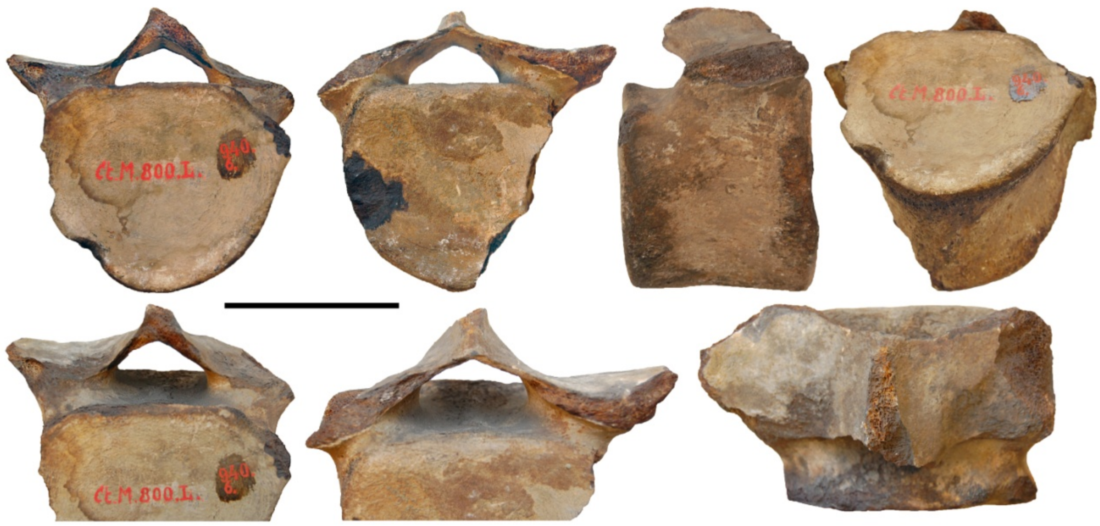


**Supplementary Fig. S46**
*Burtinopsis minutus:* specimen M800h
*Photographic representation of specimen M800h. Upper row, left to right: posterior and anterior views. Lower row, left to right: dorsal, left lateral, left ventrolateral, left ventrolateral views. Scale bar equals 10 cm.*

**Supplementary Fig. S47**
*Burtinopsis minutus:* specimen M800i
*Photographic representation of specimen M800i. Upper row, left to right: posterior and anterior views. Middle row, left to right: right lateral view, left lateral view, left posterolateral view. Lower row: dorsal view. Scale bar equals 10 cm.*

**Supplementary Fig. S48**
*Burtinopsis minutus:* specimen M800j
*Photographic representation of specimen M800j. Upper row, left to right: posterior and anterior views. Lower row, left to right: detail of anterodorsal corner of the centrum (left side) in anterior view; left lateral view, detail of the anterodorsal corner of the centrum (right side) in anterior view. Lower row: dorsal view. Scale bar equals 10 cm.*

**Supplementary Fig. S49**
*Burtinopsis minutus:* specimen M800k
*Photographic representation of specimen M800k. Left column: anterior and right lateral views. Right column: posterior, dorsal and ventral views. Scale bar equals 10 cm.*



**Supplementary Fig. S50**
*Burtinopsis minutus:* specimen M800l
*Photographic representation of specimen M800l. Upper row, left to right: posterior, anterior, right lateral, anteroventral views. Lower row, left to right: posterodorsal, anterodorsal, ventral views. Scale bar equals 10 cm.*

**Supplementary Fig. S51**

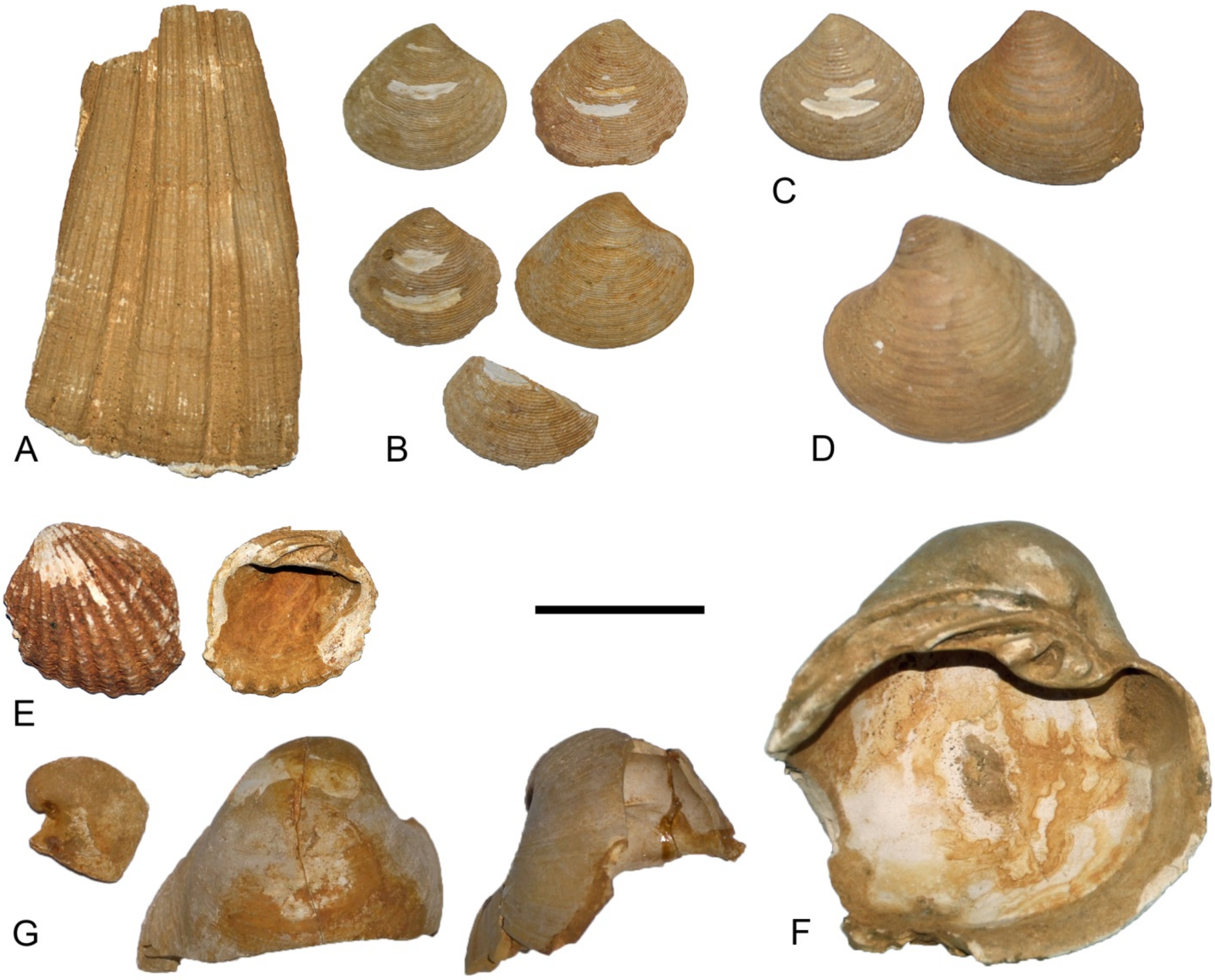
*Burtinopsis minutus:* specimen M800m

*Photographic representation of specimen M800m. Upper row, left to right: anterodorsal and posterior views. Middle row, left to right: posterior and dorsal views. Lower row: right lateral and anterodorsal views. Scale bar equals 10 cm.*

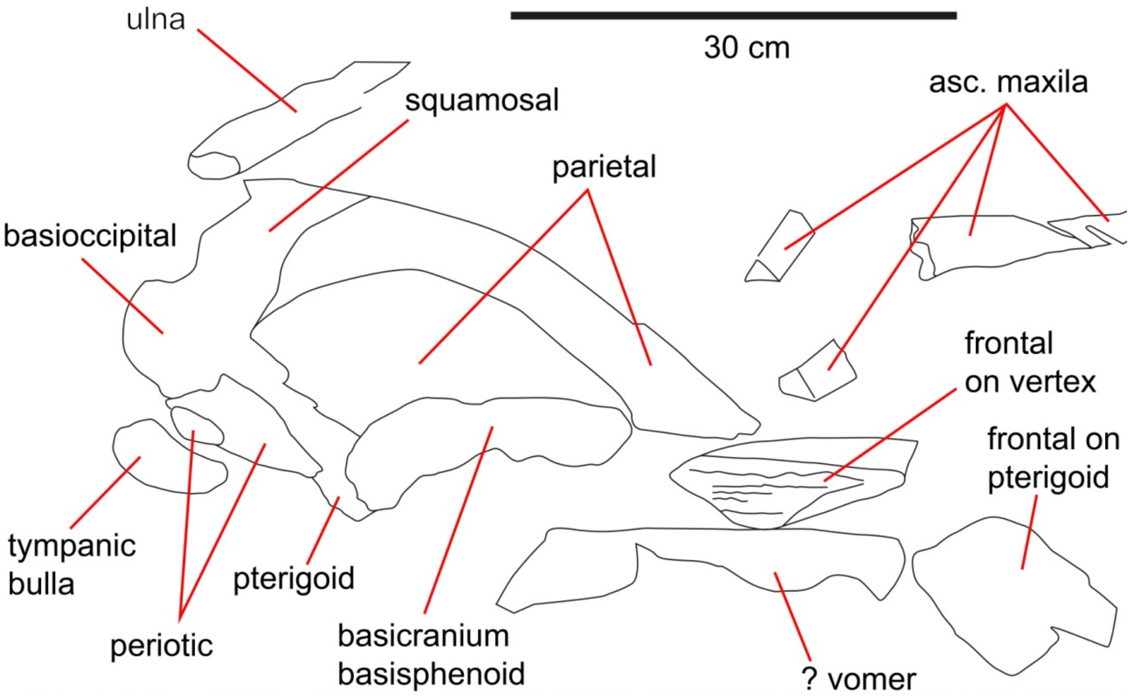
**Supplementary Fig. S52**

*Burtinopsis minutus:* specimen M800n

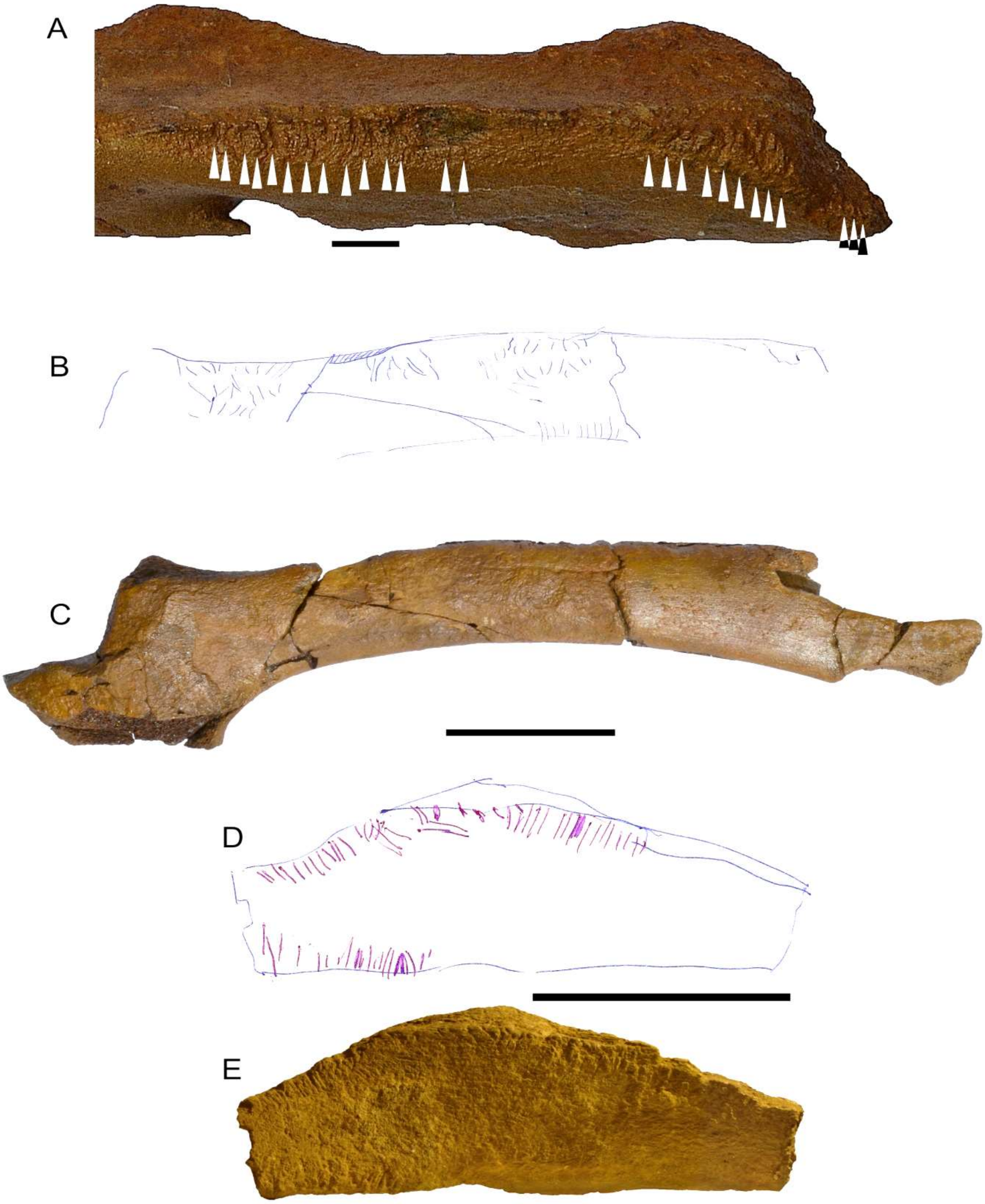
*Photographic representation of specimen M800n. Upper row, left to right: posterior and anterior views. Middle row, left to right: dorsal and right lateral views. Lower row, left to right: ventral view and details of the neural arc in left lateral view (upper) and in anterior view (lower). Scale bar equals 10 cm.*




**Supplementary Fig. S53**
Mollusk species found inside the neurocranium of *Protororqualus wilfriedneesi*
*Mollusk species found inside the neurocranium of* Protororqualus wilfriedneesi. *A,* Pecten grandis*. B,* Digitariopsis (Astarte) obliquata obliquata*. C,* Laeveastarte arijanseni*. D,* Laeveastarte omalii omalii*. E,* Cardites squamulosa ampla*. F,* Pygocardia rustica tumida*. G,* Glossus humanus*. Scale bar equals 3 cm.*



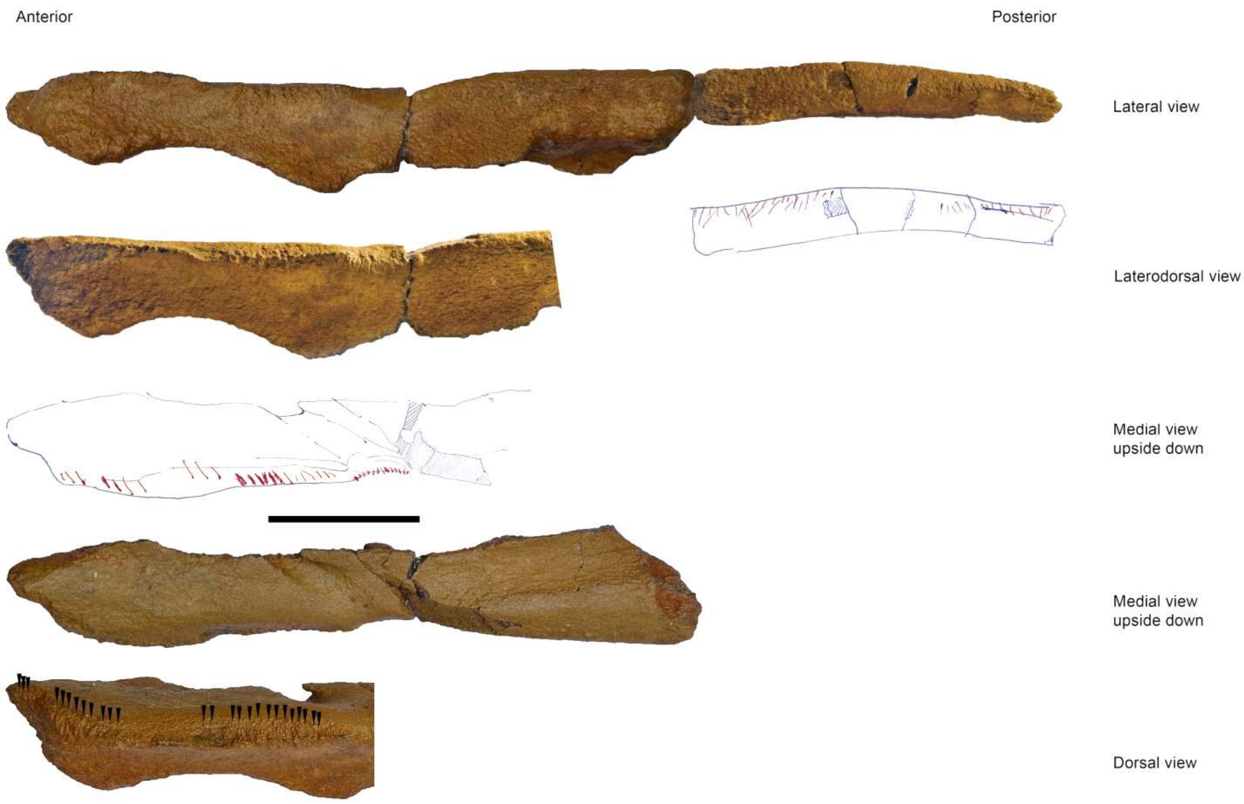

**Supplementary Fig. S54**
Biostratinomy of RBINS M2315
*Biostratinomy of the holotype of* Protororqualus wilfriedneesi*. Upper figure: distribution of the associated bones of the holotype skeleton. Lower figure: field photography of the skeleton during excavation.*



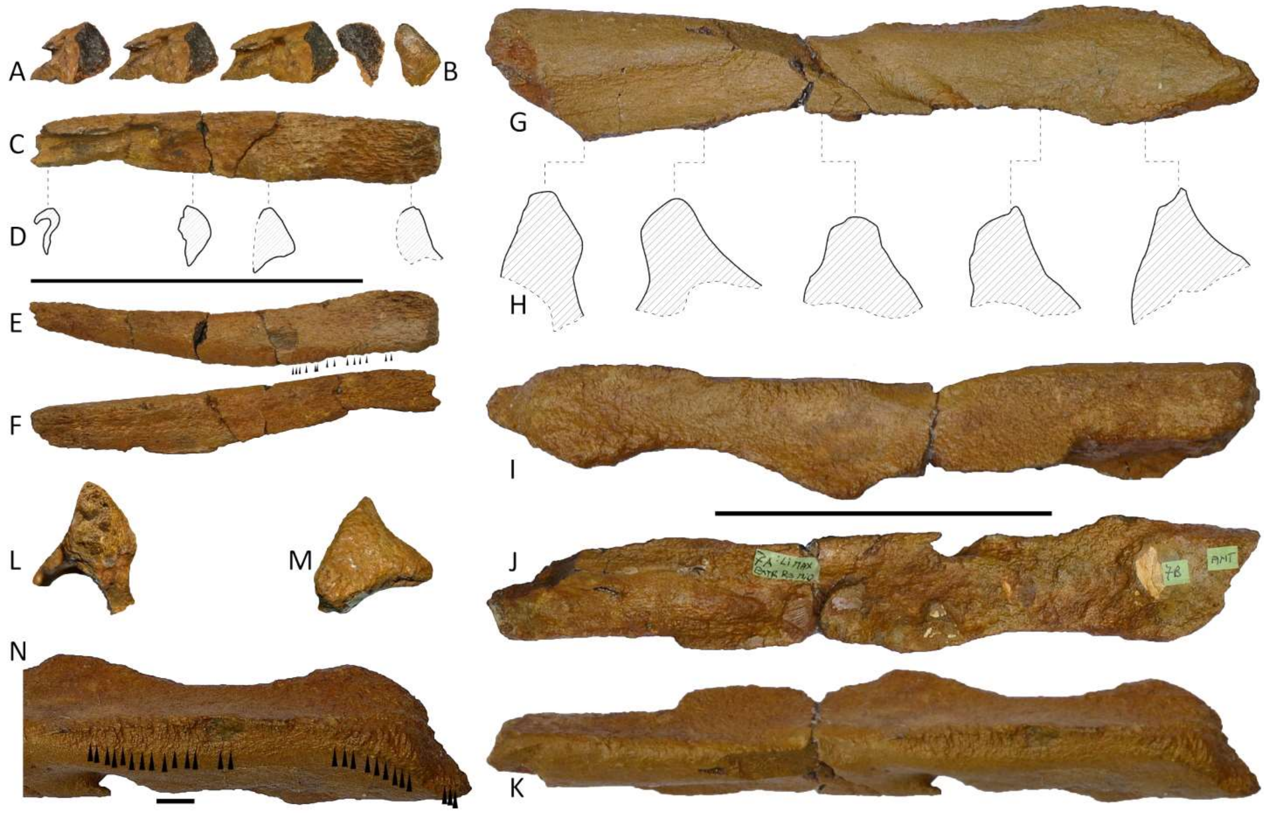

**Supplementary Fig. S55**

Bite marks on *Protororqualus wilfriedneesi*

*Bite marks on different anatomical portions of the holotype of* Protororqualus wilfriedneesi*. A, lateral side of the ascending process of the maxilla (this same portion is also shown in Supplementary Figs S56 and S57) with bite marks indicated by arrows. B, sketchy representation of the distribution of bite marks on the ulna. C, photography of the ulna. D, sketchy representation of the distribution of bite marks on the squamosal. E, photography of the squamosal represented in D. Scale bar equals 5 cm.*




**Supplementary Fig. S56**
Bite marks on ascending process of the maxilla
*Bite marks on different portions of the ascending process of the maxilla of the holotype skull of* Protororqualus wilfriedneesi*. Photographies are alternated with sketchy representations of bite marks in red. Bite marks are indicated in photographies by black arrows. Scale bar equals 5 cm.*

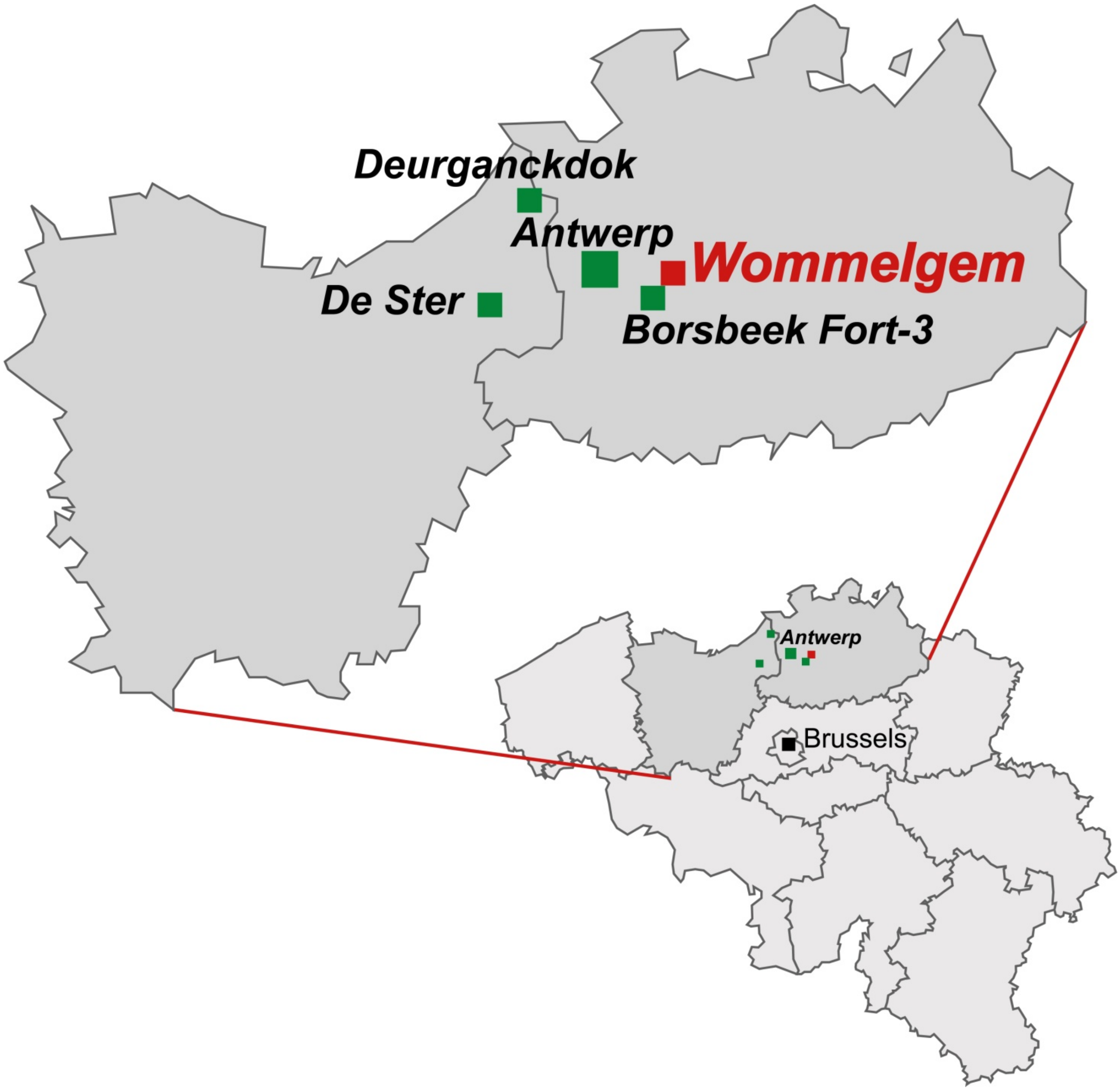



**Supplementary Fig. S57**

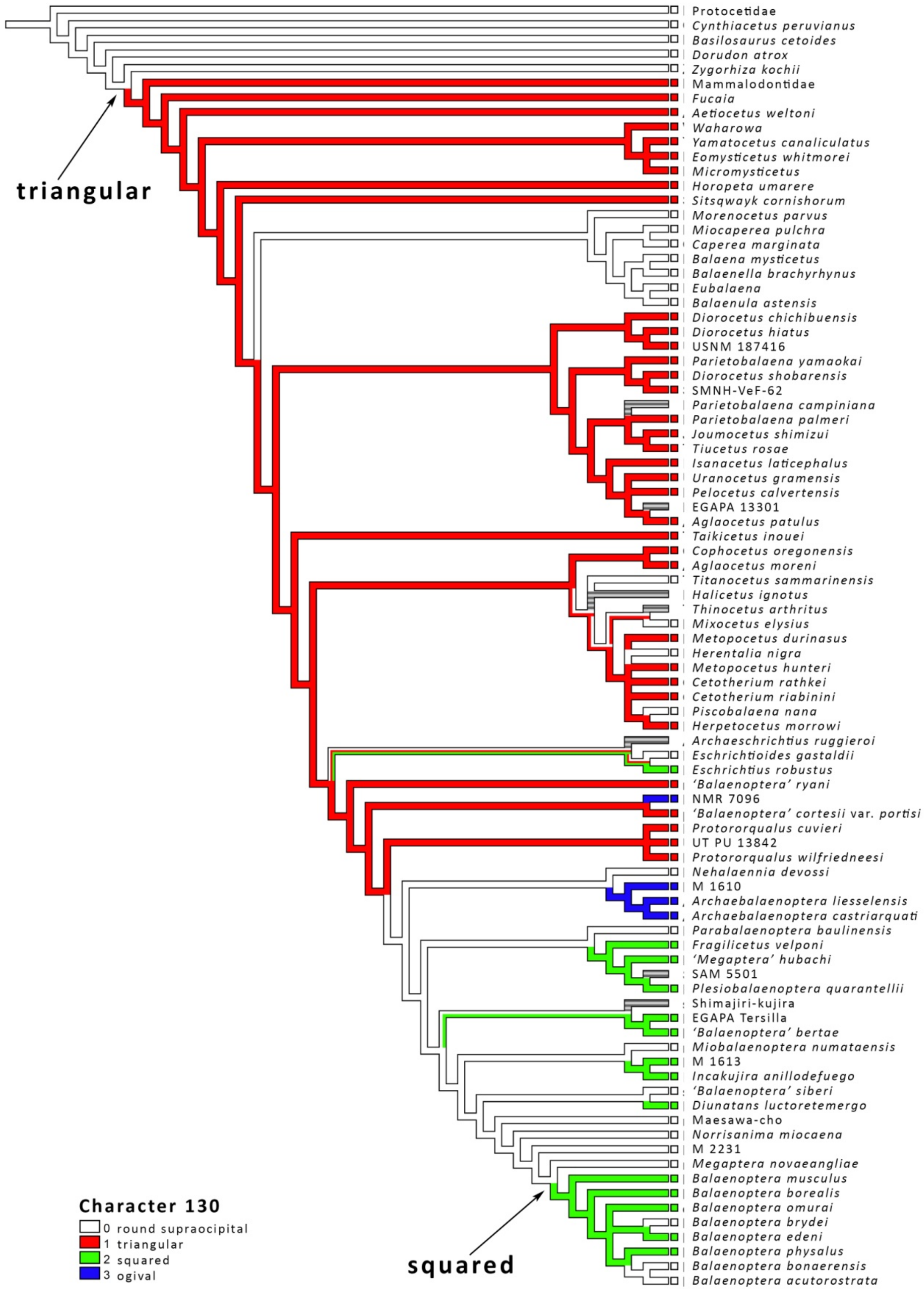
Morphology of ascending process of the maxilla

*Morphology of the ascending process of the maxilla of* Protororqualus wilfriedneesi*. A, B, C, fragments of ascending process. D, cross sections of the fragment in C. E, F, fragments of ascending process with bite marks indicated by arrows. G, large fragment of ascending process of the left maxilla. H, cross sections of the fragment in G. I, J, K, L, M, additional fragments of ascending process of the maxilla. N, bite marks on lateral side of ascending process of the maxilla indicated by black arrows (this fragment is also shown in Supplementary Fig. S…); scale bar equals 1 cm. Scale bars in A-to-K figures equal 5 cm.*


**Supplementary Fig. S58**
Virtual reconstruction of the skull of *Protororqualus wilfriedneesi*
*Virtual reconstruction of the skull of* Protororqualus wilfriedneesi *with missing part reconstructed by mirroring the preserved portions in* Photoshop. *Note the closeness of the posterior ends of the ascending processes of the maxillae and the peculiar, triangular shape of the anterior border of the supraoccipital.*



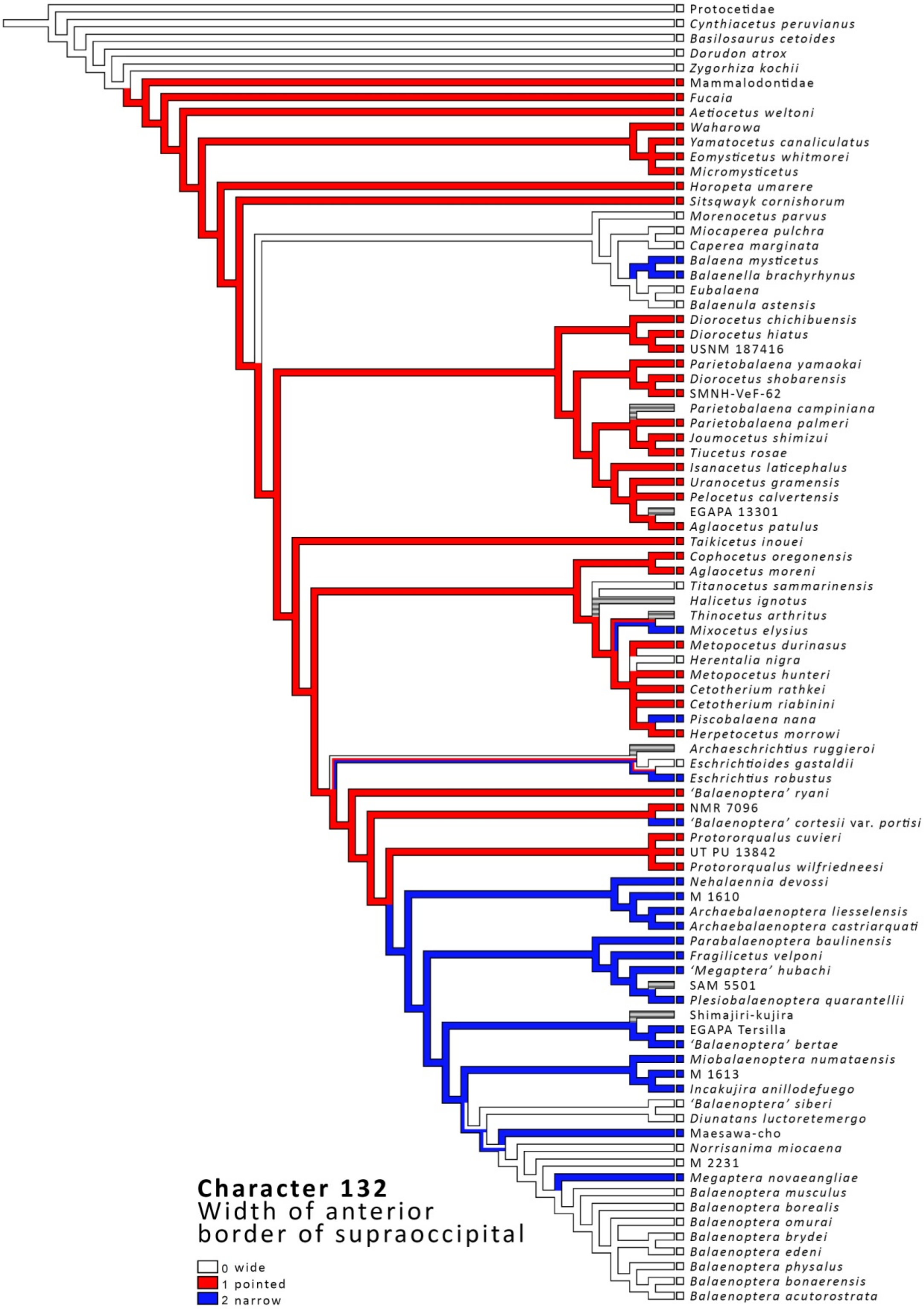

**Supplementary Fig. S59**
Map of discovery localities
*Map of discovery localities of* Protororqualus wilfriedneesi *in Belgium. Lower image: map of Belgium. Upper image: map of East-Flanders and Antwerp provinces with indications of Antwerp and surrounding cities where P. wilfriedneesi fossils have been found. The red square indicates the locality of the type specimen.*




**Supplementary Fig. S60**

Map of character 130.

*Map of states of character No. 130 regarding the shape of the anterior border of the supraoccipital. See text for methods and Character list for definitions.*




**Supplementary Fig. S61**

Map of character 132.

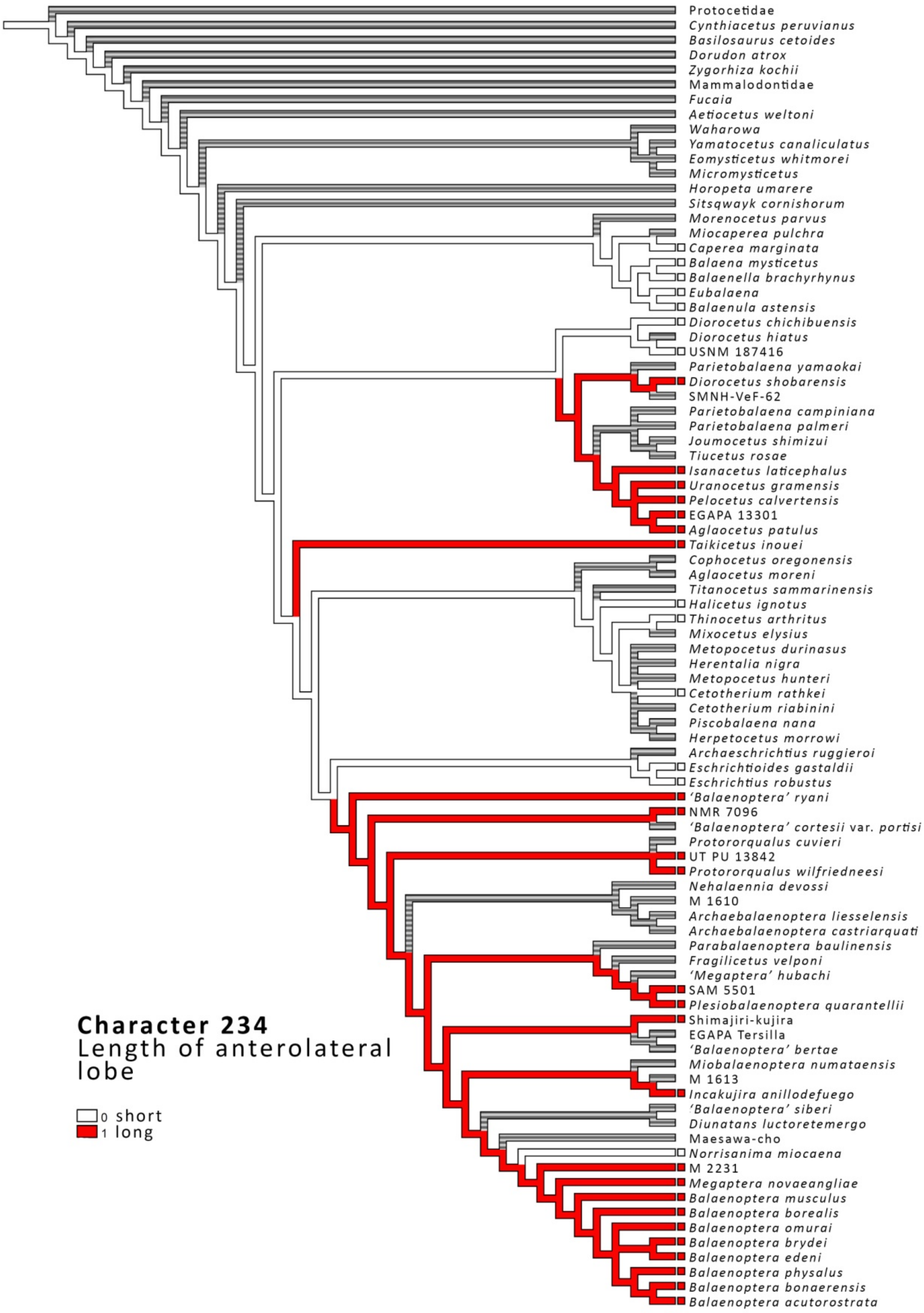
*Map of states of character No. 132 regarding the width of the anterior border of the supraoccipital. See text for methods and Character list for definitions.*


**Supplementary Fig. S62**

Map of character 218.

*Map of states of character No. 218 regarding the presence/absence of the promontorial groove in the periotic. See text for methods and Character list for definitions.*


**Supplementary Fig. S63**
Map of character 233.
*Map of states of character No. 233 regarding the presence/absence of the anterolateral expansion in the tympanic bulla. See text for methods and Character list for definitions.*




**Supplementary Fig. S64**

Map of character 234.

*Map of states of character No. 234 regarding the size of the anterolateral expansion in the tympanic bulla. See text for methods and Character list for definitions.*

# PHYLOGENETIC ANALYSIS

## CHARACTER LIST

The following character list is developed from the morphological dataset of *Bisconti et al. (2019)*. In the present dataset, selected character states were commented in order to warrant clear understanding. In defining character states, we made use of personal observations on specimens listed above and of literature. In particular, we need to cite the following papers that we used for character definitions and codings: *Boessenecker & Fordyce (2015); Fordyce & Marx (2012); Steeman (2009); Geisler & Sanders (2003); Kimura & Ozawa (2001); Benke (1993); Kellogg (1923); Miller (1925)*.

**ROSTRUM: PREMAXILLA, MAXILLA, NASAL**

**1) Rostrum length:**
(0) Rostrum length shorter or equal to neurocranium length;
(1) Rostrum length longer than neurocranium length.

**2) Rostrum width:**
*Comment: character coded 0 in archaeocetes and Balaenidae; all other mysticetes are coded 1.*
(0) Rostrum narrow;
(1) Rostrum wide.

**3) Rostrum straight:**
*Comment: character coded 1 only in Balaenidae and Eschrichtiidae.*
(0) Yes;
(1) No, rostrum highly arched.

**4) Rostrum arc:**
*Comment: character coded for Balaenidae only; code 0 is for* Balaena *and* Balaenella*; code 1 is for* Eubalaena *and* Balaenula.
(0) Continuous;
(1) Discontinuous.

**5) Mesorostral groove:**
(0) Absent;
(1) Present.

**6) Ventral keel along rostrum:**
(0) Absent;
(1) Present.

**7) Premaxilla widens at anterior end:**
(0) No;
(1) Yes.

**8) Premaxillary foramen:**
(0) Present;
(1) Absent.

**9) Posterior end of premaxilla:**
(0) More anterior than frontonasal suture;
(1) At posterior end of nasal;
(2) Anterior to nasal.

**10) Sutural contact between rostrum and frontal limited to ascending process of the maxilla:**
(0) No;
(1) Yes.

**11) Premaxilla and frontal articulation:**
(0) Sutured;
(1) Not sutured.

**12) External surface of maxilla:**
(0) Sub-vertical;

(1) Sub-horizontal.
**13) Medial border of maxilla anterior to narial fossa:**
(0) Straight;
(1) Sinuous.
**14) Lateral border of maxilla:**
(0) Uniformly concave;
(1) Straight;
(2) Uniformly convex;
(3) Sinuous
**15) Thickness of lateral border of maxilla:**
*Comment: Chaeomysticeti and Eomysticetidae are coded 1 when rostrum is preserved.*
(0) Thin;
(1) Thick.
**16) Lateral process of maxilla:**
(0) Absent;
(1) Present.
**17) Length of lateral process of maxilla:**
*Comment: a very long lateral process of the maxilla is observed in those taxa where this structure is longer than the transverse diameter of the maxilla at the level of the antorbital notch; a long lateral process is observed in those taxa where this structure is longer 50% of the transverse diameter of the maxilla at the level of the antorbital notch but is shorter than the whole transverse diameter.*
(0) Short;
(1) Long.
(2) Very long.
**18) Position of external apex of lateral process of maxilla:**
(0) Anterior to antorbital corner of orbit;
(1) Anterior and medial to orbit.
**19) Infraorbital process of maxilla:**
(0) Absent;
(1) Present.
**20) Ascending process of maxilla:**
(0) Absent;
(1) Present.
**21) Width of ascending process of maxilla relative to its length:**
(0) Narrow;
(1) Wide.
**22) Length of ascending process of maxilla:**
*Comment: Balaenidae, Neobalaenidae and basal thalassotherian taxa are coded 0; Eschrichtiidae, Cetotheriidae and Balaenopteridae are coded 1.*
(0) Short;
(1) Long;
**23) Lateral border of ascending process of maxilla:**
(0) Forms an evident corner with posterior border of maxilla;
(1) Forms a wide curve with posterior border of maxilla.
**24) Position of posterior ends of ascending processes of maxillae:**
(0) Posterior ends do not meet along midline;
(1) Posterior ends meet along midline.
**25) Meeting of ascending processes of the maxillae along the longitudinal axis of the skull:**
(0) Contact limited to posterior corners;
(1) Contact extended to most of medial borders of the ascending processes of the maxillae.

**26) Shape of posterior end of ascending process of maxilla at adulthood:**
(0) Triangular;
(1) Squared;
(2) Rounded.
**27) Shape of posterior end of ascending process of maxilla during late ontogeny:**
(0) Triangular;
(1) Squared;
(2) Rounded.
**28) Lateral and medial borders of ascending process of maxilla:**
(0) Anteriorly diverging;
(1) Parallel;
(2) Anteriorly converging.
**29) Position of posterior end of maxilla:**
(0) Anterior to nasal;
(1) At level of posterior end of nasal;
(2) Posterior to nasal.
**30) Position of posterior ends of maxillae:**
*Comment: posterior ends of maxillae are transversely far if the nasals and premaxillae have wide transverse diameter. For instance, state 0 is present in living* Balaenoptera *species and in Balaenidae; state 0 is present in early-diverging balaenopterids such as* Protororqualus *and in basal thalassotherian taxa where the transverse diameter of the nasals is massively shortened; state 2 is present in Cetotheriidae.*
(0) Transversely far;
(1) Transversely close;
(2) Transversely very close.
**31) Numerous dorsal infraorbital foramina:**
(0) Absent (only one foramen is present);
(1) Present.
**32) Location of dorsal infraorbital foramina:**
(0) Scattered along dorsal surface of maxilla;
(1) Mostly located close to the medial border of maxilla.
**33) Medial border of maxilla:**
(0) not relieved;
(1) relieved and forming a crest.
**34) Antorbital notch:**
(0) Absent;
(1) Present.
**35) Shape of antorbital notch:**
(0) Concavity in anterior edge of lateral process of maxilla without medial-projecting groove;
(1) Developed along medial-projecting groove.
**36) Articulation between maxilla and frontal:**
(0) Tight;
(1) Loose.
**37) Maxillary pocket:**
(0) Absent;
(1) Present.
**38) Infraorbital plate visible in dorsal view:**
(0) No;
(1) Yes.
**39) Teeth at adulthood in maxilla and premaxilla:**
(0) Present;

(1) Absent.
**40) Grooves for vasculature of baleen epithelium:**
(0) Absent;
(1) Present.
**41) Fissure located along posterior border of maxilla in ventral view:**
(0) Absent;
(1) Present.
**42) Elongation of fissure:**
*Comment: character coded in Balaenidae and Neobalaenidae only; state 0 is present in Neobalaenidae; state 1 is present in Balaenidae.*
(0) Fissure short;
(1) Fissure long.
**43) Nasal length:**
(0) Nasal reaching the anterior 20% of rostrum;
(1) Nasal reaching approximately rostrum midlength;
(2) Nasal reaching the posterior 20% of rostrum;
(3) Nasal reaching a point close to the anterior border of the supraorbital process of frontal.
(4) Nasal reaching a point located within the interorbital region of the frontal.
**44) Anterior border of nasal:**
(0) Concave;
(1) Straight;
(2) Convex.
**45) Median keel in nasal:**
(0) Absent;
(1) Present.
**46) Position of anterolateral corner of nasal:**
(0) Anterior to anteromedial corner;
(1) Lateral to anteromedial corner;
(2) Posterior to anteromedial corner.
**47) Position of frontonasal suture:**
(0) At anterior border of interorbital region of frontal;
(1) Well within interorbital region of frontal.
**48) Nasal borders:**
(0) With a concavity at midlength
(1) Converging anteriorly;
(2) Parallel-to-subparallel;
(3) Diverging anteriorly.
**49) Nasal width:**
(0) Nasal transversely wide;
(1) Nasal with strong transverse compression along its entire length.

**FRONTAL**
**50) Shape of supraorbital process of frontal:**
(0) Flat and forming a dorsal shield;
(1) descending from interorbital region of frontal;
**51) Diversity of depressions:**
(0) No depression;
(1) Gentle depression from interorbital region of frontal;
(2) Abrupt depression from interorbital region of frontal;
**52) Cross-sections of depressions:**

(0) No depression;
(1) Triangular;
(2) Laterally concave;
(3) Squared;
(4) Half-circle.

**53) Anteroposterior length of supraorbital process of frontal:**

*Comment: very long anteroposterior length of the supraorbital process of the frontal is observed in Balaenopteridae; a long anteroposterior length is observed in Eschrichtiidae and some Cetotheriidae while all the other mysticetes are coded 0.*

(0) Short;
(1) Long;
(2) Very long.

**54) Transverse diameter of supraorbital process of frontal with respect to length of neurocranium:**

*Comment: a short diameter of supraorbital process of frontal with respect to the length of neurocranium is observed in archaeocetes and and early toothed mysticetes; state 1 is observed in Eomysticetidae, basal thalassotherian taxa, neobalaenids and some cetotheriids; state 2 is observed in Balaenidae and Balaenopteridae.*

(0) Short;
(1) Long;
(2) Very long.

**55) Anterior border of supraorbital process of frontal:**

(0) Directed posteriorly;
(1) Directed transversely;
(2) Directed anteriorly.

**56) Anterior border of supraorbital process of frontal:**

(0) Straight;
(1) Convex;
(2) Concave.

**57) Backing of central and distal portions of the anterior border of the supraorbital process of frontal from its anteromedial corner:**

(0) Absent;
(1) Present.

**58) Posterior border of supraorbital process of frontal:**

(0) Uniformly concave;
(1) Medial concavity;
(2) Straight.

**59) Posterior border of supraorbital process of frontal:**

(0) Directed posteriorly;
(1) Directed transversely;
(2) Directed anteriorly.

**60) Supraorbital foramina:**

(0) Present;
(1) Absent.

**61) Orbitotemporal crest:**

(0) Along posterodorsal edge of supraorbital process of frontal;
(1) From postorbital corner to anteromedial end of supraorbital process of frontal;
(2) Forming a curve from postorbital corner onto dorsal surface of supraorbital process of frontal;
(3) Forming a curve along anterior edge of supraorbital process of frontal.

**62) Orbitotemporal crest:**

(0) Well developed and sharp;

(1) Well developed and rounded;
(2) Highly reduced to a line.
**63) Superimposition of parietal on interorbital region of frontal:**
(0) Absent;
(1) Present.
**64) Long superimposition of posteromedial elements of rostrum on interorbital region of frontal:**
(0) Absent;
(1) Present.
**65) Posterior border of interorbital region of frontal:**
(0) In contact with parietal;
(1) In contact with supraoccipital.
**66) Shape of coronal (frontal-parietal) suture:**
(0) Straight;
(1) Anteriorly convex;
(2) Anteriorly concave.
**67) Coronal suture in dorsal view:**
(0) Visible;
(1) Not visible because superimposed by the supraoccipital.
**68) Frontal encircles ascending process of maxilla:**
(0) No;
(1) Yes.
**69) Postorbital process and zygomatic process of squamosal:**
*Comment: state 0 is observed in those taxa where there is a long space between the anterior end of the zygomatic process of the squamosal and the postorbital process. State 1 is observed in those taxa where the space between the zygomatic process and the postorbital process is strongly reduced and these structures are almost in contact.*
(0) Far;
(1) Close;
(2) Superimposed and articulated by dedicate facet.
**70) Location of optic canal in ventral surface of supraorbital process of frontal:**
(0) Along anterior three-fourth;
(1) Along posterior one-fourth.
**71) Length of intertemporal constriction:**
*Comment: state 0 is observed in archaeocetes and Eomysticetidae; state 1 is observed in basal thalassotherian taxa; state 2 is observed in Cetotheriidae and Eschrichtiidae; state 3 is observed in Balaenidae, Neobalaenidae and Balaenopteridae.*
(0) Very long;
(1) Long;
(2) Short;
(3) Very short.
**72) Transverse diameter of intertemporal constriction:**
*Comment: state 0 is observed in archaeocetes and eomysticetiids; state 1 is observed in basal thalassotherian taxa and cetotheriids; state 2 is observed in balaenids, neobalaenids, eschrichtiids and balaenopterids.*
(0) Highly constricted;
(1) Moderately constricted;
(2) Wide.
**73) Presence of narial process:**
(0) Present;
(1) Absent.

**74) Length of narial process relative to nasal length:**
*Comment: the narial process is coded 0 if the anteroposterior length is less than the transverse width and 1 if the anteroposterior length is longer or equal to the transverse width;*
(0) Short;
(1) Long.
**75) Shape of narial process:**
(0) The narial processes form a triangle in dorsal view;
(1) The narial processes form a bilobated protrusion in dorsal view.

**PARIETAL**
**76) Location of frontal border of parietal:**
(0) Posterior to posterior apex of ascending process of maxilla;
(1) Anterior to posterior apex of ascending process of maxilla.
**77) Anterolateral corner of parietal (for Balaenidae only):**
(0) Sharp;
(1) Broad.
**78) Anterior portion of external surface along wall of temporal fossa:**
(0) Visible in dorsal view;
(1) Not visible in dorsal view because overhanged by temporal crest.
**79) Posterior portion of external surface:**
(0) Visible in dorsal view;
(1) Not visible in dorsal view because overhanged by temporal crest.
**80) Post-parietal foramen:**
(0) Present;
(1) Absent.
**81) Parietal spreading onto emergence of supraorbital process of frontal:**
(0) Absent;
(1) Present.
**82) Parietal exposed at cranial vertex:**
(0) Yes;
(1) No.
**83) Length of parietal exposure at vertex:**
*Comment: state 0 is observed in archaeocetes, Eomysticetidae; state 1 is observed in basal thalassotherian taxa; state 2 is observed in Cetotheriidae and Eschrichtiidae; state 3 is observed in Balaenopteridae.*
(0) Long;
(1) Moderate;
(2) Short;
(3) Very short.
**84) Sagittal crest at cranial vertex:**
(0) Present;
(1) Absent.
**85) Attach for temporalis muscle at intertemporal constriction:**
*Comment: state 0 corresponds to a transversely narrow sagittal crest; state 1 corresponds to a sagittal crest with expanded dorsal surface (as observed, for instance, in Titanocetus sammarinensis); state 2 is observed in Cetotheriidae and Eschrichtiidae; state 3 is observed in Balaenopteridae, Balaenidae and Neobalaenidae.*
(0) Very narrow;
(1) Slightly widened;
(2) Moderately widened;
(3) Wide.
**86) Shape of sagittal crest:**

(0) Sharply-edged;
(1) Forming two opposite concavities.
**87) Tubercle at lambdoid suture:**
(0) Absent;
(1) Present.
**88) Parietal-squamosal suture:**
(0) Sinuous;
(1) Straight.

**SQUAMOSAL**
**89) Dorsoventral height of squamosal:**
*Comment: high dorsoventral height of squamosal in lateral view is observed only in Balaenidae and Neobalaenidae.*
(0) Low dorsoventral height;
(1) High dorsoventral height.
**90) Anteroposterior length of zygomatic process of squamosal with respect to its height:**
*Comment: a very long zygomatic process of the squamosal is observed in archaeocetes, Aetiocetidae and Eomysticetidae; state 1 is observed in basal thalassotherian taxa and Balaenopteridae; state 2 is observed in Cetotheriidae and Eschrichtiidae; state 3 is observed in Balaenidae and Neobalaenidae.*
(0) Very long;
(1) Long;
(2) Short.
(3) Very short.
**91) Height of zygomatic process of squamosal:**
(0) Zygomatic process higher than postglenoid process;
(1) Zygomatic process at the same level of postglenoid process;
(2) Zygomatic process much higher than postglenoid process.
**92) Projection of anterior portion of zygomatic process of squamosal in dorsal view:**
(0) Projecting anteromedially;
(1) Projecting anterolaterally;
(2) Projecting anteriorly.
**93) Projection of posterior portion of zygomatic process of squamosal in dorsal view:**
(0) Projecting anteromedially;
(1) Projecting anterolaterally
(2) Projecting anteriorly.
**94) Zygomatic process of squamosal in dorsal view:**
(0) Anteriorly straight;
(1) Anteriorly twisted.
**95) Distinctive articular facet for postorbital process of frontal on zygomatic process of squamosal:**
(0) Absent;
(1) Present.
**96) Projection of apex of zygomatic process in lateral view:**
(0) Anterior;
(1) Ventral.
**97) Postglenoid process of squamosal:**
(0) Projecting ventrally;
(1) Projecting posteroventrally.
**98) Twisted postglenoid process of squamosal:**
(0) No;
(1) Yes.

**99) Lateral surface of squamosal:**
(0) Smooth;
(1) With single fossa for sternomastoid muscle;
(2) With double fossa for sternomastoid muscle.
**100) Anteroposterior concavity along dorsolateral edge of glenoid fossa of squamosal:**
(0) Absent;
(1) Present.
**101) Glenoid fossa of squamosal:**
(0) Forming a right angle in lateral view;
(1) Slightly concave;
(2) Highly concave (half-moon shaped);
(3) Straight.
**102) Location of glenoid fossa of squamosal:**
0) posterior to orbit;
1) immediately posteroventral to orbit.
**103) Height of squamosal at nuchal crest:**
(0) Low;
(1) High.
**104) Supramastoid crest:**
(0) Present;
(1) Absent.
**105) Orientation of supramastoid crest:**
(0) Dorsal;
(1) Anterior.
**106) Nuchal crest in dorsal view:**
*Comment: state 0 corresponds to a nuchal crest with wide and round shape; state 1 corresponds to a nuchal crest with round but narrow shape; state 2 corresponds to a triangular nuchal crest.*
(0) Wide;
(1) Narrow;
(2) Very narrow.
**107) Nuchal crest in dorsal view:**
(0) Circular;
(1) Triangular.
**108) Nuchal crest in dorsal view:**
(0) Reaching a point anterior to occipital condyle;
(1) Reaching a point posterior to occipital condyle;
(2) Reaching a point at the same level as occipital condyle.
**109) Squamosal bulging into temporal fossa:**
(0) No;
(1) Yes.
**110) Extension of temporal fossa with respect to total skull length:**
*Comment: state 0 is observed in archaeocetes, Aetiocetidae and Eomysticetidae; state 1 is observed in basal thalassotherian taxa; state 2 is observed in Cetotheriidae, Balaenidae, Neobalaenidae and Balaenopteridae.*
(0) Very wide;
(1) Wide;
(2) Reduced.
**111) Extension of temporal fossa:**
(0) Longer than wide;
(1) Wider than long.
**112) Shape of temporal fossa in dorsal view:**

(0) Oval;
(1) Almond-shaped;
(2) Triangular.
**113) Surface of temporal fossa anterior to nuchal crest:**
(0) More horizontal than ventral-most portion;
(1) Developed dorsoventrally.
**114) Squamosal cleft:**
(0) Absent;
(1) Present.
**115) Shape of squamosal cleft:**
(0) Straight;
(1) Triangular.
**116) Length of squamosal cleft:**
*Comment: state (0) < 50 mm; (1) between 51 and 70 mm; (2) longer than 70 mm.*
(0) Short;
(1) Long;
(2) Very long.
**117) Origin of squamosal cleft at adulthood:**
(0) From parietal-squamosal suture;
(1) From parietal-squamosal-alisphenoid suture;
(2) From squamosal-alisphenoid suture;
(3) From squamosal-pterygoid suture.
**118) Origin of squamosal cleft during late ontogeny:**
(0) From parietal-squamosal suture;
(1) From parietal-squamosal-alisphenoid suture;
(2) From squamosal-alisphenoid suture;
(3) From squamosal-pterygoid suture.
**119) Infundibulum of Foramen ovale:**
(0) Absent;
(1) Present.
**120) Foramen ovale:**
*Comment: definitions of complete and incomplete infundibulum are from Fraser and Purves (1960).*
(0) Infundibulum complete;
(1) Infundibulum incomplete.
**121) Foramen ovale:**
(0) Located within squamosal;
(1) Located between squamosal and pterygoid.
(2) Located within pterygoid.
**122) Suture present in foramen ovale:**
(0) No;
(1) Yes.
**123) Squamosal crease:**
(0) Absent;
(1) Present.
**124) Secondary squamosal crest:**
(0) Absent;
(1) Present.
**125) Secondary squamosal fossa:**
(0) Absent;
(1) Present.

**126) Basicranial foramina:**
(0) Separate foramina in posterolateral portion of skull;
(1) Foramina confluent into a single and large posterior lacerate foramen.

**SUPRAOCCIPITAL**
**127) Supraoccipital in dorsal view:**
(0) Not visible because main development is dorsoventral;
(1) Visible because it superimposes on parietal.
**128) Anteroposterior supraoccipital elongation:**
(0) No anteroposterior elongation;
(1) Short: supraoccipital superimposed on posterior portion of parietal;
(2) Long: supraoccipital superimposed on most of parietal;
(3) Very long: supraoccipital superimposed on whole parietal and part of interorbital region of frontal.
**129) Anteroposterior supraoccipital elongation with respect to zygomatic process of squamosal:**
(0) Anterior border of supraoccipital reaching a point located more posteriorly than the anterior apex of the zygomatic process of squamosal;
(1) Anterior border of supraoccipital reaching a point located more anteriorly than the anterior apex of the zygomatic process of squamosal.
**130) Shape of anterior border of supraoccipital:**
*Comment: state (3) is observed when a triangular anterior portion of a supraoccipital shows externally convex and rounded borders rather than straight.*
(0) Round;
(1) Triangular;
(2) Squared;
(3) Ogival.
**131) Distinctive articular facets for ascending process of the maxilla in anterior border of supraoccipital:**
(0) Absent;
(1) Present.
**132) Size of anterior border of supraoccipital:**
*Comment: the anterior border of the supraoccipital is wide in archaeocetes and* Titanocetus*.*
(0) Wide;
(1) Pointed;
(2) Narrow.
**133) Elevation of anterior border of supraoccipital in lateral view:**
(0) High elevation formed by dorsal protrusion of parietals lateral and in front of the anterior border of supraoccipital;
(1) Low elevation without contribution by the parietal;
(2) No elevation at all.
**134) Distinctive depression in front to supraoccipital in lateral view:**
(0) Present;
(1) Absent.
**135) Dorsal surface of supraoccipital:**
(0) Concave;
(1) Flat-to convex.
**136) Attach sites for neck muscle attachments:**
(0) Not evident;
(1) Well developed.
**137) Attach sites for neck muscle attachments:**
(0) Shaped as triangular relieves with flat surface;
(1) Shaped as tubercles.

**138) External occipital crest:**
(0) Absent;
(1) Present.
**139) Lateral borders of supraoccipital in dorsal view:**
(0) Not visible;
(1) Uniformly convex;
(2) uniformly straight;
(3) uniformly concave;
(4) sinuous because of the presence of a transverse constriction.
**140) Position of transverse constriction of supraoccipital:**
(0) In anterior-most portion;
(1) At mid-length;
(2) In posterior half.
**141) Degree of transverse constriction with respect to maximum transverse width:**
*Comment: scarce transverse constriction is observed in Eomysticetidae, basal thalassotherian taxa, Cetotheriidae, Eschrichtiidae and* Balaenoptera*; moderate constriction is observed in* Protororqualus *and* Nehalaennia*; strong constriction is observed in* Archaebalaenoptera *and* 'Balaenoptera' cortesii *var.* portisi*.*
(0) Scarce;
(1) Moderate;
(2) Strong.
**142) Lateral borders of supraoccipital anterior to the transverse constriction:**
(0) Concave;
(1) Straight-to-convex.
**143) Length of external occipital protuberance:**
*Comment: a short external occipital protuberance is observed in* Protororqualus*; a long external occipital protuberance is observed in* 'Balaenoptera' cortesii *var.* portisi*.*
(0) Long;
(1) Moderate;
(2) Short.
**144) Anterolateral corner of supraoccipital:**
(0) Not distinguishable;
(1) Collapsed into a single anterior point;
(2) Rounded;
(3) Squared.
**145) Supraoccipital bent at midlength:**
(0) No;
(1) Yes.

**INTERPARIETAL**
**146) Interparietal:**
(0) Absent;
(1) Present.
**147) Shape of interparietal:**
*Comment: as shown in Wada et al. (2003), in Balaenopteridae, the interparietal may be anteroposteriorly long and transversely narrow and anteroposteriorly short and transversely wide; characters 147 and 148 relate to this observation.*
(0) Short;
(1) Long.
**148) Shape of interparietal:**
(0) Wide;

(1) Narrow.

**JUGAL**

**149) Jugal elongation:**

*Comment: elongated and straight jugal is observed in archaeocetes.*

(0) Jugal elongated and mostly straight;

(1) Jugal short and rounded.

**LACRIMAL**

**150) Lacrimal exposed in dorsal view:**

(0) No;

(1) Yes.

**151) Sutured lacrimal:**

(0) Yes;

(1) No.

**EXOCCIPITAL**

**152) Exoccipital in posterior view:**

(0) Anterolateral border forming a right angle with lateral edge of supraoccipital;

(1) Anterolateral border continuous with lateral edge of supraoccipital.

**153) Exoccipital development in posterior view:**

*Comment: the transverse elongation of the supraoccipital is observed in those taxa where there is a sharp corner between the anterodorsal border of the exoccipital and the posterolateral border of the supraoccipital being the lateral portion of the exoccipital protruded laterally; this character is absent in crown mysticetes and cetotheriids.*

(0) Exoccipital transversely elongated;

(1) Transverse elongation of exoccipital reduced.

**154) Protrusion of posterolateral corner of exoccipital:**

(0) At level of postglenoid process;

(1) Medial to postglenoid process.

**155) Protrusion of posterolateral corner of exoccipital:**

(0) Reaching a point more anterior than occipital condyles;

(1) Reaching a point more posterior than occipital condyles.

**156) Protrusion of posterolateral corner of exoccipital:**

(0) More posterior than postglenoid process of squamosal.

(1) More anterior than postglenoid process of squamosal;

**157) Occipital condyle:**

(0) Convex articular face;

(1) Flat-to-slightly convex articular face.

**158) Neck of occipital condyle:**

(0) Well developed;

(1) Indistinct.

**159) Condyloid foramen:**

(0) Present;

(1) Absent.

**160) Foramen in jugular notch:**

(0) Present;

(1) Absent.

**BASIOCCIPITAL**

**161) Basioccipital crest:**
(0) Absent;
(1) Present.
**162) Fusion of medial crest of basioccipital crest and falcate process of basioccipital:**
(0) Absent;
(1) Present.

**ALISPHENOID**
**163) Alisphenoid exposure in temporal fossa:**
(0) Present;
(1) Absent.
**164) Size of alisphenoid exposure in temporal fossa:**
(0) Large;
(1) Small;
(2) Very small.
**165) Alisphenoid borders:**
(0) Between frontal, parietal, squamosal and pterygoid;
(1) Between parietal, squamosal and pterygoid;
(2) Between parietal and squamosal;
(3) Between parietal and pterygoid.

**PALATINE**
**166) Palatine reaching a point located close to posterior border of skull:**
(0) No;
(1) Yes.

**PTERYGOID**
**167) Pterygoid fossa:**
(0) Absent;
(1) Present.
**168) Pterygoid hamulus:**
*Comment: well developed pterygoid hamulus is observed only in* Balaenoptera *and* Megaptera*.*
(0) Short;
(1) Well developed.
**169) Ventral lamina of pterygoid:**
(0) Absent;
(1) Present.
**170) Pterygoid exposure in temporal fossa:**
(0) Absent;
(1) Present.

**PERIOTIC**
**171) Posterior process exposure in lateral wall of skull:**
(0) Absent;
(1) Present.
**172) Posterior process length:**
*Comment: a short posterior process is observed in archaeocetes, odontocetes and early-diverging chaeomysticetes (Eomysticetidae); a long posterior process is observed in extant Balaenidae and Balaenopteridae.*
(0) Short;

(1) Moderate;
(2) Long.
**173) Posterior process size and shape:**
(0) Prismatic and robust;
(1) Transversely compressed and flattened.
**174) Facial sulcus along posterior process:**
(0) Absent;
(1) Present.
**175) Facial sulcus along posterior process:**
*Comment: a long facial sulcus is developed along approximately the whole length of the posterior process otherwise it is considered short.*
(0) Short;
(1) Long.
**176) Position of facial sulcus on posterior process:**
(0) Along medial border and hidden in ventral view;
(1) Ventromedial;
(2) Completely ventral.
**177) Borders of facial sulcus:**
(0) Sulcus bordered by crests;
(1) Sulcus widened and bordered by narrow relieves.
**178) Facial sulcus completely included in a tube-like structure:**
(0) No;
(1) Yes.
**179) Shape of posterior border of posterior process:**
(0) Clavate;
(1) Squared;
(2) Pointed.
**180) Stylomastoid fossa:**
(0) Not distinguishable;
(1) Elongated and shallow;
(2) Elongated and covered by a relieved dorsal edge in the posterior process;
(3) Short and included within posterior process as a notch.
**181) Anterior process:**
(0) Absent;
(1) Present.
**182) Anterior process length:**
*Comment: a short anterior process is observed when the anterior process length is less-to-equal to the posterior process length otherwise the anterior process is long.*
(0) Short;
(1) Long.
**183) Anterior process thickness:**
*Comment: a blade-like anterior process is observed in some Cetotheriidae where the anterior process is subtle in medial view; the anterior process is thick in balaenids and in all those taxa where the maximum height of the anterior process is equal-to-longer to the dorsoventral height of the pars cochlearis in medial view otherwise it is thin.*
(0) Thick;
(1) Thin;
(2) Blade-like.
**184) Origin of anterior process:**
(0) Abruptly depressed from dorsal surface of periotic;

(1) Anterior process continuous with dorsal surface of periotic.
**185) Anterior process in dorsal (or ventral) view:**
(0) Squared;
(1) Irregular shape;
(2) Triangular;
(3) Elliptical.
**186) If triangular, medial edge of anterior process:**
(0) Convex or straight;
(1) Concave.
**187) If triangular, lateral edge of anterior process:**
(0) Convex or straight;
(1) Concave.
**188) If triangular, apex of anterior process:**
(0) Round;
(1) Pointed.
**189) Lateral tuberosity:**
(0) Absent;
(1) Present.
**190) Size of lateral tuberosity:**
(0) Small;
(1) Large.
**191) Shape of lateral tuberosity:**
(0) Protruding and squared or rounded;
(1) Protruding and triangular.
**192) Lateral process of anterior process:**
(0) Absent;
(1) Present.
**193) Length of lateral process of anterior process:**
*Comment: the lateral process of the anterior process is long if its apex reaches the mid-length of the posterior process; if it does not reach that point then it is short. This character is coded for Balaenidae.*
(0) Long;
(1) Short.
**194) Shape of lateral process of anterior process:**
(0) Broadly triangular;
(1) Sharply triangular.
**195) Medial emergence of anterior process:**
(0) Absent;
(1) Present.
**196) Tensor tympani groove along anterodorsal edge of pars cochlearis:**
(0) Present;
(1) Absent.
**197) Dorsal surface of periotic:**
(0) Highly relieved;
(1) Low.
**198) Highly relieved dorsal surface of periotic:**
(0) Squared;
(1) Dome-shaped.
**199) Dorsal surface of periotic and anterior process forming a straight line in medial view:**
(0) No;
(1) Yes.

**200) Suprameatal area:**
(0) Concave;
(1) Gently descending;
(2) Convex and protruding.
**201) Superior process:**
(0) Present;
(1) Absent.
**202) Size of superior process:**
(0) Convex dorsal profile in medial view;
(1) Reduced to a low ridge;
(2) Absent.
**203) During late ontogeny, internal acoustic meatus including:**
(0) Tractus spiralis foraminosus, foramen singulare and endocranial opening of facial canal;
(1) Tractus spiralis foraminosus and foramen singulare.
**204) At adulthood, internal acoustic meatus including:**
(0) Tractus spiralis foraminosus, foramen singulare and endocranial opening of facial canal;
(1) Tractus spiralis foraminosus and foramen singulare.
**205) Crista transversa during ontogeny:**
(0) Septum-like;
(1) Thick.
**206) Crista transversa during adulthood:**
(0) Septum-like;
(1) Thick.
**207) Position of crista transversa at adulthood:**
(0) Does not reach medial rim of internal acoustic meatus;
(1) Reaches medial rim of internal acoustic meatus.
**208) Fissure in endocranial opening of facial canal during ontogeny:**
(0) Absent;
(1) Present.
**209) Fissure in endocranial opening of facial canal at adulthood:**
(0) Absent;
(1) Present.
**210) Vascular groove:**
(0) Evident;
(1) Reduced;
(2) Absent.
**211) Transverse elongation of pars cochlearis:**
*Comment: transverse elongation of the pars cochlearis is observed only in Balaenopteridae and Eschrichtiidae.*
(0) Short;
(1) Elongated.
**212) Anteroposterior elongation of pars cochlearis:**
*Comment: anteroposterior elongation of pars cochlearis is observed only in Balaenopteridae and Eschrichtiidae.*
(0) Short;
(1) Elongated.
**213) Inflation of pars cochlearis:**
(0) Absent;
(1) Present.
**214) Anterior crest along pars cochlearis:**

(0) Absent;
(1) Present.
**215) Cochlear window (round window) and aperture for cochlear aqueduct (endolymphatic foramen) confluent during late ontogeny:**
(0) No;
(1) Yes.
**216) Cochlear window (round window) and aperture for cochlear aqueduct (endolymphatic foramen) confluent at adulthood:**
(0) No;
(1) Yes.
**217) Cochlear window (round window) and aperture for cochlar aqueduct (endolymphatic foramen) opening in a tube-like channel:**
(0) No;
(1) Yes.
**218) Promontorial groove:**
(0) Absent;
(1) Present.
**219) Size of promontorial groove:**
*Comment: a large promontorial groove is observed in* Plesiobalaenoptera quarantellii*,* ‘Megaptera’ hubachi *and SAM 55001.*
(0) Small;
(1) Large.
**220) Endocranial opening of facial canal connected to internal acoustic meatus by a groove:**
(0) No;
(1) Yes.
**221) Pyramidal process:**
(0) Present;
(1) Absent.

**TYMPANIC BULLA**
**222) Shape of posterior border:**
(0) Bilobated;
(1) Transversely straight;
(2) Convex;
(3) Keeled.
**223) Elongation of portion posterior to conical process:**
(0) Present;
(1) Absent.
**224) Posterior border fissurated:**
(0) Yes;
(1) No.
**225) Elliptical foramen:**
(0) present;
(1) absent.
**226) Ventral keel:**
(0) Absent;
(1) Present.
**227) Ventral concavity:**
(0) Present;
(1) Absent.

**228) involucral protrusion in dorsal view:**
(0) Absent;
(1) Present.
**229) Dorsal border of involucrum in medial view:**
(0) Gently descending;
(1) Not descending.
**230) Position of Eustachian opening relative to overall height of tympanic bulla:**
*Comment: the Eustachian opening is located more ventrally in early diverging mysticetes including eomysticetids, basal thalassotherian taxa and cetotheriids; in all the other baleen-bearing mysticetes it is located at a higher position.*
(0) Low;
(1) High.
**231) Eustachian opening bordered anteriorly:**
(0) no;
(1) yes.
**232) Flat posterior dorsomedial face:**
(0) No;
(1) Yes.
**233) Anterolateral expansion:**
(0) Absent;
(1) Present.
**234) Extension of anterolateral expansion:**
*Comment: a short anterolateral expansion is observed in Balaenidae and Neobalaenidae.*
(0) Short;
(1) Long.
**235) Shape of anterolateral expansion in dorsal view:**
(0) Round;
(1) Pointed.
**236) Tympanic cavity with respect to length of tympanic cavity:**
*Comment: a low tympanic cavity is observed in Balaenidae and Neobalaenidae only.*
(0) High;
(1) Low.
**237) Height of tympanic bulla:**
*Comment: a low tympanic bulla is observed in Balaenidae and Neobalaenidae only.*
(0) High;
(1) Low.
**238) Anterior border:**
(0) Anteriorly convex;
(1) Anteriorly straight-to-concave.
**239) Sigmoid process:**
(0) Anteroposteriorly elongated;
(1) Transversely elongated.
**240) Conical process:**
(0) High;
(1) Very reduced.
**241) Proportional size of tympanoperiotic complex with respect of head size:**
*Comment: small-sized tympanoperiotic complex is observed in* 'Balaenoptera' cortesii *var.* portisi *and* Incakujira anillodefuego*.*
(0) Large;

(1) Small.
**242) Outer lip and dorsal border of involucrum:**
(0) Descending parallel toward anterior end;
(1) Posteriorly diverging as the outer lip is more inclined than involucrum.

**DENTARY**
**243) Cranio-mandibular joint:**
(0) Tight;
(1) Loose.
**244) Teeth on dentary at adulthood:**
(0) Present;
(1) Absent.
**245) Mental symphysis:**
(0) Present;
(1) Absent.
**246) Groove for mental ligament:**
(0) Absent;
(1) Present.
**247) Anterior torsion:**
(0) Absent;
(1) Present.
**248) Massive elongation of dentary ramus:**
(0) Absent;
(1) Present.
**249) Coronoid process height:**
*Comment: state 0 is present in archaeocetes and early mysticetes including Eomysticetidae; state 1 is observed in basal thalassotherian taxa and early-diverging Balaenopteridae; state 2 is observed in Cetotheriidae and Balaenopteridae; state 3 is observed in Neobalaenidae, Balaenidae and* Megaptera novaeangliae*.*
(0) High;
(1) Moderately high;
(2) Low;
(3) Very low-to-absent.
**250) Postcoronoid crest:**
(0) Absent;
(1) Present.
**251) Postcoronoid fossa:**
(0) Absent;
(1) Present.
**252) Size of postcoronoid fossa:**
Comment: a small postcoronoid fossa is observed only in living *Balaenoptera* species.
(0) Wide;
(1) Small.
**253) Satellite process:**
(0) Absent;
(1) Present.
**254) Size of satellite process:**
(0) Large;
(1) Small.
**255) Orientation of articular surface of mandibular condyle:**

(0) Posterodorsal;
(1) Dorsal;
(2) Posterior.
**256) Posterodorsal corner of dentary:**
(0) Round;
(1) Sharp.
**257) Angular process:**
*Comment: state 0 is observed in archaeocetes and early mysticetes including Eomysticetidae; state 1 is observed in basal thalassotherian taxa; state 2 is observed in Balaenidae, Neobalaenidae and basal balaenopterids; state 3 is present in living balaenopterids.*
(0) High;
(1) Moderately high;
(2) low;
(3) Very low.
**258) Angular process in lateral view:**
(0) Located more anteriorly than articular surface of condyle;
(1) Rounded and not protruded.
(2) Projecting ventrally;
(3) Projecting posteriorly.
(4) Squared and not protruding.
**259) Mandibular foramen:**
*Comment: a small mandibular foramen is observed in Balaenidae, Neobalaenidae, Balaenopteridae and Eschricthiidae.*
(0) Wide;
(1) Small.
**260) Shape of mandibular foramen:**
(0) Posteriorly concave;
(1) Triangular;
(2) Fissurated.
**261) Gingival foramina:**
(0) Absent;
(1) Present.
**262) Mental foramina:**
(0) Only one per dentary;
(1) Several mental foramina present per dentary.
**263) Dentary curvature in dorsal view:**
(0) Dentary with lateral concavity in dorsal view;
(1) Dentary straight;
(2) Dentary moderately bowed;
(3) Dentary strongly bowed.
**264) External curvature in dorsal view:**
(0) Absent;
(1) Continuous;
(2) Discontinuous.
**265) Presence of dorsoventral curvature in dentary in lateral view:**
(0) Absent;
(1) Present.
**266) Types of dorsoventral curvature in dentary in lateral view:**
(0) Absent;
(1) Continuous;

(2) Discontinuous.
**267) Mylohyoidal groove:**
(0) Absent;
(1) Present.
**268) Crest along the ventral border of the dentary with a parallel groove:**
(0) Absent;
(1) Present.
**269) Medial face of dentary ramus:**
(0) Flat;
(1) Convex.
(2) Concave.

**VERTEBRAE**
**270) Cervical vertebrae:**
(0) Free;
(1) Fused.
**271) Cervical vertebrae:**
(0) Elongated;
(1) Shortened.
**272) Neural processes of cervical vertebrae:**
(0) Free;
(1) Fused.
**273) Dorsal process of C3:**
(0) Present;
(1) Absent.
**274) Dorsal process of C4:**
(0) Present;
(1) Absent.
**275) Dorsal process of C5:**
(0) Present;
(1) Absent.
**276) Dorsal process of C6:**
(0) Present;
(1) Absent.
**277) Dorsal process of C7:**
(0) Present;
(1) Absent.
**278) Ventral process of C3:**
(0) Present;
(1) Absent.
**279) Ventral process of C4:**
(0) Present;
(1) Absent.
**280) Ventral process of C5:**
(0) Present;
(1) Absent.
**281) Ventral process of C6:**
(0) Present;
(1) Absent.
**282) Ventral process of C7:**

(0) Present;
(1) Absent;
(2) Reduced to a tubercle.
**283) Foramen transversarium in C3:**
(0) Complete;
(1) Incomplete.
**284) Foramen transversarium in C4:**
(0) Complete;
(1) Incomplete.
**285) Foramen transversarium in C5:**
(0) Complete;
(1) Incomplete.
**286) Foramen transversarium in C6:**
(0) Complete;
(1) Incomplete.
**287) Foramen transversarium in C7:**
(0) Complete;
(1) Incomplete.
**288) Foramen transversarium**
(0) Complete in C2;
(1) Incomplete in C2.
**289) Fusion of sacral vertebrae:**
(0) Present at least in part;
(1) Absent.
**290) Number of sacral vertebrae:**
(0) >1;
(1) 1.
**291) Sharp lateroventral projection of transverse process:**
(0) Present;
(1) Absent.
**292) Foramen at emergence of transverse process:**
(0) In caudal vertebrae;
(1) In last lumbar and caudal vertebrae.

**SCAPULA**
**293) General proportions of scapula:**
*Comment: state 0 is observed in archaeocetes and Balaenidae; state 1 is observed in all the other chaeomysticetes.*
(0) High and short;
(1) Low and wide.
**294) Orientation of scapular spine:**
(0) Divergent from margo cranialis and directed dorsally;
(1) Parallel to margo cranialis and directed anterodorsally.
**295) Development of teres fossa:**
(0) Small;
(1) Enlarged.
**296) Margo cranialis:**
(0) Straight;
(1) Convex;

(2) Concave.
**297) Inclination of margo cranialis with respect to horizontal axis:**
(0) High;
(1) Scarce.
**298) Margo caudalis:**
(0) Straight-to-scarcely concave;
(1) Highly concave.
**299) Development of supraspinous fossa:**
(0) Wide;
(1) Reduced;
(2) Invisible in lateral view.
**300) Scapular spine:**
(0) Well developed:
(1) Reduced.

**HUMERUS**
*Comment: anatomical terminology from Benke (1993).*
**301) Orientation of caput humeri:**
(0) Along longitudinal axis of humerus;
(1) Located posteriorly to longitudinal axis.
**302) Size of tuberculum majus:**
*Comment: size is assessed with respect to total humeral length: state 0 is if dorsoventral height of tuberculum majus is less than 10% of the total humeral length; state 1 is if the height is more than 15%..*
(0) Small;
(1) Large.
**303) Direction of tuberculum majus:**
(0) Anteroposterior;
(1) Dorsal;
(2) Ventral.
**304) Shape or margo ulnaris:**
(0) Straight;
(1) Concave.
**305) Shape of caput humeri:**
(0) Flat;
(1) Highly convex.
**306) Lateral edge of caput humeri:**
(0) Straight;
(1) Forming a corner.
**307) Orientation of lateral edge of caput humeri:**
(0) Anteroposterior;
(1) Oblique (from a posterodistal to an anteroproximal position);
(2) Anteroposterior posterodistally and dorsoventral anteroproximally.
**308) Lateral expansion of articular surface of caput humeri:**
*Comment: state 1 is observed in Balaenidae.*
(0) Scarce;
(1) Well developed.
**309) Deltopectoral crest:**
(0) Present;
(1) Absent.
**310) Tuberculum deltoideus:**

*Comment: state 0 is observed in those taxa where the tuberculum forms a long and evident crest; state 1 is observed in those taxa where the tuberculum is reduced to a small-sized relief.*
(0) Highly relieved;
(1) Reduced;
(2) Absent.
**311) Articulation with radius and ulna:**
(0) Rotational;
(1) Non-rotational.
**312) Position of ulnar epycondyle:**
*Comment: state 1 is observed in those taxa where the ulnar epycondyle is located close to the posterodistal corner of the ulna.*
(0) High;
(1) Low;
(2) Almost absent.
**313) Relative length of humerus:**
(0) Longer than radius and ulna;
(1) Humerus length nearly equals that of radius and ulna;
(2) Much shorter than radius and ulna.
**314) Proximal surface of tuberculum deltoideus:**
(0) Continuous with deltopectoral crest;
(1) Concave;
(2) Straight and projecting posteriorly.

**RADIUS**
**315) Proximal curvature:**
(0) Massive;
(1) Reduced-to-absent.
**316) Distal expansion:**
(0) Absent;
(1) Present.
**317) Proximal contact with ulna:**
(0) Present;
(1) Absent.
**318) Size of radius with respect to ulna:**
(0) Anteroposterior diameter similar to that of ulna;
(1) Anteroposterior diameter larger than that of ulna.

**ULNA**
**319) Olecranon: proximal corner:**
(0) Directed proximally;
(1) Directed distally.
**320) Olecranon: size:**
(0) Well developed;
(1) Reduced.
**321) Olecranon: dorsal and ventral borders:**
(0) Parallel;
(1) Diverging posteriorly;
(2) Forming a right angle.
**322) Olecranon: ventral angle:**
(0) Right angle-to-obtuse;

(1) Acute.
**323) Olecranon: posterior border:**
(0) Squared;
(1) Round;
(2) Straight.
**324) Proximal articular facet of ulna and upper side of olecranon:**
(0) Forming a corner;
(1) Straight.
**325) Distal expansion of ulna:**
(0) Absent;
(1) Present.

**MANUS**
**326) Articulation of carpals:**
(0) Tight articulation;
(1) Loose articulation.
**327) Digit number:**
(0) Five;
(1) Four.
**328) Hyperphalangy:**
(0) Absent;
(1) Present.
**329) Proportions of manus:**
(0) Manus wide;
(1) Manus narrow.
**330) Trapezium:**
(0) Present;
(1) Absent.
**331) Separate cartilagineous fields for trapezoid and unciform:**
(0) Yes;
(1) No.

**HINDLIMB**
**332) Pelvis articulated with vertebral column:**
(0) Yes;
(1) No.
**333) Massive reduction of pelvis size:**
(0) No;
(1) Yes.
**334) Functional hindlimbs in adults:**
(0) Yes;
(1) No.

**STERNUM AND RIBS**
**335) Number or ribs articulated to sternum:**
(0) >1;
(1) 1.
**336) First rib shape:**
(0) Not expanded;

(1) Expanded.

**337) Sternum formed by several sternebra:**

(0) Yes;

(1) No, only by one manubrium.

**338) Head of first rib:**

(0) Bifid;

(1) Single.

**339) Ribs with bifid head posterior to 5th:**

(0) Yes;

(1) No.

**340) Pachyosteoschlerotic ribs:**

(0) Absent;

(1) Present.

**DENTITION**

**341) Positions of upper premolars and molars:**

(0) Close to each other;

(1) Well separated by diastemata.

**342) Positions of lower premolars and molars:**

(0) Close to each other;

(1) Well separated by diastemata.

**343) Number of denticles on posterior upper teeth:**

(0) >3 along anterior or posterior borders;

(1) 3 or less along anterior or posterior borders.

**344) Dental generations:**

(0) Polyophiodonty;

(1) Monophiodonty.

**345) Heterodont teeth on dentary:**

(0) Present;

(1) Absent.

**346) Dentition reduced to a few anterior upper teeth:**

(0) No, complete dentition is present;

(1) Yes.

**347) Inferred or observed loss of mineralization in teeth (due to C4*orf* gene mutation):**

(0) Absent;

(1) Present.

**BALEEN**

**348) Inferred or observed presence of baleen:**

(0) Negative;

(1) Positive.

**349) Inferred or observed length of baleen:**

*Comment: long baleen are observed or inferred in Balaenidae and Neobalaenidae.*

(0) Short;

(1) Long.

**350) Direction of baleen racks:**

(0) Limited to posterior part of rostrum;

(1) Parallel;

(2) Anteriorly convergent.

**ADDITIONAL CHARACTERS**

**351) Rostral proportions among straight-rostrum chaeomysticetes:**

(0) narrow skull (total skull length/width of maxillae at bases of lateral processes between 3.5 and 3.9);

(1) wide skull (value between 2 and 3.4);

(2) very narrow skull (value > 4);

(3) very wide skull (value < 2.99).

**352) Distinctive anterolateral corner in supraoccipital in posterior view:**

(0) present;

(1) absent.

**353) Wide curve at posterior apex of nuchal (lambdoid crest) in posterior view:**

(0) present;

(1) absent.

**354) Direction of zygomatic process of squamosal in posterior view:**

(0) lateral;

(1) ventrolateral;

(2) dorsolateral.

**355) Triangular protrusion of inner posterior prominence of tympanic bulla:**

(0) absent;

(1) present.

## MATRIX

Protocetidae

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*Cynthiacetus peruvianus*

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*Basilosaurus cetoides*

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*Dorudon atrox*

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*Zygorhiza kochii*

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Mammalodontidae

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*Fucaia*

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*Aetiocetus weltoni*

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*Eomysticetus whitmorei*
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*Caperea marginata*

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*Miocaperea pulchra*
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*Balaenella brachyrhynus*
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*Balaena mysticetus*
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*Balaenula astensis*
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*Eubalaena*
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1110

*Atlanticetus patulus*
110-11111  1110111101 11000-0?01 1100111001 10-3101030 1111110000 1111101001
0200--0-11 1001000010 1011000100 0301000010 11100----1 0110001121 1011000-02 ---
-100--1 0111110111 1110130100 1010112100 311011---1 000--01010 012?0?00?0
10010?0010 0011110110 0111100001 001??????? ?????????? ?????????? 0100?0??0?
0??1?????1 11???????? ?????????? ?????????? ?????????? ?????????? ?---11-110
210001

MPTA 13301
??0-1????  ?????????? ?????????? ?????????? ?????????? ?????????? ??????????
?????????? ?????????0 ?????????? ?????????0 ????0----1 01???????? ??????????
?????????? ?????????? ???????100 ??10112100 311011---1 010--01010 012?0?00?0
10010?0010 0011110110 0111100001 0?1??????? ?????????? ?????????? 010???????

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?????1

*Pelocetus calvertensis*
110-11111  1110211101 11000-0?01 1100101001 10-3?01031 1110121000 1111101001
0200--0-11 1001000010 1011000100 0301000010 11100----1 0110001121 1011000-03 ---
-100--1 0111110111 1110130100 1120112100 310??????? ??0--01??? ??????????
?0010??010 ??21110110 0111100001 0011111012 1100-00120 ?113100001 010?0?00?0
?02?1??101 11?1011110 0110011211 212?-????? ?????010?? ?????11110 0---11-110
210000

*Uranocetus gramensis*
110-11111  1110211101 11000-0?01 1100101001 10-3101131 1111110000 1111101001
0200--0-11 1001000010 1011000100 0301000110 11100----1 0110001121 1011000-14
0010100--1 0111110111 11101?0100 1020112100 311??1---1 000--01010 012?0?00?0
10010?0010 0?21110110 0111100001 00111???12 1100-00120 1113000001 100000000?
?100????01 1??0102011 0110011211 ?122?10100 011100???? ?????????? ?---11-110
23?000

*Isanacetus laticephalus*
110-11111  1110211001 11000-2?01 1100111011 10-3101021 1111121000 1111101001
0200--0-11 1001???010 1011000100 1301000110 11100----1 0110001121 10110?????
????100--1 01111?01?? ?1110-0100 1010112100 311011---1 000--01010 012?0?00?0
10010?0010 0111110110 0111100001 00111???1? ?????????? ?????????? ??????????
?????????1 1????????? ?????????? ?????????? ?????????? ?????????? ?---11-110
230000

*Joumocetus shimizui*
110-11111  1110011001 11000-0?01 1100111011 10-3101131 1111220?0 1111101001
0200--0-11 1001001010 10??????00 ??01??0000 11100----1 0110001121 101100???4
0010100--1 01111?0111 11110-0100 1010112100 ?1???1---? 000--0???? ??????????
?0010????? ??11110110 0110--0001 ?01111101? ?????0013? ?112000001 ??????????
?????????1 1????????? ?????????? ?????????? ?????????? ?????????? ?---11-110
231110

*Parietobalaena palmeri*
110-11111  1110??1001 11000-2101 11001?10?1 10-3101021 1111112000 1111101001
0200--0-11 1001000010 1011000000 1101000100 11100----1 0110011121 1010000-14
0010100--1 0111110111 1110130100 1010112100 310001---1 000--01010 0121111?0
1001000010 1111110110 0110--0001 0011111012 1100-00120 1111000001 0100000000
0??1?????1 11???????? ?????????? ?????????? ?????????? ?????????? ?---11-110
201020

*Parietobalaena campiniana*
110-11111  1110111001 ?????????? ?100111001 10-??????? 1111122020 111??????1
02???-?-?? ?0?????010 1011000000 1101000100 11100----1 0110001121 ??????????
?????????1 ?111100111 111??30100 1010112100 ?10001---1 000--01010 012?1?11?0
10010?0010 1111110110 0110--0001 0011111012 1100-00120 1111000001 0100000000
112??111?1 1????????? ?????????? ?????????? ?????????? ?????????? ?---11-110
2???20

*Tiucetus rosae*
110-11??1  111??????1 110?0-0?02 2100??10?1 1??3000121 111????-?? 1?11101001
0200--0-11 1001111010 1011000000 0101000100 11101000?1 0110011121 1011101014
0010100--1 0111100111 1110100100 1110112100 ?11???---1 000--01??0 ??????????
?0010??010 ??11110110 011???0001 001??????? ?????????? ?????????? ??????????
?????????1 1????????? ?????????? ?????????? ?????????? ?????????? ?---11-110
2?1110

*Taikicetus inouei*
????1???1  111???10?1 10000-0?01 0100??1001 ?????0?020 1111122100 1110100001
0200--0-00 0001011000 1021000002 1101011020 11100----1 01?0011121 1012100-03 ---

0000--? ??11110??? 1110--?1?0 1120112100 010??20001 110--10??? ??????????
????0?0??? ??2???010? ???110010? ???111??12 1100-00120 111????000 010???????
?????????? ?????????? ?????????? ?????????? ?????????? ?????????? ?---11??10
??0000

SMNH-VeF-62
110-11?1?  1110211011 11000-???1 2100111011 10?????0?? 1111010021 ?111001001
0200--0-00 1001010000 1011000000 1301001000 11100----1 01?0001121 1012101004
0010100--? ??1110011? ?11????1?0 ?110112100 ?????????? ?????????? ??????????
?????????? ?????????? ?????????? ??111??112 1100-00120 1111000001 ??????????
?????????1 ?????????? ?????????? ?????????? ?????????? ?????????? ?---11-110
2??110

*Parietobalaena yamaokai*
110-11011  1110111??1 11000-0?01 21001?10?1 10-????0?? 1111020001 ?11110100?
0200--0-00 1001000000 10220?0000 1101001000 11100----1 0000001121 1010100-14
0010100--? ??1111011? ?11???0100 ?????????? ?????????? ?????????? ??????????
?????????? ??11110100 01?0--0011 00?1111012 1100-00120 1112100001 010?00??00
???11????1 ??01000112 1????????? ?????????? ?????????? ?????????? ?---11-110
2?1020

*Diorocetus shobarensis*
110-11111  1111211001 11100-0?01 21001?1001 10-3101020 11110020?? ???10000?
?201--0-00 1001000?0 1000000?00 ?301001000 11100----1 0??0001121 1012101-14
0010100--? ??1100011? ?1????0100 ?????????? ?????????? ?????????? ??????????
?????????? ??1?11010? ???1100011 00?1111012 1100-????0 1113100001 ??????????
?????????1 1001000112 1????????? ?????????? ?????????? ?????1110? 0---11-110
23002?

*Diorocetus chichibuensis*
110-11111  1111111101 11000-0?01 1100111001 10-2000020 1111010000 ?111000001
0200--0-00 1001000000 1011000??0 0101001120 11100----1 00?0001121 1012101014
0011000--? ????11011? ???0110100 1????????? ?????????? ?????????? ??????????
?????????? ??11110100 0111010011 001111?12 1100-????0 111????001 ??????????
?????????1 ?????????? ?????????? ?????????? ?????????? ?????????? ?---11-110
2?1000

*Diorocetus hiatus*
110-11111  1110110110 11000-0?01 2100111001 10-2001030 1111020000 1111100001
0200--0-00 1002000010 1011000100 0101001100 11100----1 0010001121 1012100014
0011000--1 0111110111 1110130100 0010102000 311013---1 000--01010 212?1?11?0
10010?0010 1111110100 0110--0011 0011111012 1100-00131 ?111000001 01?????0??
??2????101 1101012010 0????????? ?????????? ?????????? ?????????? ?---11-110
201000

USNM187416
110-11?11  1110110110 10000-0?02 2100111001 10-2001020 1111010021 1111101001
0200--0-00 1002000010 1021000100 0101001100 11100----1 00?0001121 1012100-14
0001000--1 0111110111 1110130100 0120112000 ?????????? ?????????? ??????????
?????????? ??111101?? 0111010011 01???????? ?????????? ?????????? ??????????
?????????1 ?????????? ?????????? ?????????? ?????????? ?????????? ???-11-110
2?10??

*Mixocetus elysius*
110-11111  1110110110 1111002?01 1100100001 10-3001120 1121021002 1210102001
0210--1-00 1002111010 202100000? 0301000001 1100?----1 0010001120 0022110-01 ---
-000--1 0111110111 1110110100 ???2?????? ?????????? ?????????? ??????????
?001?????? ?????????? ?????????? ?1?1111012 ???0-00211 ?11?000000 01?0000000
000???00?1 ?1?1?1?111 1????????? ?????????? ?????????? ?????????? ?---11-110
20110?

*Cetotherium rathkei*
100-1???0  111??10110 1111102?02 2???10?001 1103101130 1121021021 1210102001
0210--0-00 1002111010 2022000001 0301000000 11000----1 00?0001120 1012100-14
0111000--1 0111010111 1111--0110 0????????? ?????????? ?????????? ??????????
?????????? ??201101?? 0111000011 01???????? ?????????? ?????????? ??????????
?????????1 ?????????? ?????????? ?????????? ?????????? ?????????? ?-?-11-110
2?1100

*Cetotherium riabinini*
100-11?10  1110110110 1111102?02 210011?001 10-2211120 1121010001 1210102001
0210--1-00 1002111010 2022000001 0301000000 11000----1 0110001120 1012100-14
0011000--1 0111110111 1110120100 0120????0? ?????????? ?????????? ??????????
?????????? ??201101?? ???0--00?1 01?1111012 1100-10021 2111000001 010?0001?0
002?0001?1 1000110002 111101???1 1112-10100 011100???? ??111????1 1---11-110
221100

*Metopocetus durinasus*
??0-1???0  111??????0 111?100?02 2?????0??? ???3???130 11???????? ???010200?
?210--1-00 1002111010 ???000??? 0301000101 11?00----1 0??0??112? 1012100-14
0111000--1 ?111?10111 11101??100 ????????0? 311113---1 000--00010 012?1?11?0
10010?0010 10???????? ?????????? ?????????? ?????????? ?????????? ??????????
?????????1 ?????????? ?????????? ?????????? ?????????? ?????????? ???????1??
??110?

*Metopocetus hunteri*
??0-1???0  111??????0 111?000?02 2????????? ???????1?0 1121?????? ???010200?
?210--1-00 1002111010 2022000001 0301001101 11?01000?1 0000001120 1012100-11 ---
-100--1 ?111110111 1110120100 011010201? ?1111????? ???????010 012?1?11??
?0000?0010 1021110110 0110--0001 011??????? ?????????? ?????????? ??????????
?????????1 ?????????? ?????????? ?????????? ?????????? ?????????? ???????1??
??1100

*Piscobalaena nana*
100-11110  1110110110 1111110?02 2100111001 1104001130 1121021000 1210102001
0210--1-00 1002111010 2022000101 0301000000 11000----1 0110001120 0022100-11 ---
-200--1 0110101?? ?111--0100 0100102000 311113---1 000--00010 012?1?1110
00010?0010 1101110110 0110--0001 0111111012 1100-00131 2112000001 0100000000
0020001101 1101011100 0111011211 2111210100 0111001??? 0?11110110 0---11-110
221120

*Herpetocetus morrowi*
100-11??0  111?110110 1111112?02 2100111001 10-3001130 1121022001 1210102001
0210--0-00 0002111010 1022000001 0001002100 11000----1 0100001120 1012100-14
0012000--1 0111110111 1110020110 1100102010 311113---1 100--01010 012?1?1110
10010?0010 1001110110 0110--0001 0111111012 1100-00130 1112000001 0?????????
????????01 110??????? ?????????? ?????????? ?????????? ?????????? ?---11-110
221100

*Herentalia nigra*
??0-1???0  111??????0 111?000?02 2????????? ???????120 1121?????? 121010200?
?210--1-00 1002111010 ?????????? ???1??0001 11?01001?1 0000?0112? 0002101011 ---
-200--1 ?111010111 1110220100 0120102000 ?1111????1 000--?1010 ??????????
?00??????? ?????????? ?????????? ?????????? ?????????? ?????????? ??????????
?????????1 ?????????? ?????????? ?????????? ?????????? ?????????? ???????1??
??10??

*Thinocetus arthritus*
??0-1????  ?????????? ?????????? ?????????? ?????????? ?????????? ??????????
???????-?? ?????????0 ?????????? ?????????? ?????????? ??????1??? ??????????
?????????? ???010111 111???0100 ??20112010 31111????1 000--00100 01??1?11?0
00010?0010 1011110100 0111000011 011??????? ?????????? ?????????? 010000??00

0??0????01 1101110111 0112011211 1112210100 011100???? ????10110 ???????1??
?????0

*Halicetus ignotus*
??0-1????  ?????????? ?????????? ?????????? ?????????? ?????????? ??????????
???????-?? ?????????0 ?????????? ?????????? ?????????? ??????1??? ??????????
?????????? ?????????? ?????????? ??10112000 31101????0 100--01100 01??1?11?0
00010?0010 1011110100 0111010011 011??????? ?????????? ?????????? 0100000000
0110111101 110??????? ?????????? ?????????? ?????????? ?????????? ???????1??
?????0

*Titanocetus sammarinensis*
110-11010  1110110110 11100-2?00 0100100001 10-3001100 1111120002 1100102001
0210--0-00 1001111010 1011000001 0301000011 11100----1 0??0001120 0-02100-01 ---
-200--1 0111010111 1110120100 01???????? ?????????? ?????????? ??????????
?????????? ?????????? ?????????? ?1?1111012 1100-10120 1113100000 010???????
????????11 ?????????? ?????????? ?????????? ?????????? ?????????? ???????1??
?1012?

*Cophocetus oregonensis*
110-11111  1110110110 11010-2?01 1100100001 10-3001120 1111121002 1210102001
0210--0-00 1002111010 1022000100 0101000010 11110----1 0011001121 1-12100-04
0101000--1 0111010111 1110110100 0020?????? 311013---1 000--00100 012?0?01?0
10010?0010 0111110100 0110--0011 00111??012 1100-20120 2112100001 0100000000
011????01 1101111002 011?011211 2122-????0 010100???? ?????????? ?---11-110
21011?

*Aglaocetus moreni*
110-11110  1110110110 10000-2?01 1100110001 10-3001100 1111110001 1110102001
0210--0-00 1002111010 1011000100 0101000010 11110----1 0011001121 1-12100-04
0101000--1 0111010111 1110110100 0020?????? ?????????? ?????????? ??????????
?????????? ?????????? ?????????? ???1111012 1100-0012? ?112000001 ??????????
?????????1 ?????????? ?????????? ?????????? ?????????? ?????????? ?---11-110
21????

*Eschrichtius robustus*
101011011  1110211001 10000-2211 0100111001 10-4102120 1121110021 1220102101
0211--0-00 1002121010 2122000101 0301000001 2111111?21 0101001120 2-22101114
11103010-1 0111110111 1110100110 1020???02 3101120001 000--111-0 01211011?0
101111100- 1211111000 0111000010 0111111013 00-1110131 2112011000 0100000000
0001111101 1100110001 1112011211 1111211100 0201011111 ??11111110 0---11-110 2-
1120

*Eschrichtioides gastaldii*
110-11??0  1110?????1 10000-2?11 0100??1001 10-3101120 1121110011 1220100001
0211--0-00 1002121010 2111000101 0301000101 2101100?1 01?1001120 0-02101101 ---
-00???1 0111100111 111???0110 ?????????? ?????????? ?????????? ??????????
?????????? ??10111000 0111000010 0111111013 00-1110131 2112011000 010???????
????????11 ?????????? ?112011211 2121-????0 020200???? ??111????? ?---11-110
2?112?

*Archaeschrichtius ruggieroi*
????????? ? ????????? ?????????? ?????????? ?????????? ?????????? ??????????
???????-?? ?????????? ?????????? ?????????? ?????????? ?????????? ??????????
?????????? ?????????? ?????????? ?????????? ?????????? ?????????? ??????????
?????????? ?????????? ?????????? ???1111012 11010????? ?112011002 ??????????
?????????1 ?????????? ?????????? ?????????? ?????????? ?????????? ?---11-11?
??????

M2231
110-?????  111???1001 10100-??1? ??????1?1? ???????1?0 1230020022 1320102011
131???1-11 1003121010 ????????01 0?01000000 21211011?1 0110001121 0002100-01 ---

-200--? ?111110111 111011?1?? 1020112100 1110020011 110--11010 012?0?00?0
11111?110- 0131111100 0101100001 0011111012 1100-21331 2113100002 010????0??
??2????111 ???1110002 1112011211 2112-10?00 01120?1??? ?????????? ?---11-110
2?1120

*'Balaenoptera' ryani*
?????????  ?????????? 1???0-???2 0????????? ???????0?0 1231?0???2 111110100?
?210--0-01 1002121010 ?????????? ???1??1100 21?11000?1 010?00112? 1012101004
1110100--? ?11??10111 111020?110 1????????? ?111120011 000--11010 012?0?01?0
00011?1010 01????11?0 01?110000? ??0??????? ?????????? ?????????? ??????????
?????????1 ?????????? ?????????? ?????????? ?????????? ?????????? ???????1??
??11?0

*Protororqualus cuvieri*
110-11010  1110211001 10100-2?12 1100111111 10-4101120 1242101012 1320102011
0220--1-11 1003021010 1?11000??? ??01002100 2121?????1 01?1001121 1012101014
0201100--? 0111100111 111???0110 ?????????? ?????????? ?????????? ??????????
?????????? ??3111110? ?10??000?1 01?1111012 1100-21241 ?111000000 0100????0?
????????01 11?111?112 1112001211 1121210100 0101001??1 ??1111???? ?---11-110
211120

*Protororqualus wilfriedneesi*
??0-?????  11???????? 101?0-2?12 2??0?11??? ???????1?? 12421??11 1??0102012
122???1-11 1003021010 ???1?10101 0?01001000 2121110?1 010100112? 10121????4
0201100--? ?111110111 111010?1?0 1120112100 ?111120001 100--001-1 112?0?01??
?1110?1010 0131111100 1101100001 011??????? ?????????? ?????????? ??????????
?????????1 ?????????? ?112?11211 ?1???????? ?????????? ?????????? ???????1??
2?1120

UT PU13842
110-11112  1111211??1 10100-1?12 1100??1111 10-4201120 1242200012 1320102012
1211--1-11 1003021010 1121010101 0101001100 2121?????1 01?1001121 1012101014
0201110--1 0111100111 111010?110 1?2??????? ?111120001 100--011-1 112?0?01?0
21110?0010 0131111100 1101100001 0111111012 1100-21241 2112100000 0100000000
0021111101 1101112112 1110010001 2122-10100 011100???? ??11111111 0---11-110
211120

*'Balaenoptera' cortesii* var. *portisi*
*100-11112  111011???1 10100-0?12 2111??1??1 1??????130 1231100011 1321102111*
*122???0-11 1002121010 1011100111 0100000100 2121112230 1?00011213 1021111004*
*1212100--? 0111110111 1111--0110 1120112100 ?111120011 110--001-0 112?0?00?0*
*21110?000- 0131111110 010??0000? ?1?1111012 1100-21131 2112000000 0100000000*
*000????11 ???1112112 1112011211 11122????1 001200???? ?????????? ?---11-110*
*221120*

NMR7096
??0-1?112  1110?????? 10100-0?12 2101?????1 ???????130 1231?????? ???110201?
?221--1-11 1002121010 1211100012 0100000100 211211123? 1100001121 3012110-04
1212100--? ?111110111 11100??1?0 1020102100 11010200?1 110--00010 112?1?11??
?1110?000- 0131111110 010110000? ?11??????? ?????????? ?????????? ??????????
?????????1 ?????????? ?????????? ?????????? ?????????? ?????????? ?-?-1?-110
2?1120

MPTA 207.13307
110-110?1  1110??10?1 10100-2?12 210???1111 1??4010130 1232100012 1320102011
1210--1-11 1003121010 2011000001 0301001100 2121110210 1000011212 2022101004
1210300--? ?111110111 111011?1?0 1110112100 1111120001 110--001-0 0???1?11??
?1110?100- 01???????? ?????????? ?????????? ?????????? ?????????? 0100000000
0021111101 ?????????? ?????????? ?????????? ?????????? ?????????? ???????1??
2?112?

*Plesiobalaenoptera quarantellii*

110-11111  1111211O?1 10100-2?1? 1100111?11 1????????? 12?21????? ???01?????
??1????-11 1???121??? ?????????? ?????????? ?????????? ???????12? 2022010-04
01030????? ?????1011? ?????????? ??21112000 1111020011 110--00010 012?1?11?0
21110?0011 1130111100 1101100001 0011111012 1100-21341 0113100002 01000???00
???11????1 11???????? ?????????? ?????????? ?????????? ?????1111? ?---11-110
2???20

SAM55001
?????????  ?????????? ?????????? ?????????? ?????????? ?????????? ??????????
???????-?? ?????????0 ?????????? ???0?????0 ?????????1 010100???? ??????????
?????????? ?111?????? ???????1?? ?????????? 1110200111 010--00010 012?1?11?0
21110?0011 1030111100 1101100001 0?1??????? ?????????? ?????????? ??????????
?????????1 ?????????? ?????????? ?????????? ?????????? ?????????? ???????1??
2???20

*Parabalaenoptera baulinensis*
110-11111  1110??1001 10100-2?11 2100111?01 1??3001120 1232201022 1320102011
?220001-11 1003121010 1021100001 0301001100 21211?2??1 01?000?121 0022101014
1100210--? 0111??011? ?????????? ?????????? ?????????? ?????????? ??????????
?????????? ?????????? ?????????? ???1111012 1110-21241 0113000002 0100????0?
???1????01 11???????? ?????????? ?????????? ?????????? ?????????? ?---11-110
2?1120

*Fragilicetus velponi*
??0-?????  11???????? 10100-2?11 2????????? ???????110 1232????22 1??010201?
1221--1-11 1003121010 10110?0000 0301000101 1120112?1 0100001121 2022101014
1110300--? ?111110111 111111?1?0 1120112100 1111200?1 110--001-1 112?1?11?0
11110?0010 11???????? ?????????? ?????????? ?????????? ?????????? ??????????
?????????1 ?????????? ?????????? ?????????? ?????????? ?????????? ???????1??
2?1120

*'Megaptera' hubachi*
110-11010  1110111001 10100-2?11 1100111111 1??3011120 1232101021 1320102011
1210001-11 1003121010 1021000000 0101000100 11211100?1 0100001121 2022101004
1110300--? 0111110111 11?11101?0 1021112002 1111?2000? ??0--00??? ????1?11?0
21110?0011 11???????? ?????????? ???1111012 1100-21241 ?113000002 0100000000
0021111101 1101110111 1110011211 2112110100 0111001111 0111111111 0---11-110
23112?

*Incakujira anillodefuego*
110-11111  1110311101 10100-2?11 1100111111 10-4011130 1242200112 1320102012
1210001-11 1003121010 1011110111 0201001100 21211????1 01?0001121 2022101012 ---
-301101 0111110111 1110210110 1121?????? ?11??20??1 100--00??? ??????????
?1110?001? ??31111110 1101100001 0111111012 1100-2134? ?112000?0? 0100000000
00?0????01 1111111110 1110011211 2122110100 0111001111 01111?1?11 0---11-110
201120

M1613
110-11111  1110311101 10100-2?12 1100111111 10-3011130 1242202122 1320102012
1211--1-11 1003121010 1011110112 0101000100 21211100?1 0010001121 2022101012 ---
-30110? 0111110111 11102001?0 102??????? ?????????? ?????????? ??????????
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*Archaebalaenoptera castriarquati*
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*Archaebalaenoptera liesselensis*
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*Nehalaennia devossi*
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*'Balaenoptera' bertae*
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*Miobalaenoptera numataensis*
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*Diunatans luctoretemergo*
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*Norrisanima miocaena*
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*'Balaenoptera' siberi*
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*Megaptera novaeangliae*
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*Balaenoptera physalus*
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*Balaenoptera acutorostrata*
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*Balaenoptera bonaerensis*
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*Balaenoptera omurai*
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*Balaenoptera brydei*
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11111?000- 0030111101 1101100001 0011111012 1100-21331 2113200012 0100000000
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*Balaenoptera edeni*
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11111?000- 0030111111 1101100001 0011111012 1100-21331 2113200012 0100000000
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*Balaenoptera borealis*
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*Balaenoptera musculus*
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## REFERENCES CITED IN THE SUPPLEMENTARY INFORMATION FILE

**Benke H. 1993.** Investigations on the osteology and functional morphology of the flipper of whales and dolphins (Cetacea). *Investigations on Cetacea* **24:**9–252.

**Bisconti M. 2000.** New description, character analysis and preliminary phyletic assessment of two Balaenidae skulls from the Italian Pliocene. *Palaeontographia Italica* **87:**37–66.

**Bisconti M. 2005.** Morphology and phylogenetic relationships of a new diminutive balaenid from the lower Pliocene of Belgium. *Palaeontology* **48:**793–816.

**Bisconti M. 2006.** *Titanocetus*, a new baleen whale from the Middle Miocene of northern Italy (Mammalia, Cetacea, Mysticeti). *Journal of Vertebrate Paleontology* **26:**344–354.

**Bisconti M. 2007a.** A new basal balaenopterid from the Early Pliocene of northern Italy. *Palaeontology* **50:**1103–1122.

**Bisconti M. 2007b.** Taxonomic revision and phylogenetic relationships of the rorqual-like mysticete from the Pliocene of Mount Pulgnasco, northern Italy (Mammalia, Cetacea, Mysticeti). *Palaeontographia Italica* **91:**85–108.

**Bisconti M. 2008.** Morphology and phylogenetic relationships of a new eschrichtiid genus (Cetacea: Mysticeti) from the Early Pliocene of northern Italy. *Zoological Journal of the Linnean Society* **153:**161–186.

**Bisconti M. 2010.** A new balaenopterid whale from the Late Miocene of the Stirone River, northern Italy (Mammalia, Cetacea, Mysticeti). *Journal of Vertebrate Paleontology* **30:**943–958.

**Bisconti M. 2011.** New description of *'Megaptera' hubachi* Dathe, 1983 based on the holotype skeleton held in the Museum für Naturkunde, Berlin. In: Bisconti M, Roselli A, Borzatti de Loewenstern A, eds. *Climatic Change, Biodiversity, Evolution: Natural History Museum and Scientific Research. Proceedings of the Meeting. Quaderni del Museo di Storia Naturale di Livorno* **23:**37–68.

**Bisconti M. 2012.** Comparative osteology and phylogenetic relationships of *Miocaperea pulchra*, the first fossil pygmy right whale genus and species (Cetacea, Mysticeti, Neobalaenidae). *Zoological Journal of the Linnean Society* **166:**876–911.

**Bisconti M, Bosselaers M. 2016.** *Fragilicetus velponi*: a new mysticete genus and species and its implications for the origin of Balaenoperidae (Mammalia, Cetacea, Mysticeti). *Zoological Journal of the Linnean Society* **177:**450–474.

**Bisconti M, Lambert O, Bosselaers M. 2013.** Taxonomic revision of *Isocetus depawi* (Mammalia, Cetacea, Mysticeti) and the phylogenetic relationships of archaic 'cetothere' mysticetes. *Palaeontology* **56:**95–127.

**Bisconti M, Varola A. 2006.** The oldest eschrichtiid mysticete and a new morphological diagnosis of Eschrichtiidae. *Rivista Italiana di Paleontologia e Stratigrafia* **119:**447–457.

**Boessenecker RW. 2013.** A new marine vertebrate assemblage from the Late Neogene Purisima Formation in Central California, part II: Pinnipeds and Cetaceans. *Geodiversitas* **35:**815–940.

**Boessenecker RW, Fordyce RE. 2015.** Anatomy, feeding ecology, and ontogeny of a transitional baleen whale: a new genus and species of Eomysticetidae (Mammalia: Cetacea) from the Oligocene of New Zealand. *PeerJ* **3**(3):e1129

**Bosselaers M, Post K. 2010.** A new fossil rorqual (Mammalia, Cetacea, Balaenopteridae) from the Early Pliocene of the North Sea, with a review of the rorqual species described by Owen and Van Beneden. *Geodiversitas* **32:**331–363.

**Bouetel V, De Muizon C. 2006.** The anatomy and relationships of *Piscobalaena nana* (Cetacea, Mysticeti), a Cetotheriidae s.s. from the early Pliocene of Peru. *Geodiversitas* **28:**319–395.

**Buono MR, Fernández MS, Cozzuol MA, Cuitiño JI, and Fitzgerald EMG. 2018.** The early Miocene balaenid *Morenocetus parvus* from Patagonia (Argentina) and the evolution of right whales. *PeerJ* **5**:e4148

**Caretto PG. 1970.** La balenottera delle sabbie plioceniche di Valmontasca (Vigliano d'Asti). *Bollettino della Società Paleontologica Italiana* **9**:3–75.

**Clapham PJ. 2002.** Humpback whale (*Megaptera novaeangliae*). In: Perrin WF, Wursig B, Thewissen JGM, eds. *Encyclopedia of Marine Mammals*. London: Academic Press, 589–592.

**Deméré TA, Berta A, McGowen MR. 2005.** The taxonomic and evolutionary history of fossil and modern balaenopteroid mysticetes. *Journal of Mammalian Evolution* **12:**99–143.

**Fitzgerald EMG. 2006.** A bizarre new toothed mysticete (Cetacea) from Australia and the early evolution of baleen whales. *Proceedings of the Royal Society Series B*, https://doi.org/10.1098/rspb.2006.3664.

**Fraas E. 1904.** Neue Zeuglodonten aus dem Unteren Mitteleocän vom Mokattam bei Cairo. *Geol. Palaeont. Abh.* **6:**199–220.

**Freschi A, Cau S. 2015.** La riscoperta di Monte Pulgnasco: nuova collocazione cronostratigrafica e geografica di *Protororqualus cuvieri* (Cetacea: Misticeti, Balaenopteridae). *Quaderni del Museo Civico di Storia Naturale di Ferrara* **3:**21–30.

**Gottfried MD, Bohaska DJ, Whitmore FC Jr (1994).** Miocene cetaceans of the Chesapeake Group. *Proceedings of the San Diego Society of Natural History* **29:**229–238.

**Govender R. 2019**. Fossil cetaceans from Duinefontein (Koeberg) an early Pliocene site on the southwestern Cape, South Africa. *Palaeontologia Electronica* **22:**1.6A.

**Govender R, Bisconti M, Chinsamy A. 2016.** A late Miocene–early Pliocene baleen whale assemblage from Langebaanweg, west coast of South Africa (Mammalia, Cetacea, Mysticeti). *Alcheringa* **40:**542–555.

**Horwood J. 2002.** Sei whale (*Balaenoptera borealis*). In: Perrin WF, Wursig B, Thewissen JGM, eds. *Encyclopedia of Marine Mammals*. London: Academic Press, 1069–1071.

**Hulbert RC Jr. 1998.** Postcranial osteology of the North American Middle Eocene protocetid *Georgiacetus*. In: Thewissen JGM, ed. *The emergence of whales*. New York: Plenum Press, 235–267.

**Hulbert RC Jr, Petkewich RM, Bishop GA, Bukry D, Aleshire DP. 1996.** A new Middle Eocene protocetid whale (Mammalia: Cetacea: Archaeoceti) and associated biota from Georgia. *Journal of Paleontology* **72:**907–927.

**Jones ML, Schwartz SL. 2002.** Gray whale (*Eschrichtius robustus*). In: Perrin WF, Wursig B, Thewissen JGM, eds. *Encyclopedia of Marine Mammals*. London: Academic Press, 524–537.

**Kato H. 2002.** Bryde's whales (*Balaenoptera edeni* and *B. brydei*). In: Perrin WF, Wursig B, Thewissen JGM, eds. *Encyclopedia of Marine Mammals*. London: Academic Press, 171–177.

**Kellogg R. 1936.** A review of the Archaeoceti. *Carnegie Institution Washington* **482:**1–366.

**Kellogg R. 1934a.** The Patagonia fossil whalebone whale, *Cetotherium moreni* (Lydekker). *Contributions in Palaeontology, Carnegie Insitution Washington* **447:**63–81.

**Kellogg R. 1934b.** A new cetothere from the Modelo Formation at Los Angeles, California. *Contributions in Palaeontology, Carnegie Insitution Washington* **447:**85–104.

**Kellogg R. 1965.** A new whalebone whale from the Miocene Calvert Formation. *United States National Museum Bulletin* **247:**1–45.

**Kellogg R. 1968a.** Miocene Calvert mysticetes described by Cope. *United States National Museum Bulletin* **247:**103–132.

**Kellogg R. 1968b.** A hitherto unrecognized Calvert mysticete. *United States National Museum Bulletin* **247:**133–161.

**Kellogg R. 1968c.** A sharp-nosed cetothere from the Miocene Calvert. *United States National Museum Bulletin* **247:**163–197.

**Kellogg R. 1968d.** Supplement to description of Parietobalaena palmeri. *United States National Museum Bulletin* **247:**175–197.

**Kemper CM. 2002.** Pygmy right whale (*Caperea marginata*). In: Perrin WF, Wursig B, Thewissen JGM, eds. *Encyclopedia of Marine Mammals*. London: Academic Press, 1010–1013.

**Kenney RD. 2002.** North Atlantic, North Pacific, and Southern right whales (*Eubalaena glacialis*, *E. japonica*, and *E. australis*). In: Perrin WF, Wursig B, Thewissen JGM, eds. *Encyclopedia of Marine Mammals*. London: Academic Press, 806–813.

**Kimura T, Hasegawa Y. 2010.** A new baleen whale (Mysticeti: Cetotheriidae) from the earliest Late Miocene of Japan and a reconsideration of the phylogeny of cetotheres. *Journal of Vertebrate Paleontology* **30:**577–591.

**Kimura T, Ozawa T. 2002.** A new cetothere (Cetacea: Mysticeti) from the Early Miocene of Japan. *Journal of Vertebrate Paleontology* **22:**684–702.

**Kimura T, Adaniya A, Oishi M, Marx FG, Hasegawa Y. 2015.** A Late Miocene balaenopterid ("Shimajirikujira") from the Okamishima Formation, Shimajiri Group, Miyako Island, Okinawa, Japan. *Bulletin of the Gunma Museum of Natural History* **19:**39–48. (in Japanese with English abstract).

**Leslie MS, Peredo CM, Pyenson ND. 2019.** *Norrisanima miocaena*, a new generic name and redescription of a stem balaenopteroid mysticete (Mammalia, Cetacea) from the Miocene of California. *PeerJ* **7**:e7629 http://doi.org/10.7717/peerj.7629.

**Marx FG, Bosselaers MEJ, Louwye S.** 2015. A new species of *Metopocetus* (Cetacea, Mysticeti, Cetotheriidae) from the late Miocene of Netherlands. *PeerJ* **4**:e1572; DOI 10.7717/peerj.1572

**Marx FG, Kohno N. 2016.** A new Miocene baleen whale from the Peruvian desert. *Royal Society Open Science* **3:**160542. http://dx.doi.org/10.1098/rsos.160542.

**Oishi M, Kawakami T, Hasegawa, Y. 1985.** Pliocene baleen whales and bony-toothed bird from Iwate Prefecture, Japan (Parts I–VI). *Bulletin of the Iwate Prefectural Museum* **3:**143–157.

**Owen R. 1848.** Description of teeth and portions of jaws of two extinct Anthracotherioid quadrupeds (Hyopotamus vectianus and Hyop. bovinus) discovered by the Marchioness of Hastings in the Eocene deposits on the NW coast of the Isle of Wight: with an attempt to develope Cuvier's idea of the Classification of Pachyderms by the number of their toes. *Quarterly Journal of the Geological Society of London* **4:**103–141. DOI 10.1144/GSL.JGS.1848.004.01-02.21.

**Packard EL, Kellogg R. 1934.** A new cetothere from the Miocene Astoria Formation of Newport, Oregon. *Publication of Carnegie Institution Washington* **447**:1–62.

**Peredo CM, Uhen MD. 2016.** A new basal Chaeomysticete (Mammalia: Cetacea) from the Oligocene Pysht Formation of Washington, USA*. Papers in Palaeontology* **2016**:1–22.

**Perrin WR, Brownell RL Jr. 2002.** Minke whales (*Balaenoptera acutorostrata* and *B. bonaerensis*). In: Perrin WF, Wursig B, Thewissen JGM, eds. *Encyclopedia of Marine Mammals*. London: Academic Press, 750–754.

**Pilleri G. 1986.** *Beobachtungen an den fossilen Cetaceen des Kaukasus*. Ostermundigen: Brain Anatomy Institute.

**Pilleri G. 1989.** *Balaenoptera siberi*, ein neuer Spätmiozäner Bartenwal aus der Pisco-Formation Perus. In: Pilleri G, ed. Beiträge zur Paläontologie der Cetaceen Perus. Ostermundigen: Hirnanatomisches Institut der Universitat Bern (Schweiz), 63–84.

**Rugh DJ, Shelden KEW. 2002.** Bowhead whale (*Balaena mysticetus*). In: Perrin WF, Wursig B, Thewissen JGM, eds. *Encyclopedia of Marine Mammals*. London, Academic Press, 12–131.

**Sanders AE, Barnes LG. 2002a.** Paleontology of the Late Oligocene Ashley and Chandler Bridge Formations of South Carolina, 2: *Mycromysticetus rothauseni*, a primitive cetotheriid mysticete (Mammalia: Cetacea). In: Emry RJ, ed. *Cenozoic mammals of land and sea: tributes to the career of Clayton E. Ray*. *Smithsonian Contributions in Paleobiology* **97:**271–293.

**Sanders AE, Barnes LG. 2002b.** Paleontology of the late Oligocene Ashley and Chandler Bridge formations of South Carolina, 3: Eomysticetidae, a new family of primitive mysticetes (Mammalia: Cetacea). In: Emry RJ, ed. *Cenozoic mammals of land and sea: tributes to the career of Clayton E. Ray*. *Smithsonian Contribution in Paleobiology* **93:**313–356.

**Sears R. 2002.** Blue whale (*Balaenoptera musculus*). In Perrin WF, Wursig B, Thewissen JGM, eds. *Encyclopedia of Marine Mammals.* London: Academic Press, 112–116.

**Sears R, Calambokidis J. 2002.** Assessment and update report Status Report on the Blue Whale *Balaenoptera musculus* Atlantic population Pacific population in Canada. Ottawa: COSEWIC, 1–32.

**Steeman ME. 2009.** A new baleen whale from the Late Miocene of Denmark and early mysticete hearing. *Palaeontology* **52:**1169–1190.

**Tanaka Y, Watanabe M. 2019.** An early and new member of Balaenopteridae from the upper Miocene of Hokkaido, Japan. *Journal of Systematic Palaeontology* **17:**1197–1211.

**Tsai C-H, Boessenecker RW. 2017.** The earliest-known fin whale, *Balaenoptera physalus*, from the Early Pleistocene of Northern California, U.S.A. *Journal of Vertebrate Paleontology* e1306536.

**Tsai C-H, Fordyce RE. 2015.** The Earliest Gulp-Feeding Mysticete (Cetacea: Mysticeti) from the Oligocene of New Zealand. *Journal of Mammalian Evolution* **23:** 33–59.

**Uhen MD. 1998.** Middle to Late Eocene basilosaurines and dorudontines. In: Thewissen JGM, ed. *The emergence of whales: evolutionary patterns in in the origin of Cetacea*. New York: Plenum Press, 29–63.

**Uhen MD. 2004.** Form, function, and anatomy of *Dorudon atrox* (Mammalia, Cetacea): an archaeocete from the middle to late Eocene of Egypt. *University Michigan Paper in Paleontology* **34:**1–222.

**Uhen MD. 2008.** New protocetid whales from Alabama and Mississippi, and a new cetacean clade, Pelagiceti. Journal of Vertebrate Paleontology 28:589–593. DOI 10.1671/0272-4634(2008)28[589:NPWFAA]2.0.CO;2.

**Van Beneden P-J. 1882.** Description des ossements fossiles des environs d'Anvers. Genres: *Megaptera*, *Balaenoptera*, *Burtinopsis*, *Erpetocetus*. *Annales du Musée Royal d'Histoire Naturelle de Belgique* **7:**1–90 plus atlas.

**Wada S, Oishi M, Yamada TK. 2007.** A newly discovered species of living baleen whale. *Nature* **426:** 278–291.

**Zeigler CV, Chan GL, Barnes LG. 1997.** A new late Miocene balaenopterid whale (Cetacea: Mysticeti), Parabalaenoptera baulinensis, (new genus and species) from the Santa Cruz Mudstone, Point Reyes Peninsula, California. *Proceedings of the California Academy of Sciences* **50**:115–138.