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SUPPLEMENTARY ONLINE MATERIAL FOR

A new kogiid sperm whale from northern Italy supports psychrospheric conditions in the early Pliocene Mediterranean Sea

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Supplementary Online Material

SOM 1. List of characters used in the cladistic analysis.
SOM 2. Character/taxon matrix.

SOM 1. List of characters used in the cladistic analysis

Characters taken from Collareta et al. (2017b).

1. Rostrum length: 0, rostrum elongated, ratio between rostrum length and skull width > 1.2; 1, ratio ≤ 1.2 and ≥ 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, ≥ 40 and < 60 cm; 2, ≥ 60 and < 100 cm; 3, ≥ 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 ≤ 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° from the axis of the rostrum; 1, 15-35°; 2, > 35°.
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, paraoccipital concavity moderately excavated; 2, present and well developed, paraoccipital concavity transformed in a wide and deep notch.
30. Occipital shield: 0, convex and forming an angle of about 40° from the axis of the rostrum; 1, as state 0 with an angle of about 60°; 2, flat or concave forming an angle of about 90°; 3, flat or concave forming an angle distinctly greater than 90°.
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. Loss of dental enamel: 0, absent; 1, present.
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. Ventral position of the mandibular condyle: 0, absent, well developed angular process; 1, present, angular process 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 cochlaris 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 moderatly 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°; 1, 35°-55°; 2, > 55°.
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.

SOM 2. Character/taxon matrix

Data matrix of 53 characters for 3 outgroups (*Agorophius*, *Cynthiacetus*, and *Zygorhiza*) and 25 extinct and extant physeteroid taxa (*Eudelphis*, *Zygophyseter*, *Brygmophyseter*, *Acrophyseter deinodon*, *Acrophyseter robustus*, *Acrophyseter* sp., *Livyatan*, '*Aulophyseter*' *rionegrensis*, *Orycterocetus*, *Physeterula*, *Idiorophus*, *Diaphorocetus*, *Placoziphius*, *Aulophyseter*, *Physeter*, *Idiophyseter*, *Thalassocetus*, *Aprixokogia*, *Scaphokogia*, *Praekogia*, *Kogia*, *Koristocetus*, *Nanokogia*, Scaphokogiinae sp., and *Pliokogia* gen. nov.). *Acrophyseter* sp. refers to MUSM 2182, a partial skull from the site of Cerro Los Quesos (late Miocene, Pisco Formation). Scaphokogiinae sp. refers to MUSM 3291 and MUSM 3405, two partial skulls from the sites of Cerro Los Quesos and Cerro Blanco respectively (late Miocene, Pisco Formation), representing a new form of Kogiidae sharing similarities with *Scaphokogia cochlearis*. Extant genera are highlighted in blue. All characters are unordered. 0, primitive state; 1, 2, 3, derived states; a, variable between 0 and 1; b, variable between 1 and 2; c, variable between 1, 2, and 3; n, character inapplicable; ?, missing character.

	5	**10**	**15**	**20**	**25**	**30**	**35**	**40**	**45**	**50**	**53**
Zygorhiza	00000	0000n	?000n	nn00n	n000n	00002	00000	00000	0n000	00000	?0?
Cynthiacetus	00000	0010n	?000n	nn00n	n000n	00002	01000	10000	0n000	00?00	000
Agorophius	??010	0?01n	00000	0000n	0?010	00000	?????	?0???	1000?	0????	???
Eudelphis	101?0	0?110	01??0	1?1?0	?????	?100?	1????	00???	?????	?0???	???
Zygophyseter	10110	01210	21101	12111	?1001	0110?	12?11	10101	100?0	0?2?0	11?
Brygmophyseter	??1??	0?210	21101	??1??	???11	01101	????1	101?1	???0?	????0	??1
Acro. deinodon	20110	001?0	3?100	111?1	0??02	01101	?2011	10101	1??0?	01201	1??
Acro. robustus	??110	0?020	2110?	01101	01002	01101	???1?	10??1	10?00	01??1	?11
Acrophyseter sp.	00110	00120	????0	??1??	???0?	0110?	?????	10?01	1?0??	01??1	???
Livyatan	21211	01320	2?1?0	????0	?1?12	01?0?	?????	10011	10?0?	1????	1??
'Aulo.' rionegr.	?0110	00110	11100	01110	0?011	01101	?????	??2?1	2001?	0???0	???
Orycterocetus	10110	00110	11101	01110	1?011	11102	22011	012??	20?00	1011?	???
Physeterula	??10?	0?210	21101	??1?0	0??11	?1102	2????	0121?	?000?	?0??0	1??
Idiorophus	00110	00210	?????	????0	???11	?????	?????	0121?	?0?0?	????0	???
Diaphorocetus	??110	0?120	?1101	11??0	???1?	1110?	?????	??2??	20?1?	10???	???
Placoziphius	?0120	??110	?1101	11?10	??011	?110?	2????	?????	20???	?0???	?0?
Aulophyseter	10100	1n210	21101	02110	01022	21102	?201?	01???	200??	1010?	???
Physeter	a022a	1n310	31101	02110	01022	21102	22011	0121a	20011	10110	102
Idiophyseter	?????	1?1?0	2110?	121?0	???22	1???2	?????	?????	?????	?????	???
Thalassocetus	?????	??010	1101?	???20	1??11	?1101	?????	?????	?011?	?????	???
Aprixokogia	??2?0	0?010	01111	021?0	?1121	01112	2????	?????	1110?	10???	???
Scaphokogia	?1111	1n020	01011	02120	11121	a1013	?211?	?????	1100?	1????	???
Praekogia	?????	??021	0101?	??120	1?1?1	11021	2????	?????	?111?	10???	???
Kogia	21220	1n021	01011	0b120	11122	2102b	22111	01c1a	21112	10212	2?2
Koristocetus	21120	01021	31011	??120	?11?1	01121	?????	?????	2100?	1????	???
Nanokogia	21110	1n021	01011	??120	11021	01021	2????	0?11?	11012	10??0	1??
Scaphokogiinae sp.	?1111	01020	01011	02120	11121	????3	?????	?????	2100?	?????	???
***Pliokogia* gen. nov.**	??1?0	?n021	01011	021?0	??121	?????	?????	?1???	?1?1?	?????	???