

PART 1: RECONSTRUCTION AND ADDITIONAL PHOTOS OF HOLOTYPE.



Figure S1. Reconstruction of the head and neck of *Umoonasaurus demoscyllus* showing hypothesised soft tissues associated with the crests of an adult (top) and juvenile (bottom).

Artwork by Josh Lee (Adelaide).



Figure S2. Teeth from holotype skull of *Umoonasaurus demoscyllus* (AM F99374) in lateral view.

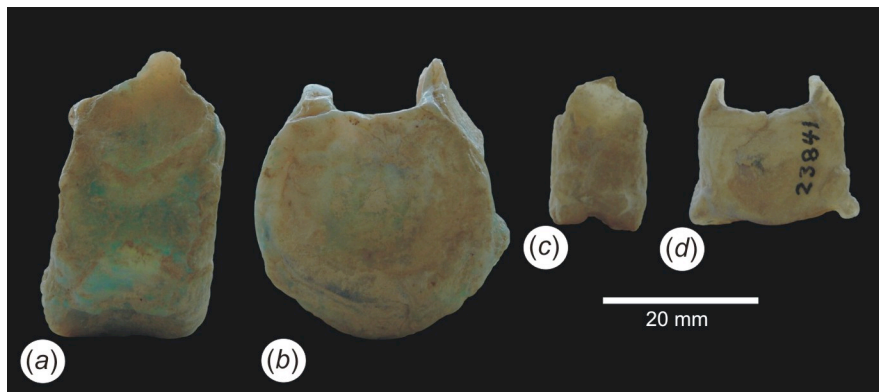


Figure S3. Anterior cervical vertebrae of *Umoonasaurus demoscyllus* (referred specimen SAM P23841) in (a,c) lateral, and (b,d) anterior views.



Figure S4. Posterior cervical vertebrae of *Umoonasaurus demoscyllus* holotype (AM F99374) in dorsal view.

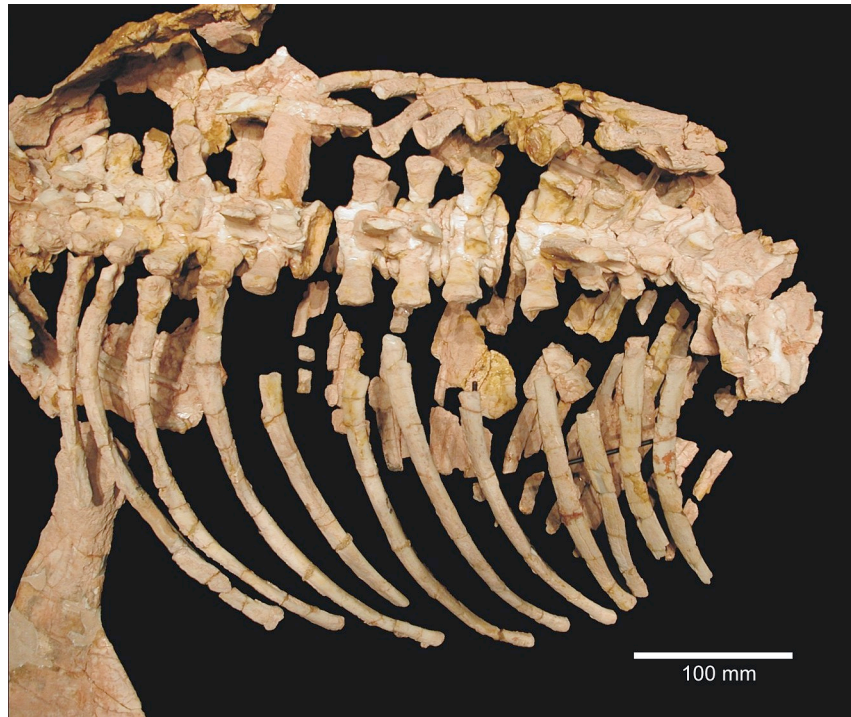


Figure S5. Anterior torso region of *Umoonasaurus demoscyllus* holotype (AM F99374) in dorsal view.

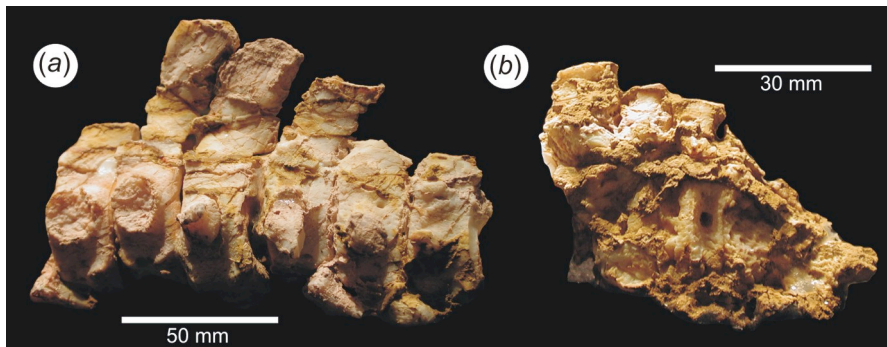


Figure S6. Posterior caudal vertebrae (a) and close-up of 'pygostyle-like' tail tip (b) of *Umoonasaurus demoscyllus* holotype (AM F99374) in lateral view.

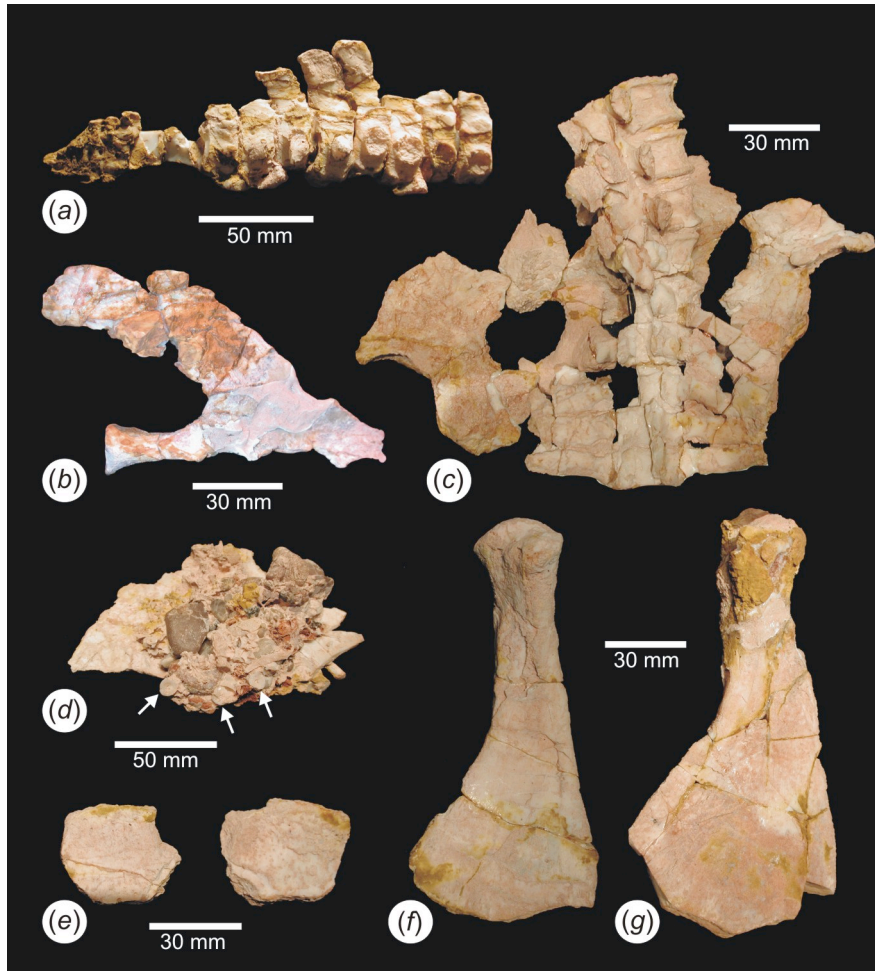


Figure S7. Holotype postcranium of *Umoonasaurus demoscyllus* (AM F99374). (a) Distal caudal vertebral series with terminal 'pygostyle-like' tail tip; (b) scapula in lateral view; (c) pelvis and sacral region in dorsal view; (d) gastric mass with small teleost vertebrae (arrowed); (e) epipodials; (f) humerus and (g) femur in dorsal view.

PART 2: PHYLOGENETIC ANALYSIS – METHODS

Umoonasaurus was added to the most comprehensive published phylogenetic data set of Plesiosauria (O’Keefe 2004). Character matrix followed O’Keefe (2004) (see below); analyses returned almost identical trees whether with all multistate characters were left unordered, or were ordered where possible into morphoclines (see Typeset command in Nexus file below). Maximum parsimony trees, bootstrap frequencies (1000 replicates), and Bremer support were calculated using heuristic searches in PAUP (Swofford 2002) with 200 random-addition replicates. Analyses with characters ordered yielded five most parsimonious trees (Length = 462; Consistency Index = 0.44, Retention Index = 0.71); relationships within the relevant clade (Pliosauroidae) are fully resolved and identical across all five trees, and are shown in figure. 3.

PART 3: CHARACTER LIST AND DATA MATRIX IN NEXUS FORMAT

#NEXUS

BEGIN DATA;

DIMENSIONS NTAX=36 NCHAR=170;

FORMAT SYMBOLS= " 0 1 2 3" MISSING=? GAP=x ;

CHARSTATELABELS

1 Rel_Skull_Length, 2 Rel_Neck_Length, 3 'Rel. Isch/Pub l.', 4 'Rel. Scap/Corc l.', 5 'Rel. Hum/Fem l.', 6 'Pre/Post orb s. l.', 7 fin_AR, 8 Elongate_Rostrum, 9 Constricted_Snout, 10 Temp_Emarg, 11 'Prem/Par contact', 12 'No Prmx/naris con.', 13 Dor_Medial_Foram., 14 'Frontals Pair/Fuse', 15 'Par. Pair/Fuse', 16 Front__p.lat_proc., 17 Postorb_Bar, 18 'Front/Temp. Fossa', 19 F_cont_ext_naris, 20 P_Foramen_Loc., 21 P_For_Ant_Bor., 22 Prefrontal, 23 Acc_Orb_Fenes., 24 'F/Prf Orbital Proc.', 25 Par_Skull_Table, 26 Sq_lat_process, 27 Sq_Dors_Proc., 28 'Sq/PO Contact', 29 'J/Sq Contact', 30 Jugal_Ant_Extent, 31 J_Cont_Orb_Mar., 32 'j/prf suture', 33 J_Cheek_Bar, 34 Quadratojugals, 35 Nasals, 36 ext_nar_post_nasal, 37 grv_ant_ex_naris, 38 Nas_Bord_Ext_Nar., 39 PF_Bord_Ext_Nar., 40 PF_&_POF_Exclude_F., 41 'Max/Sq Contact', 42 'Exoc./Occ. Condyle', 43 Occ_Cond_Morph., 44 Paraocc_Proc., 45 'Sq Notch, P. Proc.', 46 P_Proc_Morph., 47 P_Proc_Artic., 48 ParaProc_Vent_Ext., 49 'P. Proc/Pt Fl Cont.', 50 Q_Fl_Pt_Artic., 51 Quad_Proc_for_Sq, 52 Epi_Dorsal_Wing, 53 'Epi/Par Contact', 54 Dished_quadrate, 55 sq_bulb, 56 Supraocc_Morph., 57 Suprocc_Depth, 58 Q_Pt_Fl_Shape, 59 Squared_Pt_Lapet, 60 Ant_InterPt_Vac., 61 Post_InterPt_Vac., 62 Pt_Meet_Post_PIPV, 63 Pt_Meet_Ant_PIPV, 64 basi_exp_post_pt., 65 Ecto_reaches_PPIV, 66 'Ecto/po bar contact', 67 Dished_ptery, 68 'pst. ptery/para con', 69 Lat_Flanges_PIPV, 70 Parasphen_Morph., 71 Parasphenoid_keel, 72 Psph_exp_ant_PIPV, 73 basi_plate, 74 'Para/Basi contact', 75 'Pt/Basi Artic.', 76 Basi_Tubers_Red., 77 Pal_Jugal_Exposure, 78 Lat_Palatal_Fen., 79 'Pal/Int. Naris', 80 Pals_Meet_at_Mid., 81 'Premax/Int. Naris', 82 'Sub-orb Fenestra', 83 V_post_int_nares, 84 'Ecto Boss/Pt Flange', 85 Ecto_Boss_Contact, 86 Bowed_maxilla, 87 open_Mkl_canal, 88 Man_Ventral_Ridge, 89 Mand_Symph., 90 Spl_in_Symph, 91 Lin_Mand_Fen., 92 'Dent/Ang/Sang Sut.', 93 Coronoid, 94 long_ling_cor_proc., 95 Cor_exp_lat_man., 96 Prearticular, 97 'Prart gr./Ang Fac.', 98 'Jaw Art./Tooth R.', 99 Diastema, 100 1st Tooth_Aft_Dias., 101 'Premax/Dent Fangs', 102 Canif_Max_Teeth, 103 Tooth_Form, 104 'Teeth w/plane surf.', 105 Tooth_ornament, 106 #Premax_Teeth,

Hauffiosaurus

1021010210????????????????????1??01?????0?1?????00??1???200111010002022x0?00000
101110?0310?????00110000?21???000?000?02?0????11?0?0??00?11001111?11?110000111
120211000???

Peloneustes

1211111210110xx000110000201010010110000000110000110011110200111010002022x00
010001111200031010100001100100110002201000102001001112000?0001100111101111
100001101210110000?0

Pliosaurus

12???1?220110xx000?100002?11100101110??00011?1??1??0011??20?11?0??0?3???x??0??
1?1?11?0002101011000110011111????2?0000112?0?00111?0??????????0??111011?1100011
10121??1?00???

Liopleurodon

1211111220110xx0001100002010100101100000001101001100111?0201111000003022x0?
00111111110102101010000110010101???22000001121010011120?0?0??11001111111111
00001101210110000?0

Brachauchenius

12???1?210110xx00001000020111001011100100??1?1?0???1111??100111000003022x0?0?
0?1?111000?21?1??0?001?0010??????22?001112?0?0111120????????????????????11??01??
0??1?11?00???

Kronosaurus

1221?1?2????????????????????01?1??1?1?????????111020100??1??20011?0??02??x0?00???
??1??03?????????????01?????1?22????11?2?0?00?1120????0?011?0??11111??1?00??012
1??1???????

Muraenosaurus

21012010000000x000011?0021101200???x0??1?011?0?0?????10?1102100x0100010110000
0100010x01000000010100x000000010111000?11021111111121?001112110011110111111
100110121111001?00

Cryptoclidus

20012010000000x00011100021101200112x0x110111?0100?0??1011102100x010001021000
0000?000x01000000010100x000001010100100011020111111121?00011211001111011111
1000110121111001000

Tricleidus

20?10210000000x??0?10000211?1200112x0x?100011011000??10??102100x010101021101
??00?00x010000000?0110x000000?1?100100011021011111120000210211001111011?111
100110121211?01000

Kimmerosaurus

????2?3000??0x0?0?11?00211?1??11?x??1?11110000?0??1011102100x0?010?0211?(01)
??0??0x??000?0101?11?0020?321??2?0001102?11?1??1?0?????????????????????????
?????????10?0

Morturneria

????21300?????????????????111????1?x??x?00?110?1????1??1??1?0x??0??1?2?101??0?1
????010?????0??010x0020?22002?2??011102?0????11?????????????????????11?????????1?
?1??1??0

Edgarosaurus

02???011000100x00011000021101200012x0x11200111????0??0?11021100011101?21????
????0?0x0x021000?10110x0110?1011222?100110?0?0??11?????????????????????1111001
10121?111?0?0

Polycotylus

?2110?1????????????????????????????x????????????????????????0?????????11???????????

??x0??0?001011????10???112220?00110110?1111120x002011111??1110111111100110121
311?01???

Dolichorhynchops

1211011200100xx000?1000121101200012x0x1120011011100001011102120001110102110
100001100x0x032000010110x0000?00112221?00110210?1111120x0020111110111101111
110001101213111?1000

Trinacromerum

1211111200100xx0?0?1?00121101200012x0x112?01?011?0?0010??11212000?11010211?1
00??1?0x0?032?0?010110x0000?01112221?00110210?1111120x002011111011110111111
00011012131110100?

Microcleidus

210100000000?0?1?11?00211?1?0?012x0x?11?????????????0??1010100?0000?2100??0
??0?0x01010?0?00?010x0?000?0?0?1110110102?100111121?0??1?2?10011111111111000
111120111000???

Brancaesaurus

21210000000001x001?1100021101200012x0x111001?0?0?????00111?01??0??00?0??10?00
?001?1??0?0??????????0x0000?0??1011??00110210?001112110001?211011101111111??00
1?0121?11?000?0

Alzadasaurus

21202000000000x011?1100021111200012x0x1110011020111??00111101100010000121?00
00001010x11010000?00010x0100?00??311?01110210?0111121?00010(01)1101110101111
100101101210111?00?0

Libonectes

21?0?00000200xx?1??1100?21?11200012x0x11?00110201111?00111101200010000121?00
0?001010x?1010100000010x0100?001?0311?11110211?01?11?1?00020211?11????????????
?????????????0000

Styxosaurus

21??0000020?x?010??00021111200012x0x111??1??????1100011??????0??0?????????0??
??????1?01??0??0??10x0100?0??31??11110211?01?1121?????????????????????1?0???????
??????00??

Rhomaleo. zetland.

02??01?110101x?000110000201?100101101000??11?1111010011??1121?1?0?0000?2x0???
?????????10121??0?00001?10100?????2201000101?0?0?111?0?????????????????1????0100001
11120??1??0???

Rhomaleo. megaceph.

00010001100100x100110000201?100?0110100?1?1111?010100?1??112111100000012x000
?10011?11101211?????001?101000????02?1000101?000011120?0??????1?0?111?11101000
0111120??1?001??

Rhomaleo. victor

100120011??0?????????00?????????????????????0?????????????????11211110?00??11x??0?1101
001??01211????000??1010??????0?0?00??0??00??12??0?00111001?11111?0100001111
20311000???

Simolestes

121110111010?xx0??10000201?10010110?0??011?1001??0011?01??111?000000?2x0?0?
1?????1??0121?1010000??101000??022?00001011010?111?0?0??0?011000111111111100
01101200?1??0???

Leptocleidus

?2?1?01110101xx000?100002010100?01????0?10?1????10?0011??112111100000012x0001
??0110101??2?01010000111010000??220100110200?00111?0000000111001????????1100?
01????????1??00??

Macroplata

```
1011101110?010??0011?0002?1?100?0?101?00?011?1?0??00?1101??111?00000002x0?0??
??????1?121??????01??01001?0100201000101?0?00111?0?0000011100011111101?0001
11120??1?00???
```

Plesiopterys

```
210100001?0??00100?100001?10?????1????11?011?0000?0??1010101101x000000020000?
0001??0x0?1000?????00??000000????10??00010?0000011101????00?1100?111?111010000
111120011000111
```

Eurycleidus

```
0?0??0?1100?000100?1000010??1??01?0?01?011100??????11?0??101x?????0200?0??
??????01121??00000011?000????????????????????????????????????1110111?1?????????
??????10
```

Umoonasaurus

```
2??110?00?100xx????10??2?1?????????0??011?0?0?????11??1121110??100?2??0?0??0
1?01?????0??????11110010?????2????1??100???11121??????11?0??11?1??1100001??12
10?1000???
```

;

END;

BEGIN ASSUMPTIONS;

```
USERTYPE '1-0-2' (STEPMATRIX) = 4
```

```
0 1 2 3
```

```
[0] . 1 1 2
```

```
[1] 1 . 2 3
```

```
[2] 1 2 . 1
```

```
[3] 2 3 1 .
```

;

```
USERTYPE '0-2-1' (STEPMATRIX) = 3
```

```
0 1 2
```

```
[0] . 2 1
```

```
[1] 2 . 1
```

```
[2] 1 1 .
```

;

```
USERTYPE '2-0-1-3' (STEPMATRIX) = 4
```

```
0 1 2 3
```

```
[0] . 1 1 2
```

```
[1] 1 . 2 1
```

```
[2] 1 2 . 3
```

```
[3] 2 1 3 .
```

;

```
[USERTYPE rostrum (CSTREE) = ((2)1,3)0;]
```

```
[O'Keefe's ordering of char 8, not employed here - treated as unordered]
```

```
OPTIONS DEFTYPE=unord PolyTcount=MINSTEPS ;
```

```
TYPESET * OrderedMorphocline = unord: 4 7-8 10-14 16-24 26-29 31-34 36-40 42-
46 48 50-59 61 63-68 70 72-89 91-104 108-110 113-119 121-132 136-159 161-170, ord: 9 15
25 30 35 41 49 60 62 69 90 105-107 120 133 135 160, '1-0-2': 1-3 5-6 47 112, '0-2-1': 71
134, '2-0-1-3': 111;
```

```
CHARSET morphometric = 1-7 112 ;
```

```
TAXSET missing>50% = Styxosaurus kimmerosaurus morturneria polycotylus
eurycleidus kronosaurus;
```

TAXSET missing>45% = Styxosaurus kimmerosaurus morturneria polycotylus eurycleidus kronosaurus Cymatosaurus Rhomaleo._victor;

TAXSET missing>35% = Styxosaurus kimmerosaurus morturneria polycotylus eurycleidus kronosaurus Cymatosaurus Rhomaleo._victor Brachauchenius Hauffiosaurus Rhomaleo._zetland.;

END;

BEGIN paup;

END;

BEGIN TREES;

TRANSLATE

- 1 Simosaurus,
- 2 Cymatosaurus,
- 3 Pistosauridae,
- 4 Plesiopterys,
- 5 Plesiosaurus,
- 6 Microcleidus,
- 7 Brachauchenius,
- 8 Alzadasaurus,
- 9 Libonectes,
- 10 Styxosaurus,
- 11 Muraenosaurus,
- 12 Cryptoclidus,
- 13 Tricleidus,
- 14 Kimmerosaurus,
- 15 Morturneria,
- 16 Edgarosaurus,
- 17 Polycotylus,
- 18 Dolichorhynchops,
- 19 Trinacromerum,
- 20 Thalassiodracon,
- 21 Eurycleidus,
- 22 Attenborosaurus,
- 23 Yorkshirelongirostris,
- 24 Hauffiosaurus,

- 25 Kronosaurus,
- 26 Peloneustes,
- 27 Liopleurodon,
- 28 Pliosaurus,
- 29 Brancasaurus,
- 30 Umoonasaurus,
- 31 Rhomaleo._megaceph.,
- 32 Rhomaleo._victor,
- 33 Macroplata,
- 34 Rhomaleo._zetland.,
- 35 Simolestes,
- 36 Leptocleidus

;

tree MPT_1 =

```
(1,(2,(3,((4,(5,((6,((8,(9,10)),29)),((11,12),(13,((14,15),((16,17),(18,19))))))),((((((((((7,28),27),26),25),24),23),(30,((31,32),(33,(34,(35,36)))))),22),21),20))))));
```

tree MPT_2 =

```
(1,(2,(3,((4,(5,((6,((8,(9,10)),29)),((11,12),(13,((14,15),((16,17),(18,19))))))),20),((((((((((7,28),27),26),25),24),23),(30,((31,32),(33,(34,(35,36)))))),22),21))))));
```

tree MPT_3 =

```
(1,(2,(3,((4,((((((((((7,28),27),26),25),24),23),(30,((31,32),(33,(34,(35,36)))))),22),21),20)),(5,((6,((8,(9,10)),29)),((11,12),(13,((14,15),((16,17),(18,19))))))))));
```

tree MPT_4 =

```
(1,(2,(3,((4,(5,((6,((8,(9,10)),29)),((11,12),((13,((16,17),(18,19)),(14,15)))))),((((((((((7,28),27),26),25),24),23),(30,((31,32),(33,(34,(35,36)))))),22),21),20))))));
```

tree MPT_5 =

```
(1,(2,(3,((4,(5,((6,((8,(9,10)),29)),((11,12),((13,((16,17),(18,19)),(14,15)))))),20),((((((((((7,28),27),26),25),24),23),(30,((31,32),(33,(34,(35,36)))))),22),21))))));
```

[constraint tree - Umoonasaurs and Leptocleidus clade]

[TREE 'Umoona-Leptoc' =

```
(1,17,10,2,31,14,(36,30),35,9,7,4,29,16,33,21,27,3,25,11,34,23,8,22,19,15,18,6,28,24,26,20,13,12,32,5);]
```

END;