

Appendix 1. List of valid plesiosaur species with information on authors and date of publication.

Date	Original paper	Renamer	Species	Age
1824	De la Beche and Conybeare 1824		<i>Plesiosaurus dolichodeirus</i>	Sinemurian
1876	Blake in Tate and Blake 1876		<i>Plesiosaurus' longirostris</i>	Toarcian
1837	Buckland in Conybeare 1837		<i>Plesiosaurus' macrocephalus</i>	Sinemurian
1841	Owen 1841		<i>Pliosaurus brachydeirus</i>	Kimmeridgian
2004	Noe et al 2004		<i>Pliosaurus portentificus</i>	Kimmeridgian
1841	Owen 1841		<i>Pliosaurus brachyspondylus</i>	Kimmeridgian
1948	(Novozhilov 1948)	Tarlo 1960	<i>Pliosaurus irgisensis</i>	Tithonian
1871	(Phillips 1871)	Noe et al. 2004	<i>Pliosaurus macromerus</i>	Callovian-Tithonian
1960	Tarlo 1960		<i>Pliosaurus andrewsi</i>	Callovian
1841	Owen 1841		<i>Polyptychodon interruptus</i>	Turonian-Santonian
1868	Cope 1868,		<i>Elasmosaurus platyrurus</i>	Campanian
1869	Cope 1869		<i>Polycotylus latipinnis</i>	Santonian
1948	(Novozhilov 1948)	Halstead 1971	<i>Liopleurodon rossicus</i>	Tithonian
1869	(Seeley 1869)	Tarlo 1960	<i>Liopleurodon pachydeirus</i>	Callovian
1873	Sauvage 1873		<i>Liopleurodon ferox</i>	Callovian
1874	Hector 1874		<i>Mausaurus haasti</i>	Campanian
1865	(Owen 1865)	Seeley 1874	<i>Eretmosaurus rugosus</i>	Sinemurian
1874	Seeley 1874		<i>Muraenosaurus leedsi</i>	Callovian
1892	(Seeley 1892)	Brown 1981	<i>Muraenosaurus beloclis</i>	Callovian
1863	(Carte and Bailey 1863)	Seeley 1874	<i>Rhomaleosaurus cramptoni</i>	Toarcian
1846	(Stutchbury 1846)	Andrews 1922	<i>Rhomaleosaurus megacephalus</i>	Hettangian
1910	(Fraas 1910)	Tarlo 1960	<i>Rhomaleosaurus victor</i>	Toarcian
1840	(Owen 1840)	Seeley 1874	<i>Colymbosaurus trochanterius</i>	Kimmeridgian-Tithonian
1881	(Sollas 1881)	Bakker 1993	<i>Attenborosaurus conybeari</i>	Sinemurian
1888	Cragin 1888		<i>Trinacromerum bentonianum</i>	Turonian
1935	Russell 1935		<i>Trinacromerum kirki</i>	Turonian
1869	(Seeley 1869)	Lydekker 1889	<i>Peloneustes philarchus</i>	Callovian
1871	Phillip(s) 1871)	Seeley 1892	<i>Cryptoclidus eurymerus</i>	Callovian
1889	(Lydekker 1889)	Bogolubov, 1909	<i>Cryptoclidus richardsoni</i>	Callovian
1898	Knight 1898		<i>Megalneusaurus rex</i>	Kimmeridgian-Portlandian
1902	Williston 1902		<i>Dolychorhynchops osborni</i>	Campanian
2005	Sato 2005		<i>Dolychorhynchops herschelensis</i>	Campanian-Maastrichtian
1903	Williston 1903		<i>Brachauchenius lucasi</i>	Cenomanian-Turonian
1994	Godefroit 1994		<i>Simolestes keileni</i>	Bajocian
1877	Lydekker 1877	Bardet et al. 1991	<i>Simolestes indicus</i>	Tithonian
1909	Andrews 1909		<i>Simolestes vorax</i>	Callovian
1909	Andrews 1909		<i>Tricleidus seeleyi</i>	Callovian
1865	(Owen, 1865)	Watson 1909	<i>Microcleidus homalospondylus</i>	Toarcian
1865	Seeley, 1865?	Watson 1909	<i>Microcleidus macropterus</i>	Toarcian
1909	Watson, 1909		<i>Sthenarasaurus dawkins</i>	Toarcian
1913	Brown 1913		<i>Leurospondylus' ultimus</i>	Maastrichtian
1914	Wegner 1914		<i>Brancaosaurus brancai</i>	Berriasian
1840	(Owen 1840)	Andrews 1922	<i>Eurycleidus arcuatus</i>	Hettangian
1911	(Andrews 1911)	Cruickshank 1997	<i>Leptocleidus capensis</i>	Valanginian
1922	Andrews 1922		<i>Leptocleidus superstes</i>	Barremian
1997	Cruickshank and Long, 1997		<i>Leptocleidus clemai</i>	Hauterivian-Barremian
1924	Longman 1924		<i>Kronosaurus queenslandicus</i>	Aptian-Albian
1992	Hampe, 1992		<i>Kronosaurus boyacensis</i>	Aptian-Albian
1930	Swinton 1930		<i>Macroplata tenuiceps</i>	Hettangian
1895	(Dames 1895)	White 1940	<i>Seeleysaurus guilelmiimperatoris</i>	Toarcian
1941	Cabrera 1941		<i>Aristonectes parvidens</i>	Maastrichtian
1943	Welles 1943		<i>Aphrosaurus furlongi</i>	Maastrichtian
1890	(Williston 1890)	Welles 1943	<i>Styxosaurus snowii</i>	Santonian-Campanian
1890	Welles 1943		<i>Morenosaurus stocki</i>	Maastrichtian
1943	Welles 1943		<i>Thalassomedon haningtoni</i>	Cenomanian
1949	(Welles 1949)	Carpenter 1997	<i>Libonectes morgani</i>	Turonian
2006	Buchy 2006		<i>Libonectes atlasense</i>	Turonian
1871	(Cope 1871)	Welles 1943	<i>Hydralmosaurus serpentinus</i>	Santonian-Campanian
1943	Welles 1943		<i>Fresnosaurus drescheri</i>	Maastrichtian
1943	Welles 1943		<i>Hydrotherosaurus alexandrae</i>	Maastrichtian
1865	(Owen 1865)	Novozhilov 1964	<i>Archaeonectrus rostratus</i>	Sinemurian
1976	(Ochev 1976)	Ochev 1977	<i>Georgiasaurus penzensis</i>	Santonian
1980	Dong 1980		<i>Bishanopliosaurus youngi</i>	Toarcian
1981	Brown 1981		<i>Kimmerosaurus langhami</i>	Kimmeridgian

1982	Delair 1982		<i>Bathyspondylus swindoniensis</i>	Kimmeridgian
1985	Zhang 1985		<i>Yuzhoupliosaurus chengjiangensis</i>	Bathonian
1986	Wiffen and Moislely 1986		<i>Tuarangisaurus keysei</i>	Campanian-Maastrichtian
1996	Carpenter 1996		<i>Plesiopleurodon wellsi</i>	Cenomanian
1996	Cruikshank et al. 1996		<i>Pachycostasaurus dawni</i>	Calloviaian
1840	(Owen 1840)	Storrs and Taylor 1996	<i>Thalassiodracon hawkinsii</i>	Hettangian
1997	Gasparini 1997		<i>Maresaurus coccai</i>	Bajocian
1990	(Sciau et al. 1990)	Bardet et al. 1999	<i>Occitanosaurus tournemirensis</i>	Toarcian
1962	(Welles, 1962)	Carpenter 1999	<i>Callawayasaurus colombiensis</i>	Aptian
2001	O,Keefe 2001		<i>Hauffiosaurus zanoni</i>	Toarcian
2002	Cruikshank and Fordyce 2002		<i>Kaiwhekea katiki</i>	Maastrichtian
2002	Druckenmiller 2002		<i>Edgarosaurus muddi</i>	Albian
1949	(de la Torre and Rojas 1949)	Gasparini et al. 2002	<i>Vinielasaurus caroli</i>	Calloviaian
2003	Bardet et al. 2003		<i>Thililua longicollis</i>	Maastrichtian
2003	Sato 2003		<i>Terminonator ponteixensis</i>	Campanian
2006	Kear 2006		<i>Umoonasaurus demoscyllus</i>	Aptian-Albian
2006	Kear 2006		<i>Opallionectes andamookaensis</i>	Aptian-Albian
2005	(Sachs 2005)	Kear 2006	<i>Eromangasaurus australis</i>	Albian
1893	Marsh 1893		<i>Pantosaurus striatus</i>	Oxfordian
1900	(Knight 1900)	O'Keefe and Wahl 2003	<i>Tatenectes laramiensis</i>	Oxfordian
1990	Gasparini and Spalleti, 1990		<i>Sulcusuchus erraini</i>	Maastrichtian
1923	(Huene 1923)	Grossman 2007	<i>Hydrorion brachypterygius</i>	Toarcian
1942	Young 1942		<i>Sinopliosaurus weiyuanensis</i>	Kimmeridgian?
2006	Sato et al 2006		<i>Futabasaurus suzukii</i>	Santonian
2005	Buchy et al. 2005		<i>Manemergus anguirostris</i>	Maastrichtian
2007	Albright et al. 2007		<i>Eopolycotylus rankini</i>	Turonian
2007	Albright et al. 2007		<i>Palmula quadratus</i>	Turonian

Appendix 2. Additional material

The following list outlines additional fossil material adopted in the cladistic analysis and/or the morphometric analysis, but not figured or described herein. The list begins with specimens of uncertain taxonomic affinity (1A) and continues with a taxon list (1B). The taxon list includes the type and referred material employed in the analyses (the lists of referred material are therefore not exhaustive), and data on the type locality and horizon. Although not figured or described in this thesis, some of this material was observed first hand (observed material is indicated by the following symbol preceding the specimen number: ***), otherwise the taxa were coded from the literature, as listed in the 'remarks' section. The taxa in Appendix 1B are listed in the order that they appear in the cladograms resulting from the cladistic analysis (Figure 5.7).

Appendix 1A - Additional specimens of uncertain taxonomic affinity

OUM J.2858 '*Eurycleidus*'

Cruickshank (1994a) referred OUM J.28585, a specimen from Lyme Regis, to *Eurycleidus arcuatus*. The specimen consists of a partial skull including the mandible and some postcranial elements (from the pelvic girdle). However, this specimen may represent a new taxon in itself (O'Keefe 2004b). To test affinities of OUM J.28585, it is treated as a separate OTU in the current cladistic analysis, albeit coded from the literature.

HALB 'Uncatalogued'

This specimen from the Toarcian of Kanonenberg, northern Germany, was described by Brandes (1914) and referred to *Thaumatosauros* aff. *megacephalo* (= *Rhomaleosaurus megacephalus*). However, Grossman (2007, p. 557-558) noted that this specimen "resembles *Rhomaleosaurus victor* more than *R. megacephalus* and it is probably synonymous with the German taxon [*R. victor*]". The specimen was included in the morphometric analysis based on measurements given by Brandes (1914).

Appendix 1B - Additional taxa

Cymatosaurus Fritsch, 1894

Type material. IGWH uncatalogued, skull.

Type locality. Halle-Nietleben, Saxony-Anhalt, Germany.

Type horizon. *Myophoria* beds, Upper Röt Formation (*Beneckeia buchi* and *Dadocrinus* assemblage zone), Upper Buntsandstein (Lower Anisian, Middle Triassic).

Remarks. A review of *Cymatosaurus* is presented by Rieppel (2000).

***Pistosaurus longaevus* Meyer, 1839**

Type material. Uncatalogued, Oberfränkisches Erdgeschichtliches Museum, Bayreuth, skull.

Type locality. Lainecker Hohenzug, east of Bayreuth, southern Germany.

Type horizon. Lower Meissner Formation, Upper Muschelkalk (*atavus* to *postspinus* zones), (Upper Anisian, Middle Triassic).

Referred material. SMF R 4041, postcranial skeleton.

Remarks. Some authors have considered *Pistosaurus* as a member of the Plesiosauria (e.g. White, 1940, p. 459). Rieppel (2000) presents a concise summary of the unusual history of this genus. A cast of the holotype skull was investigated first hand (SMNS 'uncatalogued') ***

***Augustasaurus hagdorni* Sander, Rieppel and Bucher, 1997**

Type material: Holotype: FMNH PR 1974, complete skull and mandible, post-cranial skeleton consisting of posterior neck vertebrae, pectoral girdle, majority of forelimbs, dorsal vertebrae and associated fragmentary ribs and gastralia.

Type locality: Pershing County, Nevada, USA.

Type horizon: Fossil Hill Member, Farvet Formation, Star Peak Group, *Rotelliformis* Zone, Late Anisian, Middle Triassic.

Remarks: The postcranium of *A. hagdorni* is described by Sander *et al.* (1997) and the cranium is described by Rieppel *et al.* (2002). This taxon has important implications because it is only the second non-plesiosaurian sauropterygian to be discovered in the New World; *Corosaurus alcovensis* was the first (Storrs, 1991).

***Yunguisaurus liae* Cheng, Sato, Wu and Li, 2006**

Type material: NMNS 004529/F003862, almost complete articulated specimen missing the distal portion of the tail.

Type Locality: Near Huangnihe River, Chajiang, 10km northwest of Xingyi, Guizhu.

Type Horizon: Falang Formation, Carnian (early Late Triassic).

Remarks: The skull and limbs of *Yunguisaurus* were described by Cheng *et al.* (2006) but “the postcranial skeleton waits for further preparation and subsequent full description” (p.501). Consequently, some characters, presumably preserved but not described or figured for this taxon, could not be coded in this cladistic analysis; this is taken into account in the discussion (Chapter 6).

***Plesiosaurus dolichodeirus* Conybeare, 1824**

Type material. BMNH 22656, complete skeleton. ***

Type locality. Lyme Regis, Dorset, England.

Type horizon. Black Ven Marl Formation, Lower Lias Group, (*Echioceras raricostatum* Zone), (Uppermost Sinemurian, Lower Jurassic).

Referred material. NMING F8758 ***

Remarks. This genus was described by Owen (1865) and extensively revised by Storrs (1997).

***Hydrorion brachypterygius* (Huene, 1923) Grossman, 2007**

Type material. GPIT/477/1/1; complete skeleton including skull.

Type locality. Steinbruch 29, Ohmden (near Holzmaden), Baden-Württemberg, Germany.

Type horizon. Lias epsilon II, 4 (Unterer Schiefer), Posidonienschiefer, (*Harpoceras falcifer* zone), (Lower Toarcian, Lower Jurassic).

Referred material. MB.R. 1991, SMNS 51143.

Remarks. The holotype skull is described by Maisch and Rucklin (2000) as *Plesiosaurus brachypterygius*; Grossman (2006, 2007) redescribed the material pertaining to this taxon and introduced the new genus name *Hydrorion*.

***Seeleysaurus guilelmiimperatoris* (Dames, 1895) Grossman, 2007**

Type material. MB R.1992, complete skeleton.

Type locality. Holzmaden, Baden-Württemberg, Germany.

Type horizon. Lias Epsilon II, 4 (Unterer Schiefer), Posidonienschiefer, (*Harpoceras falciferum* zone), (Lower Toarcian, Lower Jurassic).

Referred material. SMNS 16812, more or less complete skeleton ***; SMNS 12039, (specimen figured by Fraas [1910]).

Remarks. Dames (1895) and Fraas (1910) described this taxon. This species was renamed ‘*Seeleysaurus*’ by White, (1940). Storrs (1997) modified Persson’s (1963) suggestion that *Plesiosaurus* contains only three valid species by proposing *P. brachypterygius* as a junior synonym of *P. guilelmiimperatoris*, reducing the number

to two. However, Maisch and Rucklin (2000, p. 38) justify retention of *P. brachypterygius*. Some workers (Bakker, 1993) have retained the name 'Seeleyosaurus' for *P. guilmiimperatoris* and recently, Grossman (2007) formalised this taxonomy.

O'Keefe (2004b) erected a new genus and species name for SMNS 16812 (*Plesiopterys wildii*), but the specimen was later regarded as a juvenile *Seeleysaurus guilmiimperatoris* (Grossman, 2007).

'Plesiosaurus' longirostris Tate and Blake, 1876

Type material: MCZ 1033 (in the collection of fossil reptiles and amphibians), damaged skull, 85 vertebrae and 4 limbs.

Type locality: Whitby, Yorkshire, England.

Type horizon: Alum Shale, Upper Lias, *serpentinus* ammonite zone, Toarcian, Lower Jurassic.

Referred material: MM 8004, skull and associated skeleton.

Remarks: '*Plesiosaurus' longirostris* has an extremely confusing taxonomic history, complicated by the perplexing history of the type material. White (1940) included the species '*Plesiosaurus' longirostris* in the genus *Macroplata* (see below). Other authors have placed it in *Rhomaleosaurus* (Broadhurst and Duffy, 1970). However, even after superficial examination, it is clear that *Plesiosaurus' longirostris* is far removed morphologically from both *Rhomaleosaurus* and *Macroplata*, not least in the extreme elongation of the rostrum (pers. obs.). O'Keefe (2004b) contended the placement of the species *longirostris* in *Macroplata* (see Chapter 3). *Plesiosaurus longirostris* may be far more abundant than previously recognised: another contemporary taxon, *Sthenarosaurus dawkinsi* (see below), may also pertain to the species *longirostris* (R. Forrest pers. comm., 2005). Even Watson (1909), in his original description of *Sthenarosaurus*, suggested the possibility that the type of *S. dawkinsi* was congeneric with '*Plesiosaurus' longirostris*. This cladistic analysis will test this contention.

***Sthenarosaurus dawkinsi* Watson, 1909**

Type material. MM L8023, a partial postcranial skeleton including both girdles, propodials, and vertebrae.

Type locality. Saltwick, Yorkshire, UK.

Type horizon. Upper Lias (*D. commune* zone) (Toarcian, Lower Jurassic)

Remarks. *Sthenarosaurus* was described and figured by Watson (1909), no cranial material has been referred to this taxon.

***Maresaurus coccai* Gasparini, 1997**

Type material: MOZ 4386 V Museo Prof. Olsacher, Zapala, Neuquén, articulated skull and mandible, atlas-axis and first cervical vertebrae.

Type locality: Chacaico Sur, (39° 15' S, 70° 18' W), 70 km southwest of Zapala, Neuquén Province, Argentina.

Type horizon: Upper part of the Los Molles Formation, Cuyo Group, *Emileia giebeli* and *Emileia multiformis* subzone, Lower Bajocian, Middle Jurassic.

Remarks: Diagnosed as a pliosaurid under the current limitations of poor understanding of pliosaur phylogeny. Noè (2001) suggests that this may be a junior synonym of *Simolestes*. The cladistic analysis presented here will test this contention.

Hauffiosaurus zanoni* O'Keefe, 2001 **

Type material: HAUFF 'Uncatalogued', complete skeleton on display in the Urwelt-Museum Hauff.

Type locality: Holzmaden, Germany.

Type horizon: Posidonien-schiefer, Toarcian, Lower Jurassic

Remarks: O'Keefe (2001a) briefly described this specimen and proposed the new taxon name.

***Brachauchenius lucasi* Williston, 1903**

Type material: USNM 4989, skull and mandible (palatal view) plus 37 ribs and associated vertebrae.

Type locality: Ottawa County, Kansas, USA.

Type horizon: Greenhorn Limestone, Turonian, Late Cretaceous.

Referred material: USNM 2361, skull and vertebrae; FMNH VP321, complete skull.

Remarks: This taxon is described by Williston (1903) and was reviewed by Carpenter (1996).

***Kronosaurus queenslandicus* Longman, 1924**

Type material: Queensland Museum (unspecified)

Type locality: Army Downs, north of Richmond, Queensland, Australia.

Type horizon: Aptian-Albian

Referred material: MCZ 1284, 1285.

Remarks: The skull of *Kronosaurus queenslandicus* was described by White (1935) and the postcranium by Romer and Lewis (1959). The genus *Kronosaurus* is currently under revision (C. McHenry, pers. comm., 2003).

***Simolestes vorax* Andrews, 1909**

Type material: BMNH R.3319, complete skeleton. ***

Type locality: Peterborough, England.

Type horizon: Lower Oxford Clay, Callovian, Middle Jurassic

Referred material: PETMG R296.

Remarks: *Simolestes* was described by Andrews (1913) based on the holotype. The most recent treatments of *Simolestes* are unpublished – Noè (2001) thoroughly described the holotype skull and also referred a second skull to this taxon (PETMG R296) originally discovered in 1990 and identified as *Liopleurodon* (Dawn, 1991).

***Liopleurodon ferox* Sauvage, 1873**

Type material: BMNH R.3536, a single tooth (but see below).

Type locality: Wast, Boulogne, France.

Type horizon: Callovian, Middle Jurassic.

Referred material: Associated skeleton (also BMNH R.3536), “the teeth of which are indistinguishable from the type” (Tarlo, 1960, p.166) and BMNH R.2680 and GPIT 1754/2 (O’Keefe, 2001a). ***

Remarks: The skull of *Liopleurodon ferox* has been described by Andrews (1913). *L. pachydeirus*, also from the Callovian (Tarlo, 1960), has been recently recognised as a junior synonym of *L. ferox* (Noè, 2001). Noè *et al.* (2003) recently described the exoccipital-opisthotic bone in this taxon. According to Noè *et al.* (2004), the species *Liopleurodon macromerus* should be assigned to *Pliosaurus*.

***Peloneustes philarchus* (Seeley, 1869) Lydekker, 1889a**

Type material: CAMSM J.46913, almost complete skeleton.

Type locality: Peterborough, England.

Type horizon: Oxford Clay, Callovian, Upper Jurassic

Referred material. SMNS 10113 (***)

Remarks: *Peloneustes* has been described by Lydekker (1889) and Andrews (1895, 1910b and 1913). According to Martill (1991), *Peloneustes* is often difficult to distinguish from *Pliosaurus* and some species may possibly be congeneric.

Peloneustes is currently under revision by H. Ketchum (H. Ketchum, pers. comm., 2006).

***Pliosaurus* Owen, 1841 (Owen, 1842)**

Type material: *P. brachydeirus* OXFUM J.9245 A.B., “teeth, lower and upper jaws, vertebral column, femur, tibia and fibula” (Tarlo, 1960, p. 152).

Type locality: Market Rasen, Lincolnshire, England.

Type horizon: Kimmeridge Clay, Kimmeridgian, Upper Jurassic.

Referred material: BRSMG Cc332 (***) , *P. brachyspondylus*, the ‘Westbury Pliosaur’ (Taylor and Cruickshank, 1993). Almost complete skull and mandible, some associated cervical vertebrae, phalanges and a rib.

Remarks: I have refrained from including both Kimmeridgian species of *Pliosaurus* because few characters separate them, many of questionable validity (Taylor and Cruickshank, 1993). However the type specimens of *P. brachyspondylus* and *P. brachydeirus* are complementary and, combined, allow a greater degree of resolution for the genus. Accordingly, I have coded *Pliosaurus* to genus level only, albeit discounting characters of the Callovian species *P. andrewsi*, which is omitted from the analysis (see table 1). The coding for *Pliosaurus* can therefore be regarded as follows: *P. brachydeirus* + *P. brachyspondylus* – *P. andrewsi*. The genus *Pliosaurus* was described by Owen (e.g. 1869) and Tarlo (e.g. 1960).

TMP 94.122.01

Type material: TMP 94.122.01, complete skeleton including the skull.

Type locality: Syncrude Canada Ltd. oil sand mine (Mildred Lake site), 30km northeast of Fort McMurray, Athabasca Oil Sands Area of northeastern Alberta, Canada.

Type horizon: Wabiskaw Member, Clearwater Formation, (Lower Albian, Lower Cretaceous).

Remarks: TMP 94.122.01 represents a distinct but as yet un-named taxon (Druckenmiller, 2006ab). A detailed unpublished description of this taxon is provided by Druckenmiller (2006a).

***Umoonasaurus demoscyllus* Kear, Schroeder and Lee, 2006**

Type material: AM F99374, quite complete opalised skeleton including the skull.

Type locality: Zorba Extension Opal Field, west of Coober Pedy, northern South Australia.

Type horizon: Bulldog Shale (Maree Subgroup) (Lower Aptian-Lower Albian, Lower Cretaceous).

Remarks: *Umoonasaurus* was briefly described and named by Kear *et al.* (2006). This plesiosaur was formally known as 'Eric' the pliosaur.

***Leptocleidus superstes* Andrews, 1922a**

Type material: BMNH R.4828 (***), incomplete skull.

Type locality: Berwick, Sussex, England.

Type horizon: Barremian, Lower Cretaceous

Remarks: The holotype of *Leptocleidus superstes* (also the holotype of the genus) is a partial skull and vertebral column associated with a complete pectoral girdle and partial limbs, from the Lower Cretaceous Upper Weald Clay (Barremian?) of Sussex, UK. BMNH R4828 was described and figured by Andrews (1922a). *Leptocleidus superstes* is omitted from the morphometric analysis because it is so far removed stratigraphically from the other taxa included, and it has already been well distinguished as a separate taxon based on discrete characteristics. Species referred to this genus are also known from South Africa and Australia (see below), making *Leptocleidus* one of the most widespread genera of plesiosaur.

***Leptocleidus capensis* (Andrews, 1911) Cruickshank, 1997.**

Type material: SAM-K5822, skull.

Type locality: Zwartkops River Valley, Algoa Basin, South Africa.

Type horizon: Sundays River Formation, (Upper Valanginian, Lower Cretaceous)

Remarks: This specimen was originally described and named '*Plesiosaurus capensis*' by Andrews (1911). It was later redescribed and refigured by Cruickshank (1997) who referred it to the genus *Leptocleidus*.

***Leptocleidus clemai* Cruickshank and Long, 1997**

Type Material: WAM 92.8.1-1 to 60, a partial postcranial skeleton.

Type locality: Kalbarri region, Western Australia.

Type horizon: Birdrong Sandstone (Hauterivian-Barremian, Early Cretaceous)

Remarks: *Leptocleidus clemai* is described by Cruickshank and Long (1997) and represents one of three species of the genus *Leptocleidus*.

***Dolichorhynchops osborni* Williston, 1903**

Type material: KUV 1300, almost complete skeleton.

Type locality: Logan County, Kansas, USA.

Type horizon: Niobrara Formation, Cenomanian, Late Cretaceous

Referred material: MCZ 1064, FHSM VP404.

Remarks: Dolichorhynchops osborni has been thoroughly described by Williston (1903), Carpenter (1996, 1997) and O'Keefe (2004a). This taxon is included as a representative polycotylid taxon to test whether polycotylids are plesiosauroids (as endorsed by Carpenter, 1997 and O'Keefe, 2001a) or pliosauroids (as endorsed by Druckenmiller, 2006ab).

Appendix 3. Anatomical abbreviations

1-4 – distal carpals 1-4
 Ang – angular
 Ar – articular
 Bo – basioccipital
 Bs – basisphenoid
 C – coronoid
 Cc – central cavity
 Co – coracoid
 D – dentary
 Ect – ectopterygoid
 Ep – epipterygoid
 Ex – external naris
 Exop – exoccipital-opisthotic
 F – frontal
 Fe – femur
 Fi – fibula
 H – humerus
 Ic – interclavicle
 In – intermedium
 Int – internal nares
 Is – ischium
 i-v – metacarpals i-v
 J – jugal
 M – maxilla
 Mc – maxillary cavity
 Oc – occipital condyle
 Or – orbit
 P – parietal
 Par – parasphenoid
 Pal – palatine
 Pin – pineal foramen
 Pm – premaxilla
 Po – postorbital
 Poc – paraoccipital process
 Pof – postfrontal
 Pre – prearticular
 Prf – prefrontal
 Pt – pterygoid
 Pu – pubis

Q – quadrate
 Qp – quadrate-ptyergoid flange
 R – radius
 Ra – radiale
 Rbs – ribs
 Sa – surangular
 Sc – scapula
 Soc – supraoccipital
 Sp – splenial
 Sq – squamosal
 St – stapes (hyoid)
 T – tibia
 Ta – tooth alveoli
 Tem – temporal fenestra
 U – ulna
 Ul – ulnare
 V – vomer

Appendix 4. Morphometric data
(all measurements in cm)

		<i>R. cramptoni</i> (NMING F8785)	<i>R. thortoni</i> (BMNH R4853)	<i>R. zelandicus</i> (YORYM G503)	<i>R. propinquus</i> (WM 851.S)	<i>R. megacephalus</i> (type cast, BRSMG Cb 2335)	<i>R. megacephalus</i> (neotype, LEICS G221.1851)	NMING F10194	WARMS G10875	<i>E. arcuatus</i> (BMNH R2028* etc.)	NMING F8749	Archaeonectrus (BMNH 38525)	<i>Macropata</i> (BMNH R5488)	<i>P. macrocephalus</i> (BMNH R1336)	BMNH 49202	HALB uncatalogued	<i>Thalassiodracon</i> (BMNH 2018*)	<i>Attenborosaurus</i> (BMNH R1339)	<i>R. victor</i> (SMNS 12478)
	Skull																		
A	Length (to posterior squamosal bulb)	88	92	73	59	63	65	67	63	?	72	51.2	61	22.5	29.5	?	16	48	35
B	Length of premaxilla	43.5	?	41	34	33	36.5	37.4	?	?	39.5	?	34.5	13.2	13.8	?	?	29.5	?
C	premaxilla tip to external nares	30.5	35	27	22.5	23.5	27	27	?	?	30	26	25	9	9.6	?	?	21	11.63
D	premaxilla tip to pineal foramen	53.5	?	47	37.5	?	45.5	45	?	?	47	37.5	41	?	19.4	?	?	33	?
E	premaxilla tip to anterior-most border orbit	37	42	34.5	27	29	33	32.5	?	?	35.5	29	32	10.5	12.4	12	?	25.5	13.91
F	Premaxillae width at anterior border of nares	7	4	5.7	5.3	3.25	4.2	3.9	?	?	4	?	4.9	1.5	2.9	?	?	?	3.55
G	premaxilla tip to dorso-median foramen	34	?	29.2	24.5	n/a	—	n/a	?	?	?	?	n/a	?	n/a	?	?	?	?
H	length of dorsomedian foramen	4	?	3.5	5	n/a	—	n/a	?	?	n/a	?	n/a	?	n/a	?	?	?	?
I	Length of pineal foramen	4.8	?	3.5	3.9	?	2.12	3.5	?	?	?	?	?	?	1.47	?	?	0.87	?
J	overlap: nares and dorso-median foramen	1.2	?	1	—	n/a	—	n/a	?	?	n/a	n/a	n/a	?	n/a	?	?	n/a	?
K	Snout tip to maxilla (lateral)	11	16.5	11.5	—	11	13.8	13.6	?	?	15	10	12.8	?	6.8	?	?	10	6.77
L	premax/maxilla suture to orbit	26	?	23	—	16.5	19.5	19	?	?	21.5	?	18	?	6.2	?	?	15	6.93
M	max width across premax. rostrum	14.5	16.8	12	—	11	8.8	8.8	?	?	11	6.5	8.5	?	5.2	6.9	?	?	6.31
N	length of external nares	5	4.5	4	3.5	2.76	3.07	3.2	?	?	2.1	?	?	?	1.45	1.9	?	?	1.85
O	Width of external nares (left)	2.9	1.6	1.9	1.9	1.12	1.37	1.1	?	?	1.7	?	?	?	2	1.2	?	?	1.1
P	(right)	2.7	?	2	1.7	1.12	1.25	1.5	?	?	?	?	?	?	n/a	1.2	?	?	1.11
Q	Width between external nares	5.9	?	4.7	3.8	2.71	4.72	4	?	?	4	?	?	?	2.68	?	?	?	1.99
R	Distance between external naris and orbit	5.3	6	5.1	3.1	4.23	4.3	3.7	?	?	4.6	?	5.5	?	1.15	?	?	?	1.64
S	Width between orbits	13.5	?	8.5	7.1	?	9	4.2	?	?	9	3.6	5.4	3.8	9.2	?	?	?	?
T	Orbit length (left)	15	18	10.5	10	?	9.8	13.5	?	?	12.6	5.5	7.5	3.9	6.5	?	?	7.7	?
U	(right)	15.5	17.5	9.8	?	?	12	14	?	?	?	5.5	7	3.9	6.5	?	?	7.7	?

		NING F8785	BMNH R4853	YORYM G503	WM 851.5	BRSMG CB 2335	LEICS G221.1851	NMING F10194	WARMs G10875	BMNH R2028* etc.	NMING F8749	BMNH 38525	BMNH R5488	BMNH R1336	BMNH 49202	HALB	BMNH 2018*	BMNH R1339	SMNS 12478
		premaxilla length/ skull length	0.49 ###	0.56	0.58	0.52	0.56	0.56	###	###	0.55	###	0.57	0.59	0.47	###	###	0.615	###
		Rostrum width/ length to orbit	0.39	0.27	###	0.38	0.27	0.27	###	###	0.31	0.22	0.27	###	0.42	0.6	###	###	0.454
		humerus length/skull length	0.6	0.54	0.59	0.56	0.64	0.54	0.58	###	0.58	###	0.55	0.46	###	###	0.924	###	1.143
		humerus length/ length to post. Vacs.	0.93	0.74	###	0.79	0.8	0.74	0.82	###	0.76	###	0.72	###	###	###	###	###	1.702
		Coracoid width at glenoid/ coracoid length	###	0.46	0.62	###	###	0.46	0.47	###	###	###	0.4	###	###	###	0.343	###	0.506
		Femur length/ skull length	0.61	0.52	0.61	0.54	0.6	0.52	0.56	###	###	0.47	0.6	0.56	###	###	0.881	###	1.1
		symphysis length/ symphysis width	0.84	1.09	###	1.01	1.09	###	1.48	0.98	0.88	###	1.36	###	0.69	0.83	1.229	###	0.79
		symphysis length/ mandible length	0.12	0.14	###	0.16	0.14	###	0.2	###	0.15	0.27	0.19	###	0.12	###	0.2	0.264	0.149
		flare humerus / length humerus	0.47	0.53	0.43	0.52	0.53	0.52	0.52	0.51	0.52	###	0.48	0.53	###	0.45	0.496	###	0.475
		postaxial humerus/ preaxial humerus	1	0.88	###	0.9	0.95	0.88	###	0.98	###	###	###	0.88	###	###	0.849	###	0.816
		Length humerus/ length femur	0.99	1.06	1.1	1.03	1.06	1.04	1.03	1.06	###	###	0.92	0.83	###	1	1.048	###	1.039
		preaxial humerus/ preaxial femur	###	1.13	1.12	###	1.13	###	###	1.02	###	###	###	0.82	###	###	1.105	###	1.152
		Humerus flare/ skull length	0.28	0.34	0.34	0.29	0.34	0.28	0.3	###	0.31	0.2	0.26	0.24	###	###	0.458	###	0.543
		Bulb-pineal foramen/ skull length	0.35	0.27	###	###	0.27	0.28	###	###	###	###	0.28	###	0.32	###	###	0.302	###
		distal width of radius/ radius length	0.71	0.58	0.68	0.68	0.58	###	0.57	0.61	###	0.49	###	###	###	###	0.57	###	0.699
		radius length/tibia length	0.63	0.68	0.9	###	0.68	###	0.62	###	###	###	###	###	###	###	0.57	###	0.837
		radius length/ humerus length	0.3	0.4	0.34	0.3	0.4	###	0.38	0.36	###	###	###	###	###	###	0.338	###	0.349
		length of post. vacs./ width across post. Vacs	1	1.11	###	0.66	1.11	0.85	0.96	###	0.81	###	0.65	###	1.12	###	###	###	1.545
		length to post vacuities/ skull length	0.65	0.73	###	0.71	0.8	0.73	0.71	###	0.76	###	0.76	###	0.75	###	###	###	0.671
		Orbit length/ilium length	0.58	0.52	0.56	###	0.52	###	###	###	###	0.44	###	###	###	###	###	0.405	###
		skull length/ total animal length	0.13	0.13	0.13	0.12	0.13	###	0.14	###	0.17	0.15	0.13	0.14	###	###	0.092	###	0.104
		Pubis length/ischium length	###	###	###	###	###	###	0.94	0.96	###	###	0.94	###	###	###	0.931	0.952	1.048
		Pubis length/coracoid length	###	0.64	###	###	0.72	0.64	0.6	0.55	###	###	0.58	###	###	###	0.559	###	0.557
		ischium length/femur length	###	###	###	###	0.72	###	0.82	0.73	###	###	0.85	###	###	###	0.723	###	0.545
		Pubis width/pubis length	###	0.87	###	###	###	0.87	0.93	0.96	###	###	1.05	###	###	###	0.947	1.15	1.091
		Ischium width/ischium length	###	0.77	###	###	0.77	###	0.76	0.88	###	###	0.77	###	###	###	0.744	0.943	0.952
		Flare femur/length femur	0.47	0.54	0.47	0.48	0.54	0.51	0.54	0.47	###	0.47	0.44	0.49	###	###	0.376	###	0.416
		ilium length/ femur length	0.49	0.49	0.5	###	0.49	###	0.55	0.52	###	0.52	###	###	###	###	###	###	0.455
		Pubis length/ coracoid width at glenoid	###	0.64	###	###	###	0.64	0.6	0.55	###	###	0.58	###	###	###	0.559	###	0.557
		symphysis length/humerus length	0.25	0.29	###	0.37	0.29	###	0.42	0.26	0.26	###	0.37	###	###	0.14	0.25	###	0.155
		symphysis length/radius length	0.84	0.73	###	1.24	0.73	###	1.11	0.73	###	2.06	###	###	###	###	0.74	###	0.444

Appendix 5. Data matrix for cladistic analysis

