

# **A new longirostrine sperm whale (Cetacea, Physeteroidea) from the lower Miocene of the Pisco Basin (southern coast of Peru)**

Olivier Lambert<sup>a\*</sup>, Christian de Muizon<sup>b</sup>, Mario Urbina<sup>c</sup> and Giovanni Bianucci<sup>d</sup>

<sup>a</sup>*Direction Opérationnelle Terre et Histoire de la Vie, Institut Royal des Sciences Naturelles de Belgique, Brussels, Belgium;* <sup>b</sup>*CR2P UMR 7207, (MNHN, CNRS, UPMC, Sorbonne-Université), Muséum national d'Histoire naturelle, Département Origines et Evolution, Paris, France;* <sup>c</sup>*Departamento de Paleontología de Vertebrados, Museo de Historia Natural – UNMSM, Lima, Peru;* <sup>d</sup>*Dipartimento di Scienze della Terra, Università di Pisa, Pisa, Italy*

\*Corresponding author. Email: [olivier.lambert@naturalsciences.be](mailto:olivier.lambert@naturalsciences.be)

## **Supplemental file 1**

**1. List of characters used in the phylogenetic analysis**

**2. Consensus tree obtained with down-weighting of homoplastic characters**

## 1. List of characters used in the phylogenetic analysis

From Collareta et al. (in press)

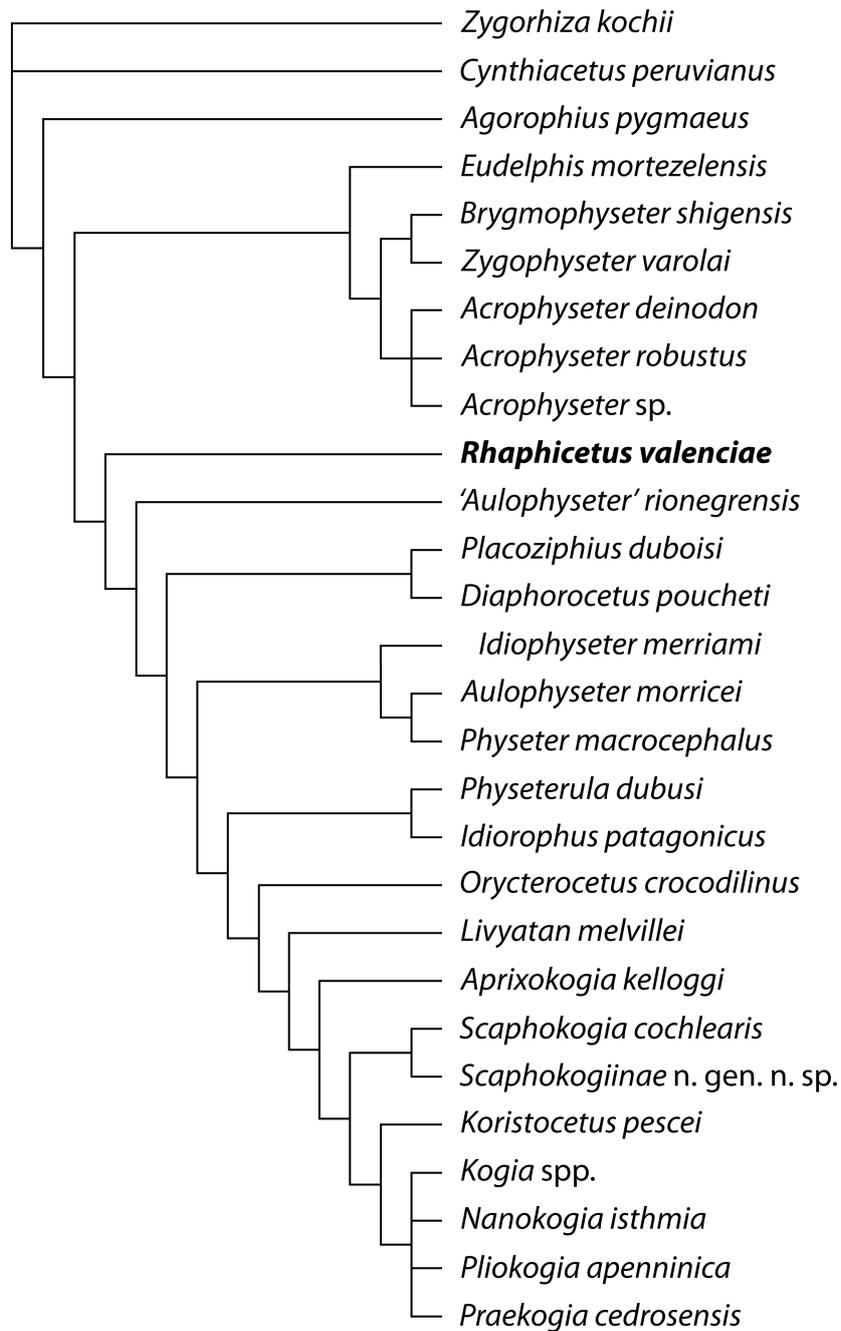
1. Rostrum length: 0, rostrum elongated, ratio between rostrum length and skull width  $> 1.2$ ; 1, ratio  $\leq 1.2$  and  $\geq 0.95$ ; 2, short rostrum, ratio  $< 0.95$ .
2. Maxillae, premaxillae and vomer, all reaching the tip of the rostrum which is not formed only by the premaxillae: 0, absent; 1, present.
3. Supracranial basin of the skull: 0, absent; 1, present; 2, extended onto the whole dorsal surface of the rostrum.
4. Dorsal exposure of the maxilla on the rostrum: 0, exposure limited to less than half the rostrum length; 1, maxilla exposed on more than half the length of the rostrum, narrower than the premaxilla at some levels; 2, wider than the premaxilla all along.
5. Constriction of premaxilla anterior to antorbital notch followed by anterior expansion: 0, absent, suture maxilla-premaxilla on the rostrum roughly anteriorly directed; 1, present, suture maxilla-premaxilla distinctly anterolaterally directed.
6. Upper tooth row: 0, deep alveoli; 1, alveoli shallow or absent.
7. Premaxillary teeth: 0, present; 1, absent. This character cannot be coded for taxa lacking distinct upper alveoli.
8. Maximum width of skull (postorbital or bizygomatic width): 0,  $< 40$  cm; 1,  $\geq 40$  and  $< 60$  cm; 2,  $\geq 60$  and  $< 100$  cm; 3,  $\geq 100$  cm.
9. Antorbital notch: 0, absent; 1, present; 2, transformed into a very narrow slit.
10. Right antorbital notch: 0, outside the supracranial basin; 1, inside the supracranial basin.
11. Number and size of dorsal infraorbital foramina, in the area of the right antorbital notch and posteriorly: 0, small to moderate size foramina, at least three-four; 1, three large foramina; 2, two large foramina; 3, one large foramen (maxillary incisure).
12. Right premaxilla: 0, posteriorly extended as the left premaxilla; 1, more posteriorly extended than the left premaxilla.
13. Right premaxilla: 0, not widened posteriorly; 1, posterior extremity of the right premaxilla laterally widened, occupying at least one third of the width of the supracranial basin, mostly on the right side.
14. Presence of a sagittal crest: 0, absent; 1, present as a shelf covered by the pointed right premaxilla.
15. Left premaxillary foramen very small or absent: 0, absent (i.e. foramen present and not reduced); 1, present.

16. Increase in size of the right premaxillary foramen: 0, absent, ratio between width of foramen and width of premaxilla at that level  $\leq 0.20$ ; 1, present, ratio  $> 0.20$ .
17. Anteroposterior level of right premaxillary foramen: 0, distinctly anterior to antorbital notch; 1, slightly anterior to antorbital notch; 2, same level or posterior to antorbital notch.
18. Asymmetry of the bony nares: 0, absent or reduced; 1, strong, left bony naris significantly larger than right naris.
19. Lack of nasals: 0, both nasals present; 1, one nasal absent; 2, both nasals absent.
20. Widening of the supracranial basin on the right side: 0, absent; 1, present, basin overhangs the right orbit.
21. Right maxilla reaching the sagittal plane of the skull on the posterior wall of the supracranial basin: 0, absent; 1, present.
22. Fusion of lacrimal and jugal: 0, absent; 1, present.
23. Projection of the lacrimal-jugal between frontal and maxilla: 0, short or absent; 1, long.
24. Dorsoventral level of the antorbital process of the frontal: 0, higher than the lateral margin of rostrum base; 1, at approximately the same level; 2, considerably lower.
25. Frontal-maxilla suture, with skull in lateral view: 0, forming an angle  $< 15^\circ$  from the axis of the rostrum; 1,  $15-35^\circ$ ; 2,  $> 35^\circ$ .
26. Temporal fossa: 0, anteroposteriorly longer than distance between preorbital process of the maxilla and anterior wall of temporal fossa; 1, approximately same length; 2, distinctly shorter.
27. Zygomatic process of squamosal in lateral view: 0, 'L'-shaped with dorsal margin ventrally bending in its posterior portion; 1, triangular, with dorsal margin dorsally bending in its posterior portion.
28. Postglenoid process of the squamosal: 0, significantly ventrally longer than post-tympanic process; 1, roughly same ventral extent as post-tympanic process.
29. In lateral view of the skull, wide notch posterior to the postglenoid process of the squamosal for the enlarged posterior process of the tympanic: 0, absent; 1, present but only partially developed, paroccipital concavity moderately excavated; 2, present and well developed, paroccipital concavity transformed in a wide and deep notch.
30. Occipital shield: 0, convex and forming an angle of about  $40^\circ$  from the axis of the rostrum; 1, as state 0 with an angle of about  $60^\circ$ ; 2, flat or concave forming an angle of about  $90^\circ$ ; 3, flat or concave forming an angle distinctly greater than  $90^\circ$ .
31. Falciform process of the squamosal: 0, contacting the corresponding pterygoid; 1, forming a thin plate not contacting the pterygoid; 2, reduced to a simple peg or absent.

32. Anterior bullar facet of the periotic: 0, very anteroposteriorly elongated; 1, reduced; 2, absent or very small.
33. Posterior extension of the posterior process of the periotic parallel to the general plane of the bone and not ventrally orientated: 0, absent; 1, present.
34. Accessory ossicle of the tympanic bulla: 0, absent or small; 1, enlarged and partially fused with the anterior process of the periotic.
35. Involucrum of the tympanic bulla with an evident central concavity, visible in ventral and medial views, due to the marked pachyostosis of its anterior and posterior portion: 0, absent; 1, present.
36. Size of teeth (greatest transverse diameter of root expressed as percentage of the maximum width of skull): 0, < 5%; 1, > 5%. Considering the strong heterodonty in *Cynthiacetus* and *Zygorhiza* this character is restricted to single-rooted teeth.
37. Dental enamel: 0, present; 1, absent.
38. Number of mandibular teeth: 0, 11; 1, 12-14; 2, > 14.
39. Labiolingual compression of the posterior lower teeth (portion out of the alveolus): 0, strong; 1, weak or absent.
40. Position of the mandibular condyle: 0, distant from the ventral margin of the mandible, with a well-developed angular process; 1, ventral, with the angular process being low or absent.
41. Anteroposterior level of last upper alveolus or posterior end of vestigial alveolar groove: 0, posterior to antorbital process; 1, at level of antorbital notch or slightly anterior; 2, distinctly anterior to the notch.
42. Lateral margin of the supraorbital process of the maxilla: 0, dorsoventrally thin; 1, significantly dorsoventrally thickened, making a subvertical wall.
43. Postorbital process of the frontal: 0, moderately posteroventrally extended; 1, much ventrally extended (vertical length of process equal or greater than horizontal length of orbit), with a correspondingly low position of the zygomatic process of the squamosal.
44. Height of temporal fossa: 0, dorsal margin at top of skull or somewhat lower; 1, much lower, temporal fossa making less than half the skull height.
45. Contact between jugal and zygomatic process of squamosal: 0, anteroposteriorly long contact; 1 proportionally short, more rounded contact; 2, no contact. In specimens with no jugal preserved, the contact surface can sometimes be observed on the zygomatic process (e.g., *Orycterocetus crocodilinus* USNM 22926).
46. Length of the zygomatic process of the squamosal (horizontal length from anterior tip to posterior margin of squamosal): 0, ratio between length of the process and bizygomatic width of skull > 0.35; 1, ratio < 0.35.

47. Medial to tympanosquamosal recess, deep and rectilinear narrow groove in ventral surface of squamosal, from spiny process area to temporal fossa: 0, absent or shallow and poorly delineated; 1, present.
48. Dorsal process of the periotic: 0, dorsally extended and anteroposteriorly long; 1, anteroposteriorly shorter, but dorsally extended beyond the medial margin of the internal acoustic meatus; 2, dorsally short.
49. Posteromedial outline of the pars cochlearis in dorsal view: 0, angular; 1, flattened, barely convex, and roughly continuous with posterior margin of dorsal process.
50. Curvature of the mandible in lateral view: 0, absent or reduced, ventral margin roughly rectilinear or rising moderately anterodorsally; 1, conspicuous, ventral margin distinctly convex rising both posterodorsally and anterodorsally; 2, present, ventral margin concave.
51. Symphyseal angle on the mandibles: 0,  $< 35^\circ$ ; 1,  $35^\circ$ - $55^\circ$ ; 2,  $> 55^\circ$ .
52. Lateral margin of atlas: 0, roughly rectilinear or laterally concave; 1, convex, with laterally pointed transverse process at mid-height of the bone. Not applicable to *Kogia* (single block of cervical vertebrae).
53. Notch in the anterior margin of the basihyal: 0, wide and shallow notch; 1, narrow and deep notch; 2, no notch, rectilinear or convex anterior margin.

## 2. Consensus tree obtained with down-weighting of homoplastic characters



**Supplemental Figure 1.** Consensus of 15 most parsimonious trees resulting from the heuristic search performed with homoplastic characters being down-weighted (k=3). Tree length 145; CI 0.52; RI 0.72.