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SUPPLEMENTARY ONLINE MATERIAL FOR

A new pliosaurid from the Pliensbachian (Early Jurassic) of Normandy (Northern France)

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SOM_1. List of characters used in the phylogenetic analysis. Characters used in previous phylogenetic analyses of Plesiosauria are listed as 'C' after the author reference.

1: Skull length: 'short' (pre-orbital length – tip of the snout to anterior border of orbits – shorter than half of the total length of the skull) =0, 'elongated' (pre-orbital length equal to or greater than half of the total length of the skull) =1.

Citations: Rieppel (1994, C9); O'Keefe (2001, C6, C8); Kear (2005, C1); Druckenmiller and Russell (2008, C2); Smith and Dyke (2008, C3); Ketchum and Benson (2010, C2).

2: Dorsal midline ridge of the premaxillae: absent =0, present =1.

Citations: Druckenmiller and Russell (2008, C6); Smith and Dyke (2008, C5); Ketchum and Benson (2010, C11).

3: Relative size of temporal fenestrae and orbits: fenestrae equal to or shorter than orbits =0, fenestrae longer than orbits =1.

Citations: Bardet et al. (1999, C5); Druckenmiller and Russell (2008, C4); Großmann (2007, C4); Smith (2007, C33); Ketchum and Benson (2010, C1).

4: Constricted snout at the premaxilla-maxilla suture: absent =0, present =1.

Citations: O'Keefe (2001, C6, C9); Kear (2005, C1); Druckenmiller and Russell (2008, C10); Smith and Dyke (2008, C 10); Großmann (2007, C2); Ketchum and Benson (2010, C4).

5: Premaxilla-maxilla sutures run parallel anterior to the external nares: absent =0, present =1.

Citation: Smith and Dyke (2008, C9).

6: Position of the external nares: in the first half =0, retracted in the posterior half =1 of the preorbital region.

7: Dorsomedian foramen between premaxillae: absent =0, present =1.

Citations: O'Keefe (2001, C13); Druckenmiller and Russell (2008, C9); Smith and Dyke (2008, C7); Ketchum and Benson (2010, C9).

8: Premaxillae-external nares contact: contacts medial margin =0, diminutive contact on anterior margin =1.

Citations: O'Keefe (2001, C12); Druckenmiller and Russell (2008, C7); Smith and Dyke (2008, C8); Ketchum and Benson (2010, C8).

9: Prefrontals-external nares contact: absent =0, present =1.

Citations: O'Keefe (2001, C39); Druckenmiller and Russell (2008, C27); Smith and Dyke (2008, C16); Ketchum and Benson (2010, C25).

10: Frontal-external nare contact: absent =0, present =1.

Citations: Bardet et al. (1999, C9); O'Keefe (2001, C19); Smith and Dyke (2008, C15); Ketchum and Benson (2010, C18).

11: Posterior extension of the premaxillae: the premaxillae contact the anterior margin of the frontal or nasal =0, partially split the frontals along the dorsal midline =1, completely split the frontals and contact the parietal =2.

Citations: Bardet et al. (1999, C8); Carpenter (1999, C8); O'Keefe (2001, C11); Druckenmiller and Russell (2008, C5); Smith and Dyke (2008, C17); Ketchum and Benson (2010, C10).

12: Maxilla-squamosal contact: absent =0, present =1.

Citations: O'Keefe (2001, C41); Kear (2005, C12); Druckenmiller and Russell (2008, C17); Großmann (2007, C12, C13); Smith and Dyke (2008, C12).

13: Maxilla-orbit contact: present =0, absent =1.

Citations: O'Keefe (2001, C32); Druckenmiller and Russell (2008, C19).

14: Frontal-orbit margin contact: present =0, absent =1.

Citations: O'Keefe (2001, C40); Druckenmiller and Russell (2008, C26); Smith (2007, C18); Ketchum and Benson (2010, C19).

15: Parietal crest: absent = 0; present =1.

Citation: Ketchum and Benson (2010, C38).

16: Posterior extension of the parietal: the parietal extends posterior to the temporal fenestra =0, stop anterior to the posterior margin of the temporal fenestra =1, stop at the level of the posterior margin of the temporal fenestra =2.

17: Jugal-squamosal contact: absent =0, present =1.

Citations: O'Keefe (2001, C29); Druckenmiller and Russell (2008, C16); Ketchum and Benson (2010, C29).

18: Postfrontal shape: triangular =0, quadrangular =1.

Citations: Bardet et al. (1999, C7); Großmann (2007, C8); Ketchum & Benson (2010, C23).

19: Postorbital posterior extension: postorbital extends posterior to the jugal =0, until the jugal posterior margin =1, stop anterior to the posterior margin of the jugal =2.

20: Postfrontal-temporal fenestra contact: present =0, absent =1.

21: Pineal foramen lies posterior to =0, anterior to =1, at the level of =2 the anterior border of the temporal fenestra.

Citations: Storrs (1991, C28); Rieppel (1994, C15); O'Keefe (2001, C20); Druckenmiller and Russell (2008, C29); Großmann (2007, C5); Smith (2007, C27); Ketchum and Benson (2010, C35).

22: Squamosals united posterior to the parietal: absent =0, present =1.

Citations: O'Keefe (2001, C27); Druckenmiller and Russell (2008, C33); Ketchum and Benson (2010, C41).

23: Inter-squamosal suture along the dorsal midline: flat =0, bulbous =1.

Citations: O'Keefe (2001, C55); Druckenmiller and Russell (2008, C34); Smith and Dyke (2008, C30).

24: Premaxilla-internal naris contact: present =0, absent =1.

Citations: Rieppel (1994, C36); O'Keefe (2001, C81); Druckenmiller and Russell (2008, C39); Smith (2007, C35); Ketchum and Benson (2010, C49).

25: Maxilla-internal naris contact: reduced to the lateral border of the internal nares =0, extended to the anterior, lateral and posterior borders of the internal nares =1, absent =2.

Citations: Bardet et al. (1999, C11); Druckenmiller and Russell (2008, C40); Smith (2007, C35); Ketchum and Benson (2010, C50).

26: Palatine-internal naris contact: present =0, absent =1.

Citations: O'Keefe (2001, C79); Druckenmiller and Russell (2008, C41); Smith (2007, C36); Ketchum and Benson (2010, C51).

27: Relative positions of internal nares: overlaps the external nares =0, anterior to external nares =1.

Citations: Druckenmiller and Russell (2008, C46); Ketchum and Benson (2010, C57).

28: Palatines meet on the midline: absent =0, present =1.

Citations: O'Keefe (2001, C80); Druckenmiller and Russell (2008, C43); Smith (2007, C38); Ketchum and Benson (2010, C52).

29: Vomers partially separated by the pterygoids along midline: absent =0, present =1.

Citation: Ketchum and Benson (2010, C54).

30: Lateral palatine vacuities: absent =0, present =1.

Citations: O'Keefe (2001, C78); Druckenmiller and Russell (2008, C45); Smith (2007, C41); Ketchum and Benson (2010, C56).

31: Anterior interpterygoid vacuity: absent =0, present =1.

Citations: Storrs (1991, C11); Carpenter (1999, C6); Bardet et al. (1999, C13); O'Keefe (2001, C60); Rieppel et al. (2002, C125); Druckenmiller and Russell (2008, C49); Großmann (2007, C15); Smith (2007, C39); Ketchum and Benson (2010, C59).

32: Ectopterygoid boss: absent =0, present =1.

Citations: O'Keefe (2001, C84); Druckenmiller and Russell (2008, C47); Ketchum and Benson (2010, C58).

33: Contact between the pterygoids posterior to the anterior interpterygoid vacuity: absent =0, present =1.

Citations: O'Keefe (2001, C63); Ketchum and Benson (2010, C60).

34: Cultriform process of the parasphenoid: elongate exposure on palate surface =0, diminutive exposure =1.

Citations: O'Keefe (2001, C72); Großmann (2007, C18); Smith (2007, C47).

35: Posterior interpterygoid vacuities: absent =0, present =1.

Citations: O'Keefe (2001, C61); Druckenmiller and Russell (2008, C49); Ketchum and Benson (2010, C62).

36: Sharp keel on the parasphenoid: present =0, absent =1.

Citations: O'Keefe (2001, C71); Druckenmiller and Russell (2008, C55); Smith (2007, C48).

37: Posterior extension of the parasphenoid: reached the posterior half of the posterior interpterygoid vacuities =0, extend until the anterior half of the posterior interpterygoid vacuities only =1.

38: Shape of the posterior interpterygoid vacuities: round =0, elongate and splint-like =1.

Citation: Smith (2007, C42)

39: Orientation of posterior interpterygoid vacuities: long axes sub-parallel =0, long axes convergent = 1.

40: Pterygoids posterior to the posterior interpterygoid vacuities: do not meet =0, do meet =1.

Citations: Bardet et al. (1999, C12); Carpenter (1999, C3); O'Keefe (2001, C62), Druckenmiller and Russell (2008, C50), Großmann (2007, C19); Smith (2007, C44); Ketchum and Benson (2010, C63).

41: Ventrally projecting flange on the pterygoid: absent =0, present =1.

Citations: O'Keefe (2001, C69); Druckenmiller and Russell (2008, C51); Smith (2007, C45); Ketchum and Benson (2010, C64).

42: Element demarcating the anterior margin of the subtemporal fenestra: ectopterygoid and pterygoid =0, ectopterygoid only =1.

Citation: Druckenmiller and Russell (2008, C48).

43: Quadratic flange of pterygoid: contacting quadrate only =0; forming contact with both quadrate and squamosal =1.

Citations: O'Keefe (2001, C50); Kear (2005, C15); Druckenmiller and Russell (2008, C59).

44: Occipital condyle visible in dorsal view: present =0, absent =1.

Citation: Smith (2007, C50).

45: Occipital condyle constriction: present = 0, absent =1.

Citations: Brown (1981, C12); O'Keefe (2001, C43); Druckenmiller and Russell (2008, C69).

46: Bowed mandible (as defined by Druckenmiller and Russell, 2008): absent =0, present =1.

Citations: O'Keefe (2001, C86); Kear, (2005, C24); Druckenmiller and Russell (2008, C75); Smith (2007, C60); Ketchum and Benson (2010, C86).

47: Mandibular symphysis: short (length lower than distance between the tip of the snout to the ventral suture between maxilla and premaxilla) =0, elongated (length sub-equal to the distance between the tip of the snout to the ventral suture between maxilla and premaxilla) =1, very long (length upper than distance between the tip of the snout to the ventral suture between maxilla and premaxilla) =2.

Citations: O'Keefe (2001, C89); Druckenmiller and Russell (2008, C79).

48: Constriction behind mandibular symphysis: absent =0, present =1.

Citations: O'Keefe (2001, C89); Druckenmiller and Russell (2008, C78); Smith (2007, C56).

49: Ventral keel on mandibular symphysis: absent =0, present =1.

Citations: O'Keefe (2001, C88); Kear (2005, C26); Druckenmiller and Russell (2008, C80); Smith (2007, C57); Ketchum and Benson (2010, C92).

50: Splenials participation in the mandibular symphysis: do not take part =0, do take part =1.

Citations: Rieppel (1994, C41); O'Keefe (2001, C90); Kear (2005, C28); Druckenmiller and Russell (2008, C76); Smith (2007, C59); Ketchum and Benson (2010, C87).

51: Development of the coronoid eminence: low =0, high =1.

Citation: Druckenmiller and Russell (2008, C85).

52: Contributions to the coronoid eminence laterally: surangular mainly =0, dentary mainly =1.

53: Anterior extension of the angular laterally: at the level of the coronoid eminence =0, anterior to the coronoid eminence =1.

54: Jaw articulation in relation to tooth row: above or colinear with tooth row =0, lower than tooth row =1.

Citations: O'Keefe (2001, C98); Kear (2005, C36); Ketchum and Benson (2010, C94).

55: Number of pairs of premaxillary teeth: five =0, more than five =1.

Citations: Brown (1981, C7); Carpenter (1999, C11); Bardet et al. (1999, C15); O'Keefe (2001, C106); Druckenmiller and Russell (2008, C93); Großmann (2007, C23); Smith and Dyke (2008, C4); Ketchum and Benson (2010, C110).

56: Regularity in size of premaxillary dentition: homodont =0, heterodont =1.

Citations: Brown (1981, C8); Storrs (1991, C39); Rieppel (1994, C44); Carpenter (1999, C10); Bardet et al. (1999, C17); O'Keefe (2001, C100); Druckenmiller and Russell (2008, C89); Ketchum and Benson (2010, C105).

57: Regularity in size of maxillary dentition: homodont =0, heterodont =1.

Citations: Storrs (1991, C41); Rieppel (1994, C45); O'Keefe (2001, C102); Druckenmiller, and Russell (2008, C90); Ketchum and Benson (2010, C106).

58: Diastema between premaxilla and maxilla: absent =0, present =1.

Citations: O'Keefe (2001, C99); Druckenmiller and Russell (2008, C11); Smith (2007, C11); Ketchum and Benson (2010, C48).

59: Tooth ornamentation all around =0, lingually only =1, no ornamentation =2.

Citations: O'Keefe (2001, C105); Druckenmiller and Russell (2008, C91); Smith (2007, C53) Ketchum and Benson (2010, C108).

60: Proportion of the cervical centra: length > height or length = height =0, length < height =1.

Citations: Brown (1981, C15); Bardet et al. (1999, C20); O'Keefe (2001, C112); Druckenmiller and Russell (2008, C102); Großmann (2007, C28); Smith, (2007, C61); Ketchum and Benson (2010, C120).

61: Articular facets for the cervical centra: amphicoelous =0, gently convex or platycoelous =1.

Citations: Brown (1981, C17); Rieppel (1994, C49); Bardet et al. (1999, C21); Druckenmiller and Russell (2008, C106); Großmann (2007, C29); Ketchum and Benson (2010, C124).

62: Nutritive foramina in cervical vertebrae: absent =0, present =1.

Citations: Storrs (1991, C47); O'Keefe (2001, C118); Rieppel et al. (2002, C127); Druckenmiller and Russell (2008, C101); Smith (2007, C65); Ketchum and Benson (2010, C119)

63: Pair of deep squared depressions on ventral surface of cervical vertebrae enclosing nutritive foramina: absent =0, present =1.

Citations: Smith (2007, C64); Ketchum and Benson (2010, C123).

64: Ventral keel on cervical vertebrae: absent =0, present =1.

Citations: O'Keefe (2001, C114); Druckenmiller and Russell (2008, C105); Smith (2007, C67); Ketchum and Benson (2010, C123).

65: Rib head of cervical vertebrae: double headed =0, single headed =1.

Citations: Brown (1981, C21); O'Keefe (2001, C117); Druckenmiller and Russell (2008, C107); Smith (2007, C72); Ketchum and Benson (2010, C125).

66: Distinct anterior process of the anterior cervical ribs: present =0, absent =1.

Citations: Rieppel (1994, C56); O'Keefe (2001, C123); Druckenmiller and Russell (2008, C115); Smith and Dyke (2008, C73); Ketchum and Benson (2010, C134).

SOM_2. Character scores included in the phylogenetic analysis. Unknown state of character are given as “?”; Inapplicable characters are coded as “X”.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	
<i>Archaeonectrus rostratus</i>	1	1	1	1	1	1	1	0	1	?	2	?	0	0	1	2	1	1	?	0	2	1	1	?	?	?	?	?	?	?	?	?	?	?	
<i>Cyonectes neutricus</i>	?	1	?	1	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	1	1	0	1	?	0		
<i>Dalichorhynchops osborni</i>	1	0	1	0	1	1	0	1	1	1	2	1	0	0	1	2	1	1	0	0	1	1	1	1	2	0	1	0	0	0	1	0	0		
<i>Hautlosaurus longicauda</i>	1	1	1	1	1	1	?	0	?	?	?	?	?	?	1	2	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	
<i>Hautlosaurus tonisotomus</i>	1	0	?	0	1	1	0	0	0	1	1	?	?	0	1	2	?	?	?	?	?	1	1	?	?	0	1	0	1	?	1	?	1		
<i>Lioleurodon tarax</i>	1	0	1	1	1	1	0	1	1	0	2	0	1	1	1	2	1	1	0	0	2	1	1	1	1	1	1	1	1	1	0	0	1	X	
<i>Melyrosaurus victor</i>	0	?	?	1	1	1	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	1	1	1	1	0	1	1	1	1
<i>Nichollsaurus borealis</i>	0	1	1	0	0	1	0	1	?	0	2	1	0	0	1	2	1	?	?	0	2	1	1	1	1	0	1	?	0	0	1	0	1		
<i>Polonestes philarchus</i>	1	0	1	1	1	1	0	1	0	1	2	0	1	0	1	2	1	1	0	0	2	1	1	1	0	0	1	0	1	0	0	1	X		
<i>Pliosaurus brachypondylus</i>	1	0	1	1	0	1	0	0	0	1	2	0	1	1	1	2	1	1	1	0	2	1	1	1	0	?	1	?	?	1	0	?	0		
<i>Rhomaleosaurus cramptoni</i>	0	1	1	1	1	1	1	0	0	1	1	1	0	0	1	1	1	1	0	?	2	1	1	1	1	1	1	0	1	1	1	1	1		
<i>Serpianosaurus mitglenensis</i>	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	X	0	0	0	0	0	0	0	0	0	X	X	
<i>Simolestes vorax</i>	1	0	1	1	0	1	0	1	0	1	2	?	0	0	1	2	?	?	?	?	0	2	1	1	1	1	1	1	0	?	?	?	?	?	
<i>Simosaurus gallardoii</i>	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	X	0	0	0	0	0	0	0	0	0	0	0	X	
<i>Thalassiodraco hawaiiensis</i>	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	1	1	0	1	1	1	1	1	1	0	1	?	1	1	?	?	0	?	0	?
	3	3	3	3	3	3	4	4	4	4	4	4	4	4	4	4	4	4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
<i>Archaeonectrus rostratus</i>	?	?	?	?	?	?	?	?	?	?	?	?	?	?	2	?	1	1	?	?	?	?	?	?	?	?	1	0	?	1	1	1	0	0	
<i>Cyonectes neutricus</i>	0	1	0	0	0	1	1	1	?	?	?	?	?	0	2	1	1	1	1	1	0	0	0	1	1	0	?	0	1	1	0	0	0	?	
<i>Dalichorhynchops osborni</i>	1	1	1	0	0	0	1	0	1	0	1	0	0	2	0	0	1	1	0	1	0	0	0	0	0	0	?	1	?	1	1	0	?	1	
<i>Hautlosaurus longicauda</i>	?	1	1	0	0	?	?	?	?	?	1	0	0	2	?	1	?	?	?	?	1	0	1	0	0	1	?	0	?	?	1	1	0	?	
<i>Hautlosaurus tonisotomus</i>	0	1	1	1	1	1	0	0	?	?	?	?	0	0	2	0	0	1	?	?	?	?	0	?	?	?	?	0	1	?	1	0	0	?	
<i>Lioleurodon tarax</i>	0	1	0	0	1	1	1	1	0	1	1	1	0	2	1	?	1	0	1	0	1	0	1	0	1	1	1	0	1	1	1	0	0	?	
<i>Melyrosaurus victor</i>	1	1	0	0	0	0	1	0	1	?	?	?	0	1	0	1	1	1	1	1	1	0	0	?	?	?	?	1	?	?	1	1	1	?	0
<i>Nichollsaurus borealis</i>	1	1	0	0	1	0	?	?	?	?	1	?	?	0	1	0	0	?	?	?	1	1	?	0	0	1	1	0	1	?	?	1	0	?	
<i>Polonestes philarchus</i>	0	1	0	0	1	1	1	1	0	1	1	1	0	2	1	0	1	0	0	0	0	1	1	1	1	0	1	1	1	0	1	0	?	?	
<i>Pliosaurus brachypondylus</i>	0	1	0	?	0	1	1	1	0	0	1	1	0	2	?	?	?	1	0	0	1	0	0	1	0	0	1	1	1	1	1	0	0	0	1
<i>Rhomaleosaurus cramptoni</i>	1	1	0	0	0	1	1	0	0	0	1	0	1	0	1	1	1	1	1	1	0	0	1	1	1	1	1	0	1	1	1	0	0	0	
<i>Serpianosaurus mitglenensis</i>	X	0	X	X	X	X	X	0	X	1	0	?	0	0	0	0	0	?	?	?	?	0	1	0	0	0	0	0	0	0	0	0	X	0	0
<i>Simolestes vorax</i>	?	1	?	?	1	0	1	1	?	1	1	1	0	0	1	1	1	1	1	1	0	1	0	1	1	1	0	1	1	1	?	0	0	0	
<i>Simosaurus gallardoii</i>	X	0	X	X	X	X	0	0	0	0	0	0	1	0	0	0	0	?	?	?	?	0	0	0	0	0	0	0	0	0	1	0	X	0	0
<i>Thalassiodraco hawaiiensis</i>	?	1	0	1	0	1	0	0	0	0	0	0	0	2	1	0	?	1	?	?	1	0	0	?	?	0	0	0	0	0	1	0	0	0	0