Supplementary Information

METHODS

Diversity through time. A stage-level stratigraphy of the genera coded in the matrix was produced by collecting data on ichthyosaurian species from the supplementary information of Benson et al. (2) and also from each of the descriptive papers used for the matrix codings, as detailed in Appendix S1. On checking each line from Benson et al. (2) to the source documentation, some were deemed incorrect and so were removed: the occurrence of *Mixosaurus atavus* (now known as *Phalarodon atavus*) in the Ladinian is noted (7) but it is marked with a question mark and therefore cannot be taken as conclusive; the occurrence of *Barracudasaurus maotaiensis* (now known as *Mixosaurus panxianensis)* in the Ladinian could not be identified from the source reference (35); the occurrence of *Phalarodon fraasi* in the Ladinian could not be identified from the source references (36, 37); and the occurrence of *Besanosaurus* in the Ladinian, the only line removal that impacted at genus level, could not be identified from the source reference (38), as despite the specimen coming from the "Upper Anisian-Lower Ladinian bituminous shales" (p. 3), it was specified as being from (only) the uppermost Anisian (p. 4). Certain species occurrences (2) were agreed, but the references were amended: *Platypterygius hauthali* in the Barremian (39); and *Phalarodon fraasi* in the Anisian (36, 37). Certain lines were added: *Besanosaurus* in the Olenekian (7); *Caypullisaurus bonapartei* in the Berriasian (39); and *Platypterygius* in the Hauterivian (40). The data were summarized at genus level.

Comparing disparity and diversity. The disparity curve is probably best compared with the uncorrected (lower, less steep) raw diversity curve because hypothetical ghost taxa are not included in the disparity calculations: this comparison then highlights the substantial difference, corresponding to likely decoupling, between disparity and diversity (13, 30, 41, 42). Morphological data for hypothetical ancestors, corresponding to ghost taxa, are not added here. Such hypothetical ancestors tend to sit in the middle of the morphospace occupied by their immediate descendants (41). In this case, because the morphospace occupied by taxa within successive time slices come close, but generally do not overlap (Fig. 2A), the hypothetical ancestors would add a modest amount to the mean sums of ranges (total disparity measure) throughout, but could not alter the massive drop at the end of the Triassic.

33. Bardet N & Fernández M (2000) A new ichthyosaur from the Upper Jurassic lithographic limestones of Bavaria *J Paleontol* 74:503-511.

34 Fröbisch NB, Sander PM & Rieppel O (2006) A new species of *Cymbospondylus* (Diapsida Ichthyosauria) from the Middle Triassic of Nevada and a re-evaluation of the skull osteology of the genus *Zool J Linn Soc* 147:515-538.

35 Jiang D-Y, Hao W-C, Maisch MW, Matzke AT & Sun Y-L (2005) A basal mixosaurid ichthyosaur from the Middle Triassic of China *Palaeontology* 48:869-882.

36 Schmitz L (2005) The taxonomic status of *Mixosaurus nordenskioeldii* (Ichthyosauria) *J Vertebr Paleontol* 25:983-985.
37 Jiang D-Y, Schmitz L, Motani R, Hao W-C & Sun Y-L (2007) The mixosaurid ichthyosaur *Phalarodon* cf *P fraasi* from the Middle Triassic of Guizhou Province China *J Paleontol* 81:602-605.
38 Dal Sasso C & Pinna G (1996) *Besanosaurus leptorhynchus* n gen n sp a new shastasaurid ichthyosaur from the Middle Triassic of Besano (Lombardy N Italy) *Paleontol Lombarda N S* 4 1-23.
39 Fernández M (2007) Redescription and phylogenetic position of *Caypullisaurus* (Ichthyosauria: Ophthalmosauridae) *J Paleontol* 81 368-375.
40 Kolb C & Sander PM (2009) Redescription of the ichthyosaur *Platypterygius hercynicus* (Kuhn 1946) from the Lower Cretaceous of Salzgitter (Lower Saxony Germany) *Palaeontographica Abt A* 288 151-192.
41 Brusatte SL, Montanari S, Yi H-Y & Norell MA (2011) Phylogenetic corrections for morphological disparity analysis: new methodology and case studies *Paleobiology* 37:1-22.

Fig. S1. Strict consensus of 120 most parsimonious trees of the Ichthyopterygia at genus level, with *Petrolacosaurus* as outgroup.

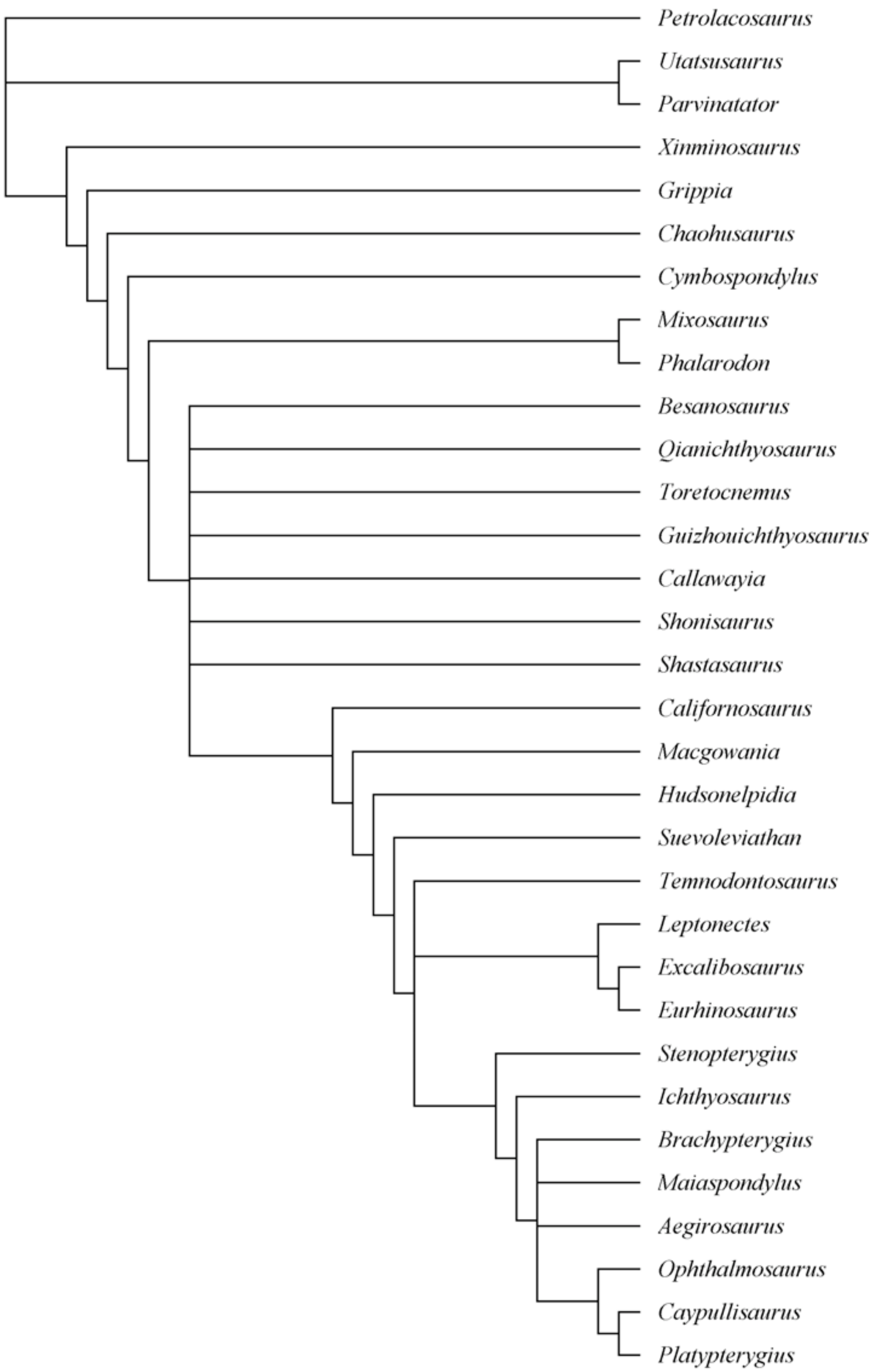


Fig. S2. Agreement subtree of 120 most parsimonious trees of the Ichthyopterygia at genus level, with *Petrolacosaurus* as outgroup. Twenty-four out of the 31 ichthyosaur taxa were included.

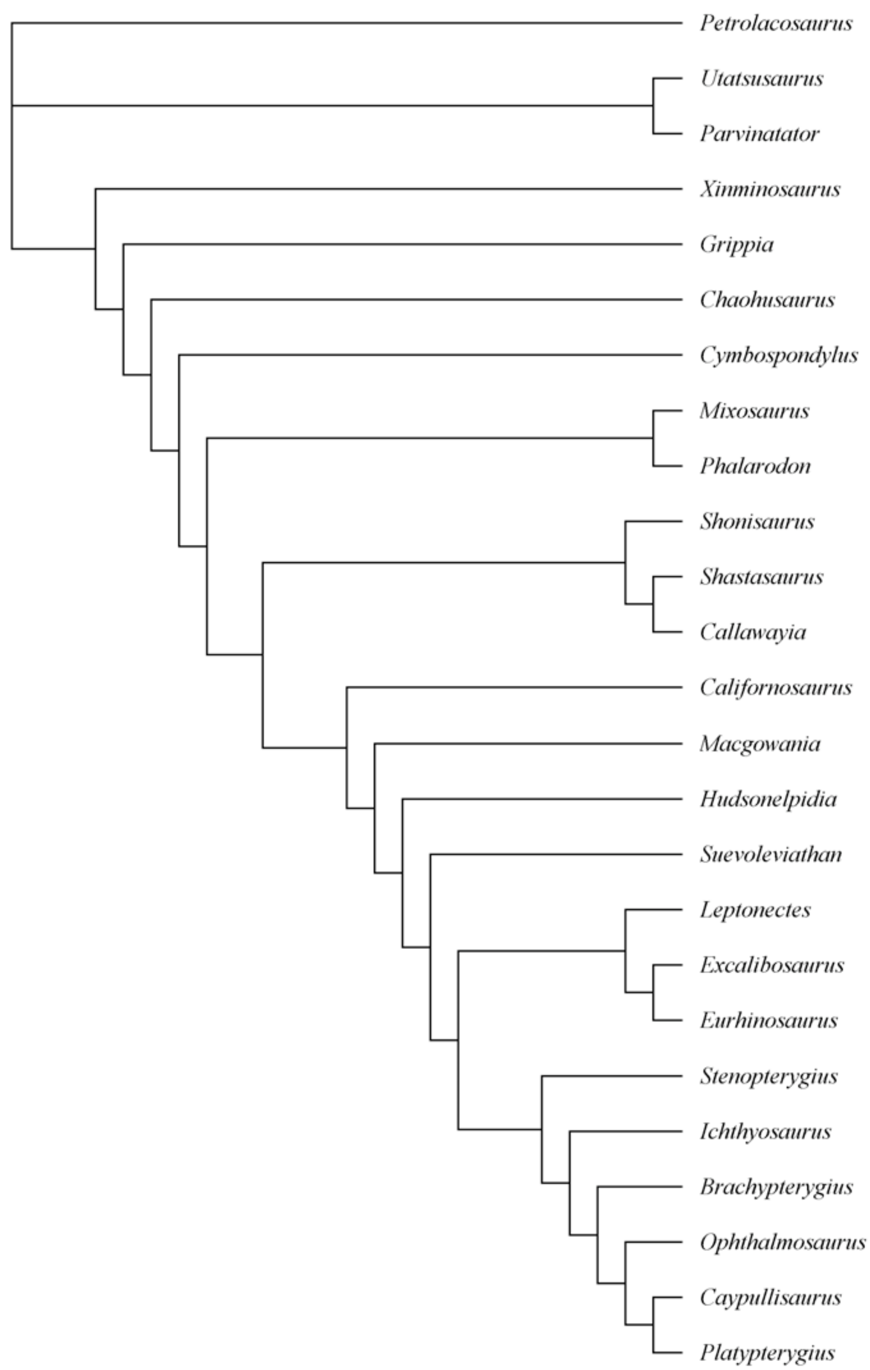


Fig. S3. Majority rule LE50 tree of 120 most parsimonious trees of the Ichthyopterygia at genus level, with *Petrolacosaurus* as outgroup. The LE50 option retains all compatible partitions with a frequency of less than 50 per cent, as long as they are not in conflict with the rest of the tree.

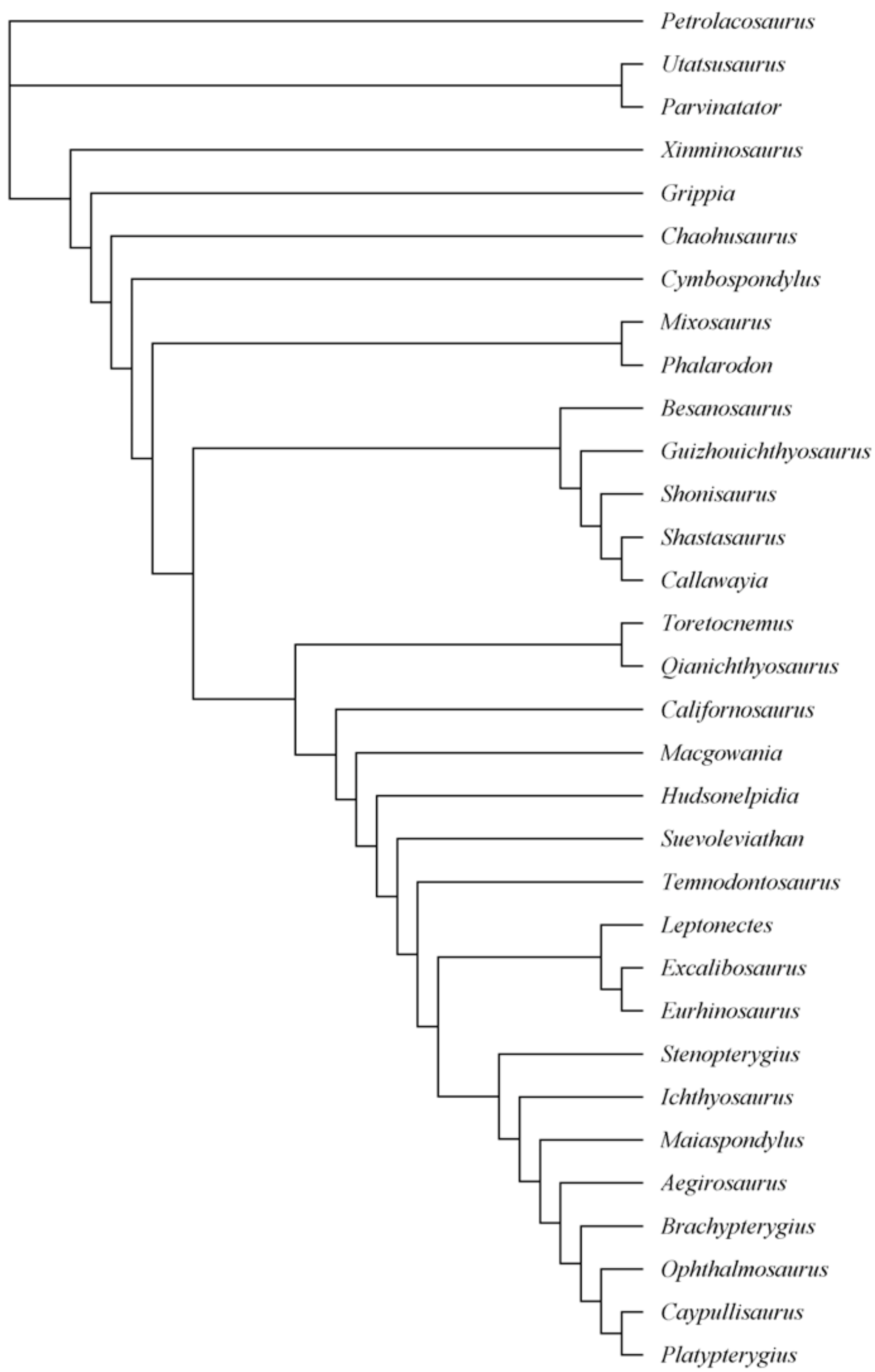
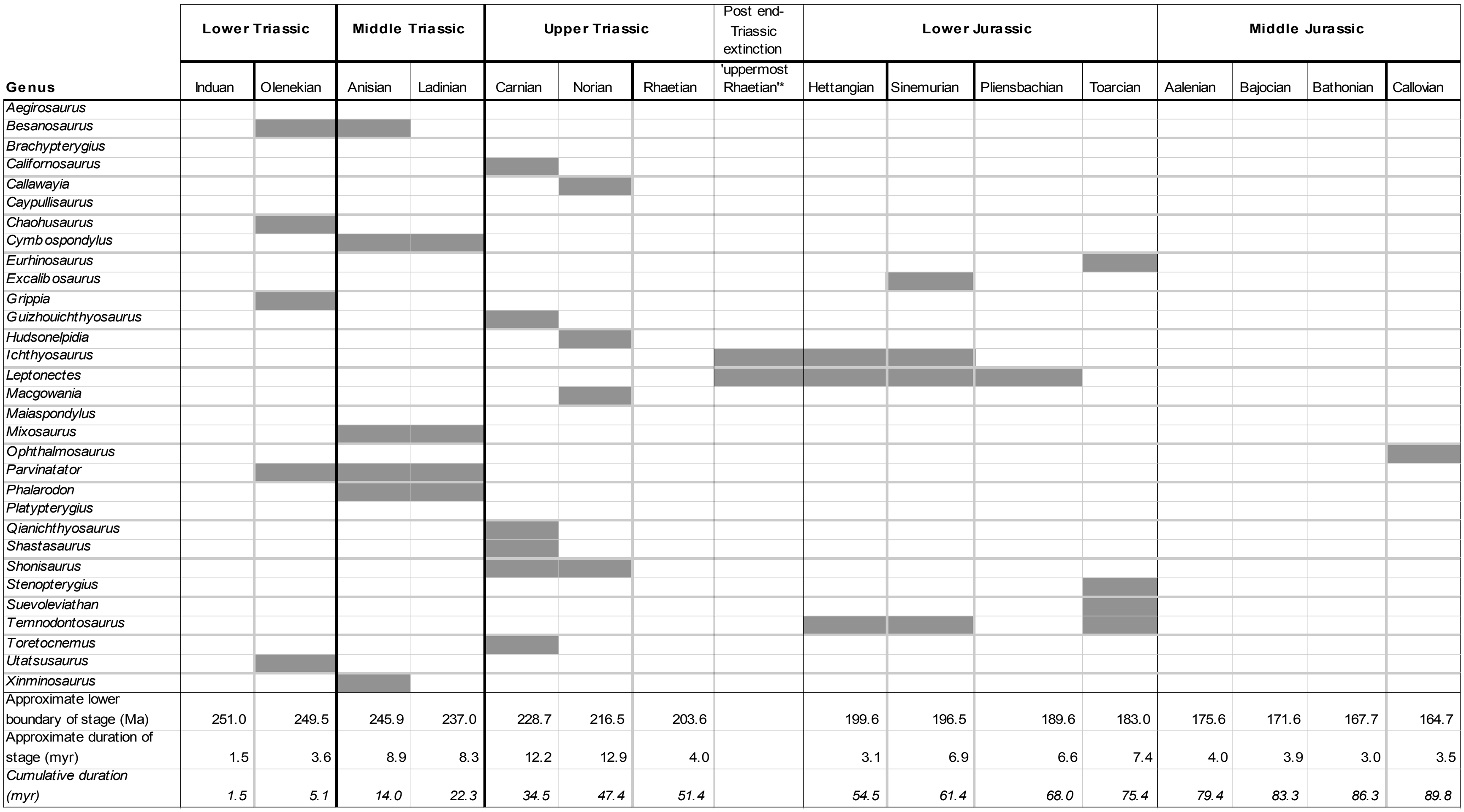


Fig. S4. Stage-level ichthyosaur stratigraphy. Only genera analyzed in the data matrix are included. Lower boundary ages are from Gradstein et al. (2004).

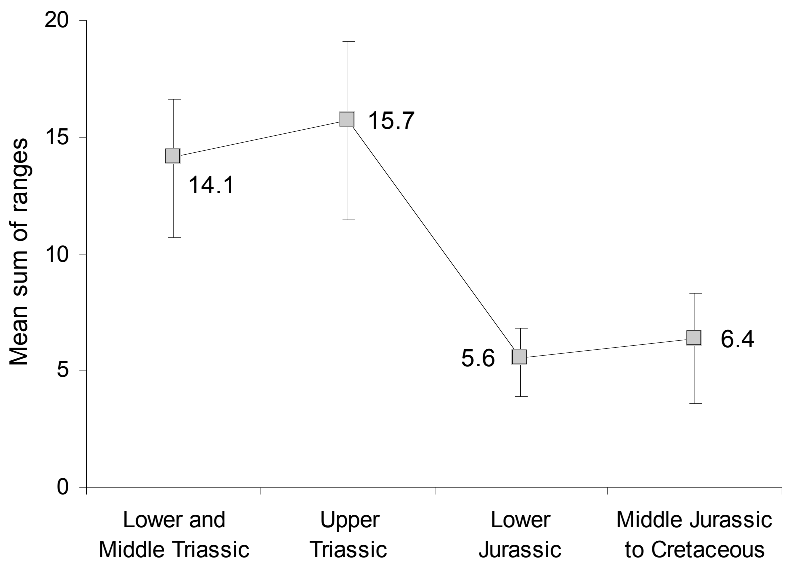


* The term 'uppermost Rhaetian' is used to represent the section of the Rhaetian after the end-Triassic mass extinction.

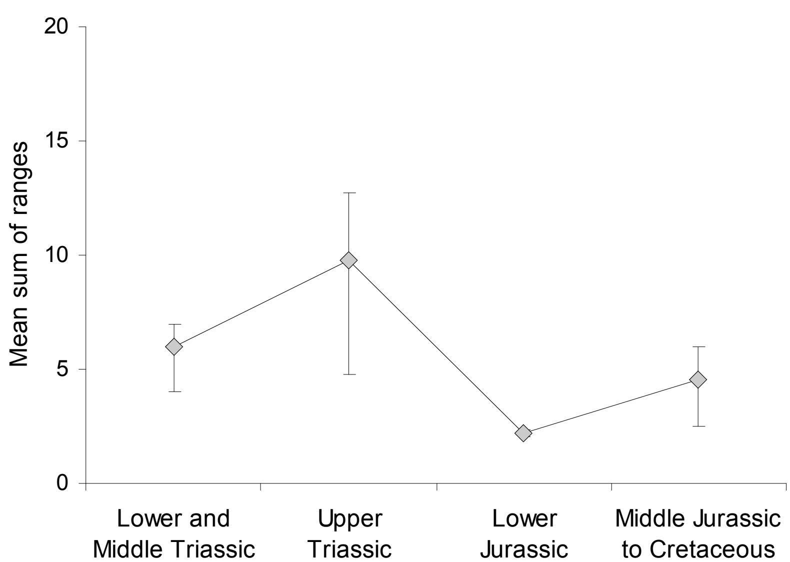
	Upper Jurassic			Lower Cretaceous						Upper Cretaceous					
Genus	Oxfordian	Kimmeridgian	Tithonian	Berriasian	Valanginian	Hauterivian	Barremian	Aptian	Albian	Cenomanian	Turonian	Coniacian	Santonian	Campanian	Maastrichtian
Aegirosaurus			■												
Besanosaurus															
Brachypterygius		■	■						■						
Californosaurus															
Callawayia															
Caypullisaurus			■	■											
Chaohusaurus															
Cymbospondylus															
Eurhinosaurus															
Excalibosaurus															
Grippia															
Guizhouichthyosaurus															
Hudsonelpidia															
Ichthyosaurus															
Leptonectes															
Macgowania															
Maiaspondylus									■						
Mixosaurus															
Ophthalmosaurus	■	■													
Parvinatator															
Phalarodon															
Platypterygius						■	■	■	■	■					
Qianichthyosaurus															
Shastasaurus															
Shonisaurus															
Stenopterygius															
Suevoleviathan															
Temnodontosaurus															
Toretocnemus															
Utatsusaurus															
Xinminosaurus															
Approximate lower boundary of stage (Ma)	161.2	155.6	150.8	145.5	140.2	133.9	130.0	125.0	112.0	99.6	93.6	88.6	85.8	83.5	70.6
Approximate duration of stage (myr)	5.6	4.8	5.3	5.3	6.3	3.9	5.0	13.0	12.4	6.0	5.0	2.8	2.3	12.9	
Cumulative duration (myr)	*95.4*	*100.2*	*105.5*	*110.8*	*117.1*	*121.0*	*126.0*	*139.0*	*151.4*	*157.4*	*162.4*	*165.2*	*167.5*	*180.4*	

Fig. S5. Plots of ichthyopterygian morphological disparity, based on the sum of ranges metric. The error bars represent a 90% confidence interval.

A Whole body characters



B Cranial characters



C Postcranial characters

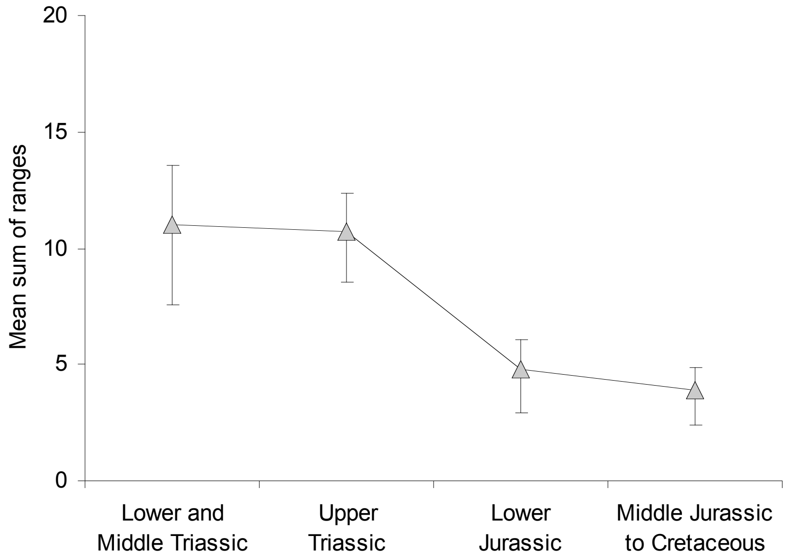
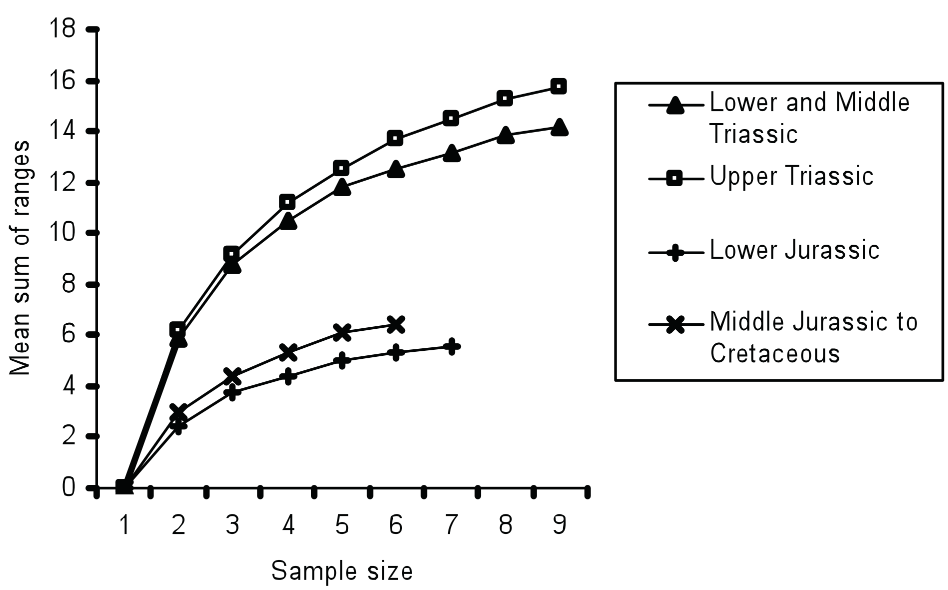
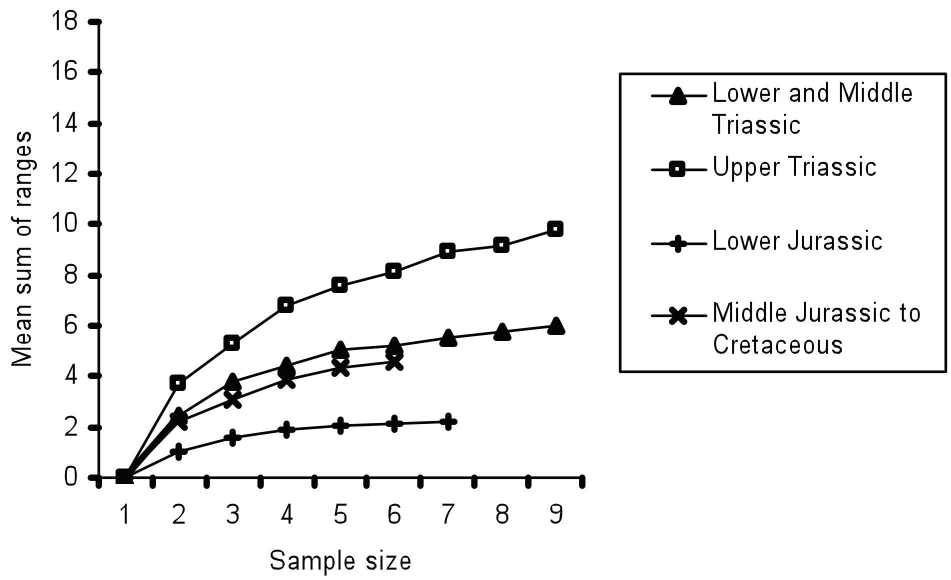


Fig. S6. Rarefaction curves of the disparity metric, mean sum of ranges, for the whole data matrix as well as the partitioned data sets for each time bin.

A All characters



B Cranial characters



C Postcranial characters

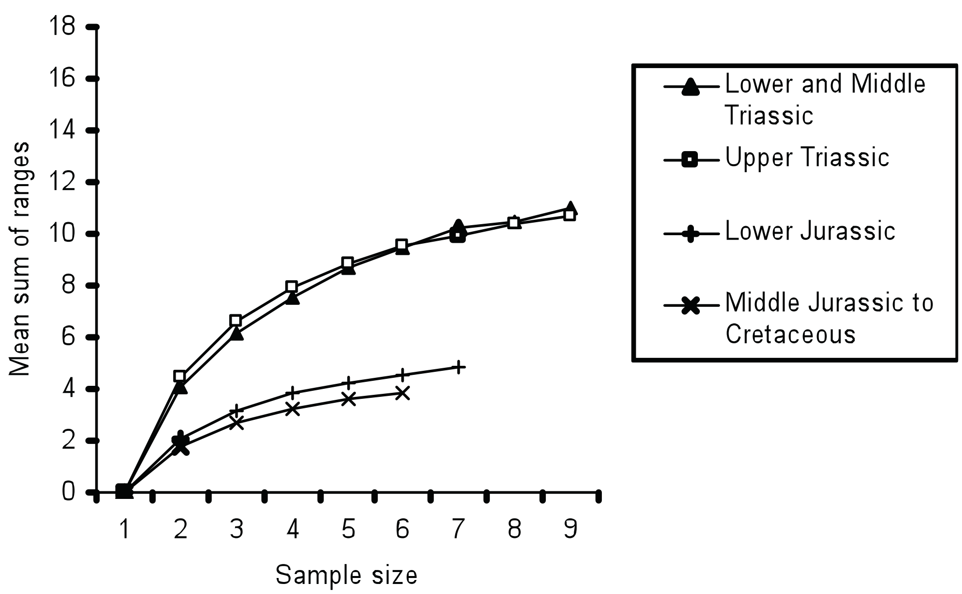


Table S1. Mantel tests, used to analyse correlation between the Euclidean distance matrices of each data set. The distances calculated from the whole body data set, the cranial data set and the postcranial data set were compared over the whole of the Mesozoic and also over the four time bin intervals, using Spearman Rank *rho* values, where *p* is the probability that the two data sets are correlated. Statistical significance: **p* < 0.05; ***p* < 0.005; ****p* < 0.0005.

Datasets	**Mesozoic**		**Lower and Middle Triassic**		**Upper Triassic**		**Lower Jurassic**		**Middle Jurassic – Cretaceous**	
	rho	***p***	***rho***	***p***	***rho***	***p***	***rho***	***p***	***rho***	***p***
Whole body vs. Cranial	0.4804	0***	0.1375	0.1982	0.4214	0.0156*	0.7042	0.0016**	0.5403	0.0960
Whole body vs. Postcranial	0.9490	0***	0.6292	0.0010**	0.8752	0***	0.6797	0.0066**	0.9292	0.0018**
Cranial vs. Postcranial	0.3515	0***	-0.0410	0.4298	0.2380	0.0680	-0.0066	0.4498	0.2994	0.1812

Table S2. NPMANOVA test for statistically significant differences in morphospace occupation between Triassic (n = 18) and post-Triassic (n = 13) taxa, based on PCO analysis output for the whole data matrix and the partitioned data sets. Statistical significance: *p < 0.05; **p < 0.005; ***p < 0.0005.

	***p* (same) overall**	**Pairwise comparisons, Bonferroni corrected**
Whole body	< 0.0001	0***
Cranial	< 0.0012	0.0004***
Postcranial	< 0.0001	0***

Table S3. NPMANOVA test for statistical significance between taxa from each of the four time bins, Lower and Middle Triassic (n = 9), Upper Triassic (n = 9), Lower Jurassic (n = 7), and Middle Jurassic – Cretaceous (n = 6), based on PCO analyses. Abbreviations: J, Jurassic; K, Cretaceous; L, Lower; M, Middle; Tr, Triassic; U, Upper. Statistical significance: **p* < 0.05; ***p* < 0.005; ****p* < 0.0005.

	***p* (same) overall**	**Pairwise comparisons, Bonferroni corrected**			
			L M Tr	U Tr	L J
Whole body	<0.0001	U Tr	0.0018**		
		L J	0.0006**	0.0006**	
		M J - K	0.0012**	0.003**	0.0042**
Cranial	<0.0001	U Tr	0.0498*		
		L J	0***	1	
		M J - K	0.0018**	1	0.2532
Postcranial	<0.0001	U Tr	0.0018**		
		L J	0.0006**	0.0006**	
		M J - K	0.0006**	0.0018**	0.0114*

APPENDIX S1

The original taxa included in Motani's (1999) data matrix and the new ichthyosaur taxa that have been identified since, in alphabetical order. The second column indicates whether each taxon was included in the Motani (1999) matrix and the third column indicates whether each taxon was included in this study. The comments provide additional information. Note that the references listed are not all of those that were reviewed, only those that have been used to amend or add character codings.

Taxa	**Included in Motani 1999**	**Included in this study**	**Comments**	**References**
Aegirosaurus	No	Yes	Genus added	Bardet and Fernández 2000; Fernández 2007
Arthropterygius	No	No	Fragmentary, non-articulated	Maxwell 2010
Barracudasaurus	No	No	Name abandoned as a result of its type species (*Mixosaurus maotaiensis*) being a nomen dubium.	Jiang *et al.* 2005*a*, 2006
Besanosaurus	Yes	Yes		
Brachypterygius	Yes	Yes	New data	Arkhangelsky 2001
Californosaurus	Yes	Yes		
Callawayia	No	Yes	Genus added, for the previously named *Shastasaurus neoscapularis*. Nicholls and Manabe (2001) named the genus *Metashastasaurus*. However, Maisch and Matzke (2000*b*) published the name *Callawayia* in the prior year, which, therefore, takes precedence.	McGowan 1994; Maisch and Matzke 2000*b*; Nicholls and Manabe 2001
Caypullisaurus	Yes	Yes	New data	Motani 1999*a*; Fernández 2001, 2007
Chacaicosaurus	No	No	Excluded by Motani originally and no further information has been identified. Partial, poorly preserved skeleton.	McGowan and Motani 2003
Chaohusaurus	Yes	Yes	New data	Maisch 2001*b*

Taxa	**Included in Motani 1999**	**Included in this study**	**Comments**	**References**
Claudiosaurus	Yes (outgroup)	No	Outgroup removed, as only 1 outgroup required for this study	
Cymbospondylus	No	Yes	Previous codings for *C. buchseri* and *C. petrinus*, plus new data, combined into one coding for the genus.	Maisch and Matzke 2004; Fröbisch *et al.* 2006
Cymbospondylus buchseri	Yes	No	Combined into a *Cymbospondylus* genus coding	
Cymbospondylus petrinus	Yes	No	Combined into a *Cymbospondylus* genus coding	
Eurhinosaurus	Yes	Yes		Maisch and Matzke 2000*b*
Excalibosaurus	Yes	Yes		
Grippia	Yes	Yes		Maisch and Matzke 2000*b*
Guanlingsaurus	No	No	Considered to be a valid genus but as no detailed description paper has been identified this genus could not be coded.	Jiang *et al.* 2005*b*
Guizhouichthyosaurus	No	Yes	Genus added	Maisch *et al.* 2006
Hauffiopteryx	No	No	New genus created by the splitting up of *Stenopterygius*. It has not been separately coded here as it is unknown if there is general consensus on the validity of the genus.	Maisch 2008
Himalayasaurus	No	No	Excluded by Motani originally and no further information has been identified. Fragmentary.	McGowan and Motani 2003
Hovasaurus	Yes (outgroup)	No	Outgroup removed, as only 1 outgroup required for this study	
Hudsonelpidia	Yes	Yes		
Hupehsuchus	Yes (outgroup)	No	Outgroup removed, as only 1 outgroup required for this study	

Taxa	**Included in Motani 1999**	**Included in this study**	**Comments**	**References**
Ichthyosaurus	Yes	Yes	New data	Maisch and Matzke 2000*a*; Motani 2005*b*
Isfjordosaurus	No	No	Excluded by Motani originally and no further information has been identified. This genus is based on a single humerus and, therefore, is too poorly known to be included.	McGowan and Motani 2003
Leptonectes	Yes	Yes	New data	McGowan and Milner 1999; Maisch and Matzke 2003*c*; McGowan and Motani 2003; Maisch and Reisdorf 2006
Macgowania	Yes	Yes		
Maiaspondylus	No	Yes	Genus added	Maxwell and Caldwell 2006
Merriamosaurus	No	No	Proposed as a replacement name for *Rotundopteryx*, an objective junior synonym of *Pessopteryx*. See *Pessopteryx*.	Maisch and Matzke 2002
Metashastasaurus	No	No	Junior synonym of *Callawayia*	
Mikadocephalus	No	No	Excluded by Motani originally and no further information has been identified. Too poorly known to be included.	McGowan and Motani 2003
Mixosaurus	No	Yes	Previous codings for *Mixosaurus cornalianus* plus new data combined into one coding for the genus	Jiang *et al.* 2005*a*, 2006
Mixosaurus atavus	Yes	No	Combined into the *Phalarodon* genus coding	
Mixosaurus cornalianus	Yes	No	Combined into the *Mixosaurus* genus coding	

Taxa	**Included in Motani 1999**	**Included in this study**	**Comments**	**References**
Mixosaurus maotaiensis	No	No	The holotype is fragmentary and undiagnostic and therefore this is a nomen dubium. Four specimens referred to this species were reassigned to *M. panxianensis*, and, therefore, were coded under *Mixosaurus*.	Motani 1999*b*; McGowan and Motani 2003; Jiang *et al.* 2005*a*, 2006
Mixosaurus nordenskioeldii	Yes	No	Nomen dubium, therefore line removed	Schmitz 2005
Mollesaurus	No	No	Fragmentary / incomplete	McGowan and Motani 2003
Nannopterygius	No	No	Excluded by Motani originally and no further information has been identified. Poor preservation and doubted authenticity.	McGowan and Motani 2003
Ophthalmosaurus	Yes	Yes		Maisch and Matzke 2000*b*
Otschevia	No	No	Synonym of *Brachypterygius*	Maisch and Matzke 2000*b*; McGowan and Motani 2003
Parvinatator	Yes	Yes		
Pessopteryx	No	No	Lack of general consensus on validity of genus and incomplete, fragmented specimens.	Maisch and Matzke 2002, 2003*a*; McGowan and Motani 2003
Pessosaurus	No	No	Fragmentary specimens, debated validity of genus.	McGowan and Motani 2003
Petrolacosaurus	Yes (outgroup)	Yes (outgroup)	Outgroup retained	
Phalarodon	No	Yes	Previous codings for *Mixosaurus atavus* plus new data combined into one coding for the genus	Wiman 1910; Maisch and Matzke 2001; Schmitz *et al.* 2004; Jiang *et al.* 2006, 2007

Taxa	**Included in Motani 1999**	**Included in this study**	**Comments**	**References**
Phantomosaurus	No	No	Excluded by Motani originally (this genus is a reclassification of the previously named *Shastasaurus(?) neubigi*) and no further information has been identified. Too poorly known to be included.	Motani 1999*b*; Maisch and Matzke 2000*b*
Platypterygius	Yes	Yes	New data	Kear 2001, 2005; Kolb and Sander 2009
Qianichthyosaurus	No	Yes	Genus added	Li 1999; Nicholls *et al.* 2002; Maisch *et al.* 2008
Quasianosteosaurus	No	No	Incomplete, fragmented specimen	Maisch and Matzke 2003*b*
Rotundopteryx	No	No	Objective junior synonym of *Pessopteryx*	McGowan and Motani 2003
Shastasaurus	Yes	Yes	Codings recreated, to exclude *S. neoscapularis*, which is now referred to the new genus *Callawayia*.	Merriam 1902; Sander 1997; Motani 1999*a*; Maisch 2000; Nicholls and Manabe 2001
Shonisaurus	Yes	Yes	New data	Nicholls and Manabe 2004
Stenopterygius	Yes	Yes	New data	Motani 2005*b*
Suevoleviathan	Yes	Yes	New data	Maisch 2001*a*
Temnodontosaurus	Yes	Yes		
Thadeosaurus	Yes (outgroup)	No	Outgroup removed, as only 1 outgroup required for this study	
Thaisaurus	No	No	Excluded by Motani originally and no further information has been identified. Too poorly known to be included.	Motani 1999*b*

Taxa	Included in Motani 1999	Included in this study	Comments	References
Tholodus	No	No	Unknown taxonomic affinity, incomplete specimens	Maisch and Lehmann 2002; McGowan and Motani 2003; Vecchia 2004
Toretocnemus	Yes	Yes		
Undorosaurus	No	No	Potential junior synonym of *Ophthalmosaurus*.	Maisch and Matzke 2000*b*; McGowan and Motani 2003
Utatsusaurus	Yes	Yes		Maisch and Matzke 2000*b;* Jiang *et al.* 2005*a*; Jiang *et al.* 2006
Wimanius	No	No	Excluded by Motani originally and no further information has been identified. Too poorly known to be included.	McGowan and Motani 2003
Xinminosaurus	No	Yes	Genus added	Jiang *et al.* 2008

Genera not added to the data matrix. Not all newly described ichthyosaur taxa were added to the matrix. Some were excluded as only poorly preserved or fragmented specimens are known to exist, which would lead to very low levels of coding and potentially clouded results. For example, the genus *Arthropterygius* was proposed by Maxwell (2010) in reference to a specimen previously referred to as *Ophthalmosaurus*. This genus has not been added to the matrix as the referred specimen is only fragmentary and non-articulated. *Mollesaurus* is based on a single fragmented specimen and so is too poorly known to be included in the analysis (McGowan & Motani 2003), as is *Quasianosteosaurus*, which is described from only an incomplete and fragmented skull (Maisch and Matzke 2003*b*).

Motani (1999b) also excluded several taxa from his matrix as a result of low levels of coding. The following taxa have been excluded from the current analysis as they were excluded by Motani originally and little or no further information has been identified that would increase the coding levels: *Chacaicosaurus*, *Himalayasaurus*, *Isfjordosaurus*, *Mikadocephalus*, *Nannopterygius*, *Phantomosaurus* (classified as *Shastasaurus*(?) *neubigi* in Motani 1999*b*), *Thaisaurus* and *Wimanius*.

Some taxa have been excluded as there are debates over their validity. According to McGowan and Motani (2003), *Pessopteryx* is invalid as the specimens are non-diagnostic. As a result of the incomplete, fragmented specimens of this genus and the lack of general consensus on its validity, it has not been included in the analysis. *Pessosaurus* has been excluded for similar reasons (McGowan and Motani 2003). Note that *Rotundopteryx* and *Merriamosaurus* are objective junior synonyms of *Pessopteryx* (Maisch and Matzke 2002; McGowan and Motani 2003) and so are also not found in the matrix. *Hauffiopteryx*, a new genus proposed by Maisch in 2008, relates to a previous subspecies of *Stenopterygius*. However, as it is currently unknown whether there is a general consensus over this division of *Stenopterygius*, the matrix has not yet been amended.

Guanlingsaurus has also been excluded (despite being considered valid by Jiang *et al.* 2005*b*) as it has yet to be described in detail. *Undorosaurus* has been excluded as it is a potential junior synonym of *Ophthalmosaurus* (Maisch & Matzke 2000*b*; McGowan & Motani 2003). *Tholodus* has been excluded as it is of debated taxonomic affinity and is also poorly known (Maisch and Lehmann 2002; McGowan & Motani 2003; Dalla Vecchia 2004).

APPENDIX S2. The table below shows the amendments made to Motani's 1999*b* data matrix for each ichthyosaur genus, in alphabetical order. There is no entry in the table if the existing coding was not queried or changed. Some general comments on taxon and coding decisions are given first.

New taxa and new codings

The following lines in the matrix were updated with new information: *Brachypterygius* (Arkhangelsky 2001), *Caypullisaurus* (Fernández 2001, 2007), *Chaohusaurus* (Maisch 2001*b*), *Ichthyosaurus* (Maisch and Matzke 2000*a*; Motani 2005*b*), *Leptonectes* (McGowan and Milner 1999; Maisch and Matzke 2003*c*; Maisch and Reisdorf 2006), *Platypterygius* (Kear 2001, 2005; Fernández and Aguirre-Urreta 2005; Arkhangelsky *et al.* 2008; Kolb and Sander 2009), *Shonisaurus* (Nicholls and Manabe 2004), *Stenopterygius* (Motani 2005*b*) and *Suevoleviathan* (Maisch 2001*a*). Note that *Otschevia* is a synonym of *Brachypterygius* (Maisch and Matzke 2000*b*; McGowan and Motani 2003).

The two separate coding lines of *Cymbospondylus* in Motani's matrix (*C. petrinus* and *C. buchseri*), were combined into one *Cymbospondylus* line in this analysis. It was updated with new information from the literature (Maisch and Matzke 2004) and the new species *C. nichollsi* (Fröbisch *et al.* 2006). Where there was a conflict of character states, the states were all entered in the *Cymbospondylus* line, resulting in a variable coding. Where a conflict involved an unknown state, the coded states were used in preference.

Motani (1999*b*) also split the genus *Mixosaurus* in his matrix, into three separate coding lines (*M. cornalianus*, *M. atavus* and *M. nordenskioeldii*) to test the monophyly of the genus. Previously, Brinkmann (1998) and Maisch and Matzke (1998) had proposed dividing up *Mixosaurus* into more than one genus, but Motani did not believe the analyses to be sufficiently robust (Motani 1999*b*). However, Jiang *et al.* (2006) supported the monophyly of the family and suggested the existence of two genera, *Mixosaurus* and *Phalarodon*. Therefore, Motani's original *Mixosaurus* lines were amended to represent those of the two newly defined genera indicated by Jiang *et al*. (2006). As the new *Mixosaurus* was found to contain the species *M. cornalianus*, *M. kuhnschnyderi* and *M. panxianensis*, the existing *M. cornalianus* line was taken as the starting point for the coding of this genus. Similarly, as the new *Phalarodon* genus was found to contain the species *P. atavus*, *P. callawayi* and *P. fraasi*, the existing *M. atavus* line was taken as the *Phalarodon* genus starting point. Additional codings for *Phalarodon* were also obtained from the literature (Wiman 1910; Maisch and Matzke 2001; Schmitz *et al.* 2004; Jiang *et al.* 2007). Schmitz (2005) found that the *M. nordenskioeldii* specimens were undiagnostic, resulting in this species becoming a nomen dubium. Therefore, this line was removed from the matrix.

The holotype of the species *Mixosaurus maotaiensis* was found to be undiagnostic by Jiang *et al.* (2006) and so it was classed as a nomen dubium. This then resulted in the abandonment of the new generic name, *Barracudasaurus*, which had been proposed for this species by Jiang *et al.* (2005*a*). The specimens described by Jiang *et al.* (2005*a*), which had been referred to *M. maotaiensis,* were then referred to the new species *M. panxianensis* by Jiang *et al.* (2006) and so were coded in the new *Mixosaurus* line in the matrix.

Character interpretation

Certain assumptions and conventions were used when interpreting the characters from Motani's matrix (1999*b*), in an attempt to maintain a consistency of coding.

The following quotation highlights a very important issue in the interpretation of ichthyosaur anatomy: "Despite the abundance of ichthyosaurian fossils, cranial suture lines are not clear in most specimens because of preservation, and this often leads to different interpretations of a single skull" (Motani 2005*b*, p. 338). In addition, ichthyosaur skull bones overlap each other extensively, creating large suture areas (Motani 2005*b*). This complicates interpretation when the external bone layers have not been preserved. There have been several recent publications (for example, Motani 2005*b*; Frobisch *et al.* 2006; and Maisch *et al.* 2008) that provide new interpretations of previously studied specimens. Character codings have been amended in line with these new interpretations. However, as a result of the nature of these specimens, it must be kept in mind that further re-interpretations are likely, which would clearly impact on the results. The interpretation of a selection of the characters has been described below.

Character 11. This character describes the shape of the postorbital. However, the shape differs depending on whether the bone is viewed as part of the skull, and then whether it is an internal or external view, or whether the bone is viewed as a completely separate element. This character has been interpreted to mean the shape of the postorbital as it would have been seen on a complete skull in external view. However, some cases are complicated by the fact that an external overlying skull bone has broken off, for example in *Guizhouichthyosaurus* and *Shastasaurus*.

Character 12. In a similar way to character 11, this character regarding postorbital participation in the upper temporal fenestra has been interpreted to mean whether any participation is visible from an external view.

Character 39. This character represents relative tooth size and is the crown height of the longest tooth divided by the skull width (Motani 1996). Motani found a clear dichotomy in this character (1999*b*) and accordingly created only two character states, a ratio of 0.1 or over, or a ratio of under 0.05. The gap of a ratio between 0.05 and 0.1 was not represented. This character was difficult to code from the literature but when both of the required measurements were available, the estimated ratio did not necessarily clearly fall into either category. For example, a ratio of between 0.08 and 0.11 was calculated for *Leptonectes*. As this was deemed to be nearer the state of over 0.1 than that of under 0.05, it was coded as the former.

Shaft reduction characters. Several of the characters (for example, characters 59, 60, 62 and 63) relate to shaft reduction in particular limb bones. The more primitive condition is a complete shaft and the derived condition is absence of a shaft (i.e. a polygonal element rather than a long bone). The intermediate character (Motani 1999*b*, p. 493) is "notch or largely reduced", so combining two potential character states into one. However, Jiang *et al.* (2006) suggest, on the basis of their finding of double notches, that emargination may not be homologous with shaft retention. If so, then the related characters in the matrix may need to be re-written and coded accordingly.

Character 74. This character relates to the presence or absence of manual centralia (medial carpals). The convention of ichthyosaurs not having any centralia (Motani 1999*a*) was followed.

Character 86. This character regarding the relative length of the pubis and the ischium has also been treated as a dichotomous feature by Motani (1999*b*). It does not account for the situation where the pubis is clearly larger than the ischium but is not twice as large, as is found in *Mixosaurus panxianensis* (Jiang *et al.* 2006). As the creation of a new state may well have impacted on Motani's prior codings, this specimen was deemed to be nearer a coding of 1 (i.e. the pubis is twice as large as the ischium) than a coding of 0, which agreed with the already existing coding of the *Mixosaurus* line.

Character 95. This presacral count character has three discrete character states which do not overlap. Where a count did not fit into any of the categories, it was coded with the deemed nearest category. For example, *Mixosaurus panxianensis* had a presacral vertebrae count of 51 (Jiang *et al.* 2006) and *Aegirosaurus leptospondylus* had a count of 52 (Bardet and Fernández 2000) and so both were coded as between 40 and 50 rather than as 55 or more.

Genus	**Character**	**References and comments**	**Coding**
Aegirosaurus	1	Bardet and Fernández 2000 p.506 figures 3 and 4	2
	2	Bardet and Fernández 2000 p.506 figures 3 and 4	0
	3	Bardet and Fernández 2000 p.506 figures 3 and 4	1
	5	Bardet and Fernández 2000 p.506 figures 3 and 4	0
	6	Bardet and Fernández 2000 p.506 figures 3 and 4	1
	7	Bardet and Fernández 2000 p.506 figure 3; Fernández 2007 Table 1	0
	8	Bardet and Fernández 2000 p.506 figures 3 and 4	1
	9	Bardet and Fernández 2000 p.506 figures 3 and 4	1
	10	Bardet and Fernández 2000 p.506 figure 3	1
	11	Bardet and Fernández 2000 p.506 figures 3 and 4	1
	12	Bardet and Fernández 2000 p.506 figure 3	1
	13	Bardet and Fernández 2000 p.506 figure 3	1
	15	Bardet and Fernández 2000 p.506 figure 3	0
	16	Fernández 2007 Table 1	1
	19	Bardet and Fernández 2000 p.506 figure 3; Fernández 2007 Table 1	2
	20	Bardet and Fernández 2000 p.506 figure 4	1
	23	Bardet and Fernández 2000 p.506 figure 4	1
	24	Bardet and Fernández 2000 p.506 figure 4	1
	25	Bardet and Fernández 2000 p.506 figure 4	0

Genus	Character	References and comments	Coding
	27	Fernández 2007 Table 1	?
	29	Fernández 2007 Table 1	?
	30	Fernández 2007 Table 1	1
	32	Bardet and Fernández 2000 p.506; Fernández 2007 Table 1	0
	33	Bardet and Fernández 2000 p.506 figure 4	0
Aegirosaurus	34	Bardet and Fernández 2000 p.506 figures 3 and 4	0
	45	Bardet and Fernández 2000 p.508	2
	52	Bardet and Fernández 2000 p.507	2
	53	Fernández 2007 Table 1	2
	54	Bardet and Fernández 2000 p.507 figure 5	0
	55	Fernández 2007 Table 1	0
	56	Fernández 2007 Table 1	1
	57	Bardet and Fernández 2000 p.507; Fernández 2007 Table 1	0
	58	Bardet and Fernández 2000 p.507 figure 5	1
	59	Bardet and Fernández 2000 p.507 figure 5; Fernández 2007 Table 1	2
	60	Bardet and Fernández 2000 p.507 figure 5	2
	61	Bardet and Fernández 2000 p.507 figure 5	1
	62	Bardet and Fernández 2000 p.507 figure 5	2
	63	Bardet and Fernández 2000 p.507 figure 5	2
	64	Bardet and Fernández 2000 p.507	0
	65	Bardet and Fernández 2000 p.507	0
	66	Bardet and Fernández 2000 p.507 figure 5; Fernández 2007 Table 1	1
	67	Bardet and Fernández 2000 p.507	0
	68	Bardet and Fernández 2000 p.507	3
	69	Bardet and Fernández 2000 p.507 figure 5	1
	70	Bardet and Fernández 2000 p.507 figure 5	1
	71	Bardet and Fernández 2000 p.507 figure 5	2
	72	Bardet and Fernández 2000 p.507 figure 5	1
	73	Fernández 2007 Table 1	0
	74	Motani 1999*a*	1

Genus	Character	References and comments	Coding
	75	Bardet and Fernández 2000 p.507 figure 5; Fernández 2007 Table 1	1
	76	Bardet and Fernández 2000 p.507 figure 5	0
	77	Bardet and Fernández 2000 p.507	1
	78	Bardet and Fernández 2000 p.507 figure 5	1
	79	Bardet and Fernández 2000 p.507	2
Aegirosaurus	80	Bardet and Fernández 2000 p.508	2
	82	Bardet and Fernández 2000 p.508	0
	83	Fernández 2007 Table 1	3
	84	Bardet and Fernández 2000 p.508	3
	85	Bardet and Fernández 2000 p.507 figure 7	1
	86	Bardet and Fernández 2000 p.507 figure 7	0
	87	Bardet and Fernández 2000 p.507 figure 7	1
	88	Bardet and Fernández 2000 p.507 figure 6	0
	89	Bardet and Fernández 2000 p.507 figure 6; McGowan and Motani 2003 p.57 (which states that pedal "digit I is lost in Merriamosaurians")	1
	90	Bardet and Fernández 2000 p.507 figure 6	1
	91	Bardet and Fernández 2000 p.508	1
	92	Fernández 2007 Table 1 codes this as ? but Bardet and Fernández 2000 p.507 figure 6 shows shaft is absent.	2
	93	Bardet and Fernández 2000 p.507 figure 6	2
	95	Bardet and Fernández 2000 p.506 estimates there are 52 presacrals. As this is closer to 50 than 55, this has been coded as 1.	1
	96	Bardet and Fernández 2000 p.506	1
	97	Bardet and Fernández 2000 p.507	1
	102	Bardet and Fernández 2000 p.507	0
Brachypterygius	3	Arkhangelsky 2001 p.630	1
	5	Arkhangelsky 2001 p.630	0
	45	Arkhangelsky 2001 p.631	2
	46	Arkhangelsky 2001 p.630 figure 2	2
	47	Arkhangelsky 2001 p.630 figure 2	1

Genus	Character	References and comments	Coding
	73	Arkhangelsky 2001 p.631 figure 3	0
	76	Arkhangelsky 2001 p.631 figure 3, p.633	From 0 to 0 and 1
	94	Arkhangelsky 2001 p.630	1
	99	Arkhangelsky 2001 p.630	1
Brachypterygius	100	Arkhangelsky 2001 p.630	1
	101	Arkhangelsky 2001 p.630	0
Callawayia	2	Nicholls and Manabe 2001 p.1001 Table A1	1
	3	McGowan 1994 p.174; Nicholls and Manabe 2001 p.987	0 and 1
	5	Nicholls and Manabe 2001 p.990 figures 5 and 6	0
	6	Nicholls and Manabe 2001 p.990 figures 5 and 6, p.987	1
	7	Nicholls and Manabe 2001 p.990 figures 5 and 6	0
	8	Nicholls and Manabe 2001 p.990 figures 5 and 6, p.987	1
	9	Nicholls and Manabe 2001 p.987	1
	10	Nicholls and Manabe 2001 p.990 figures 5 and 6, p.987	1
	11	Nicholls and Manabe 2001 p.990 figures 5 and 6	1
	12	Nicholls and Manabe 2001 p.990 figures 5 and 6, p.987	0
	13	Nicholls and Manabe 2001 p.990 figures 5 and 6, p.987	1
	14	Nicholls and Manabe 2001 p.987, p.1001 Table A1	2
	15	Nicholls and Manabe 2001 p.990 figures 5 and 6	1
	16	Nicholls and Manabe 2001 p.990 figures 5 and 6, p.987	1
	17	Nicholls and Manabe 2001 p.990 figures 5 and 6, p.987	1
	18	Nicholls and Manabe 2001 p.990 figures 5 and 6	0
	19	Nicholls and Manabe 2001 p.990 figures 5 and 6, p.987	2
	30	McGowan 1994 p.174	0
	31	McGowan 1994 p.174	1
	32	Nicholls and Manabe 2001 p.990 figure 6	1
	33	McGowan 1994 p.173 figure 3; Nicholls and Manabe 2001 p.990 figure 6	0
	34	Nicholls and Manabe 2001 p.990 figure 6	0

Genus	Character	References and comments	Coding
	35	Nicholls and Manabe 2001 p.987	0
	37	Nicholls and Manabe 2001 p.1001 Table A1	0
	38	McGowan 1994 p.174; Nicholls and Manabe 2001 p.1001 Table A1	0
	39	Nicholls and Manabe 2001 p.989	0
	41	Nicholls and Manabe 2001 p.987, p.989	0
Callawayia	43	Nicholls and Manabe 2001 p.1001 Table A1	1
	46	McGowan 1994 p.176; Nicholls and Manabe 2001 p.985, p.991, p.993 figure 9a	2
	47	McGowan 1994 p.176 figure 6; Nicholls and Manabe 2001 p.985, p.991, p.993 figure 9a	1
	48	McGowan 1994 p.176 figure 7; Nicholls and Manabe 2001 p.991, p.993 figure 9. Motani (1999*b*) uses specimen ROM (Royal Ontario Museum) 41993 as an example of a coding of (1) for this character. This is the same specimen described by McGowan in 1994 and now classed as *Callawayia*. However, the newer specimens described by Nicholls and Manabe 2001 have an angle of 45 degrees which does not strictly fit either character state. As this is character is a continuous variable which has been fitted into two discrete character states, no new state has been created. However, the 45 degree angle has been deemed closer to 60 degrees than 0 degrees, giving a coding of (1), which agrees with that of the holotype, ROM 41993.	1
	49	McGowan 1994 p.176; Nicholls and Manabe 2001 p.991	2
	52	McGowan 1994 p.174 figure 4; Nicholls and Manabe 2001 p.991, p.993 figure 10	1
	54	McGowan 1994 p.175; Nicholls and Manabe 2001 p.991	0 and 1
	55	McGowan 1994 p.174 figure 4; Nicholls and Manabe 2001 p.993 figure 10	0 and 1
	57	McGowan 1994 p.174 figure 4; Nicholls and Manabe 2001 p.993 figure 10	0
	58	McGowan 1994 p.174 figure 4	1
	59	McGowan 1994 p.174 figure 4; Nicholls and Manabe 2001 p.993	1 and 2
	60	McGowan 1994 p.174 figure 4; Nicholls and Manabe 2001 p.993	1
	61	McGowan 1994 p.174 figure 4; Nicholls and Manabe 2001 p.993 figure 10	1
	62	McGowan 1994 p.174 figure 4; Nicholls and Manabe 2001 p.993	2
	63	McGowan 1994 p.174 figure 4, p.175; Nicholls and Manabe 2001 p.993	1 and 2

Genus	Character	References and comments	Coding
	64	McGowan 1994 p.175; Nicholls and Manabe 2001 p.993	1
	65	McGowan 1994 p.174 figure 4; Nicholls and Manabe 2001 p.993	1
	66	McGowan 1994 p.174 figure 4; Nicholls and Manabe 2001 p.993	1 and 2
	67	McGowan 1994 p.174 figure 4; Nicholls and Manabe 2001 p.993 figure 10	0 and 1
	68	McGowan 1994 p.174 figure 4; Nicholls and Manabe 2001 p.993	3
Callawayia	69	McGowan 1994 p.174 figure 4; Nicholls and Manabe 2001 p.993 figure 10	1
	71	McGowan 1994 p.174 figure 4	1
	72	McGowan 1994 p.174 figure 4; Nicholls and Manabe 2001 p.993	0
	73	McGowan 1994 p.174 figure 4; Nicholls and Manabe 2001 p.1001 Table A1	0
	74	Motani 1999*a*; Nicholls and Manabe 2001 p.993 figure 10	1
	75	McGowan 1994 p.174 figure 4; Nicholls and Manabe 2001 p.993 figure 10	0
	76	McGowan 1994 p.174 figure 4; Nicholls and Manabe 2001 p.993	0
	77	McGowan 1994 p.175	1
	78	McGowan 1994 p.174 figure 4; Nicholls and Manabe 2001 p.993 figure 10	1
	80	Nicholls and Manabe 2001 p.994 figure 11	1
	81	Nicholls and Manabe 2001 p.994	1
	82	Nicholls and Manabe 2001 p.993 figure 9	1
	83	Nicholls and Manabe 2001 p.993 figure 9	1
	84	Nicholls and Manabe 2001 p.993 figure 9	2
	85	Nicholls and Manabe 2001 p.993 figure 9	0
	86	Nicholls and Manabe 2001 p.993 figure 9	0
	87	Nicholls and Manabe 2001 p.993 figure 9	0
	88	Nicholls and Manabe 2001 p.994 figure 11	0
	89	Nicholls and Manabe 2001 p.995	1
	90	Nicholls and Manabe 2001 p.994 figure 11	0
	91	Nicholls and Manabe 2001 p.994	0
	92	Nicholls and Manabe 2001 p.994	0
	93	Nicholls and Manabe 2001 p.994 figure 11	2
	94	Nicholls and Manabe 2001 p.991	0
	95	Nicholls and Manabe 2001 p.989	2

Genus	Character	References and comments	Coding
	97	Nicholls and Manabe 2001 p.989; p.991	1
	98	Nicholls and Manabe 2001 p.991	0
	99	Nicholls and Manabe 2001 p.991	1
	100	Nicholls and Manabe 2001 p.991	0
	101	Nicholls and Manabe 2001 p.991	0
Callawayia	102	Nicholls and Manabe 2001 p.991	0
	103	Nicholls and Manabe 2001 p.988 figure 3; p.991	0
Caypullisaurus	1	Fernández 2007 p.369 figure 1	2
	3	Fernández 2007 p.369	1
	5	Fernández 2007 p.369	0
	12	Fernández 2007 p.369 figure 1	1
	13	Fernández 2007 p.369 figure 1	1
	19	Fernández 2007 p.370 Table 1	2
	23	Fernández 2007 p.369 figure 1	1
	24	Fernández 2007 p.369 figure 1	1
	25	Fernández 2007 p.369 figure 1	0
	27	Fernández 2007 p.370 Table 1	0
	30	Fernández 2007 p.370	1
	33	Fernández 2007 p.369 figure 1	0
	52	Fernández 2001 p.517 states that the radial facet is the largest. However, Motani (1999*b*) coded this character as the two facets being nearly equal and the facets do appear (from visual inspection of photo) nearly the same size. Therefore, coding not amended.	No change
	67	Motani 1999*a* p.38 figure 7; Fernández 2001 p.517 figure 3. These both show the presence of a manual pisiform. Motani's forefin paper (1999*a*) was published before his ichthyosaur phylogeny (1999*b*) and so the fact it has been coded as pisiform absent is deemed to be an error in Motani's matrix. Therefore, coding amended.	From 1 to 0

Genus	Character	References and comments	Coding
	83	Fernández 2007 p.370 Table 1, p.371. Fernández' matrix indicates a coding of absent for this character. However, the text on p.371 is inconclusive. Therefore, the coding here has not been amended.	No change
	85	Fernández 2007 p.370	1
	88	Fernández 2007 p.371 figure 3	0
	90	Fernández 2007 p.371 figure 3	0
	91	Fernández 2007 p.371 figure 3	1
Caypullisaurus	92	Fernández 2007 p.371 figure 3	2
	93	Fernández 2007 p.371 figure 3	2
	95	Fernández 2007 p.370	1
Chaohusaurus	6	Maisch 2001*b* p.309 figure 2	0
	7	Maisch 2001*b* p.309 figure 2	0
	10	Maisch 2001*b* p.312	1
	19	Maisch 2001*b* p.309 figure 2	0
	23	Maisch 2001*b* p.313	1
	24	Maisch 2001*b* p.309 figure 2	1
	26	Maisch 2001*b* p.314	2
	27	Maisch 2001*b* p.314	1
	32	Maisch 2001*b* p.308 figure 1, p.315	1
	36	Maisch 2001*b* p.316	1
	37	Maisch 2001*b* p.315, 316	From 1 to 0 and 1
	44	Maisch 2001*b* p.314	1
	84	Maisch 2001*b* p.321	0
	85	Maisch 2001*b* p.321	0
	86	Maisch 2001*b* p.321	0
	87	Maisch 2001*b* p.321	0
Cymbospondylus	2	Fröbisch *et al*. 2006 p.536	1
	3	Fröbisch *et al*. 2006 p.520	0

Genus	Character	References and comments	Coding
	5	Maisch and Matzke 2004 p.377 figure 2a, p.378; Fröbisch *et al*. 2006 p.522. These both show the nasal contacting the naris. Maisch and Matzke 2004 considered the same specimens as Motani (1999*b*) but re-evaluated the skull bones and stated that Motani's interpretation was incorrect. Therefore, the coding was amended from 1 to 0 rather than to both 0 and 1.	From 1 to 0
	6	Fröbisch *et al*. 2006 p.522, p.536	1
Cymbospondylus	7	Fröbisch *et al*. 2006 p.519 figure 3, p.523. The nasal and frontal both reach the upper temporal fenestra. Therefore, there was no contact between parietal and nasal lateral to the frontal.	0
	8	Fröbisch *et al*. 2006 p.520 figure 4, p.522, p.536	1
	9	Fröbisch *et al*. 2006 p.522	1
	10	Fröbisch *et al*. 2006 p.519 figure 3, p.520 figure 4	0
	11	Maisch and Matzke 2004 p.375 figure 1b, p.379; Fröbisch *et al*. 2006, p.523. Maisch and Matzke (2004) shows *Cymbospondylus petrinus* with a postorbital posterior lamina and states that this area was misinterpreted by Motani. However, the postorbital as newly described is a very similar shape to that of *C. buchseri* (Sander 1989 p.166 figure 3) which was also coded as 1 by Motani (1999*b*), so no amendments to the coding were made.	No change
	12	Fröbisch *et al*. 2006 p.523	0
	13	Fröbisch *et al*. 2006 p.524, p.536	1
	14	Fröbisch *et al*. 2006 p.523, p.536	2
	15	Fröbisch *et al*. 2006 p.519 figure 3	0
	16	Fröbisch *et al*. 2006 p.520	0
	17	Fröbisch *et al*. 2006 p.520 figure 4, p.536	0
	18	Fröbisch *et al*. 2006 p.519 figure 3, p.532 figure 11B show a reinterpretation of the posterior skull region of this genus, where the parietal does not reach the supratemporal but instead there is another bone inbetween. A new character state was created and the coding was amended accordingly.	From 1 to 2
	19	Fröbisch *et al*. 2006 p.519 figure 3, p.523, p.536	0

Genus	Character	References and comments	Coding
	22	Fröbisch *et al*. 2006 p.524, p.532 figure 11B show a reinterpretation of the posterior skull region of this genus, where the supratemporal does not appear to have a ventral process. Coding amended to represent this new interpretation.	From 1 to 0
	23	Fröbisch *et al*. 2006 p.520 figure 4	0
	24	Fröbisch *et al*. 2006 p.520 figure 4	1
	25	Fröbisch *et al*. 2006 p.520 figure 4	0
	27	Fröbisch *et al*. 2006 p.525	0
Cymbospondylus	41	Jiang *et al.* 2006 p.68 Appendix 1	From 2 to ?
	44	Fröbisch *et al*. 2006 p.525 gives no evidence given of pterygoidal teeth.	1
	76	Fernández 2007 Table 1	From ? to 0
	94	Fröbisch *et al*. 2006 p.526 figure 7, p.536	0
	99	Fröbisch *et al*. 2006 p.528	1
	101	Fröbisch *et al*. 2006 p.529	0
	102	Fröbisch *et al*. 2006 p.529 figure 8B, p.536	0
Eurhinosaurus	3	Maisch and Matzke 2000*b* p.9 states that Motani (1999*b*) coded this incorrectly.	From 0 to 1
Grippia	23	Maisch and Matzke 2000*b* p.10 state that in their opinion preservation is insufficient to be certain about this character. However, as there is no detailed explanation, Motani's (1999*b*) coding has not been amended.	No change
Guizhouichthyosaurus	1	Maisch *et al*. 2006 p.590 figure 3	0
	2	Maisch *et al*. 2006 p.590 figure 3, p.591	1
	3	Maisch *et al*. 2006 p.590 figure 3, p.591	0
	4	Maisch *et al*. 2006 p.590 figure 3	0
	5	Maisch *et al*. 2006 p.590 figure 3, p.591	0
	6	Maisch *et al*. 2006 p.591	1
	7	Maisch *et al*. 2006 p.590 figure 3, p.591, p.592	0
	8	Maisch *et al*. 2006 p.591, p.592	1
	9	Maisch *et al*. 2006 p.590 figure 3	1

Genus	Character	References and comments	Coding
	10	Maisch *et al*. 2006 p.591	1
	11	Maisch *et al*. 2006 p.590 figure 3B, p.592	1
	12	Maisch *et al.* 2006 p.590 figure 3B, p.592	0
	13	Maisch *et al.* 2006 p.590 figure 3, p.592	1
	14	Maisch *et al*. 2006 p.590 figure 3	1
	15	Maisch *et al*. 2006 p.590 figure 3	1
	16	Maisch *et al*. 2006 p.590 figure 3, p.592	1
Guizhouichthyosaurus	17	Maisch *et al*. 2006 p.590 figure 3, p.592	1
	19	Maisch *et al*. 2006 p.590 figure 3, p.592	1
	21	Maisch *et al*. 2006 p.592	1
	23	Maisch *et al*. 2006 p.589, p.591	0
	24	Maisch *et al*. 2006 p.589 figure 2	1
	26	Maisch *et al*. 2006 p.593	2
	27	Maisch *et al*. 2006 p.593	0
	32	Maisch *et al*. 2006 p.589 figure 2	1
	34	Maisch *et al*. 2006 p.590 figure 3	0
	36	Maisch *et al*. 2006 p.593	1
	37	Maisch *et al*. 2006 p.593	0
	43	Maisch *et al*. 2006 p.593 states thecodontous implantation, which according to Motani (1997) means there is no bony fixation of the teeth to the jaw.	1
	46	Maisch *et al*. 2006 p.594	0
	76	Maisch *et al*. 2006 p.594	0
	80	Maisch *et al*. 2006 p.594	1
	95	Maisch *et al*. 2006 p.594	2
	96	Maisch *et al*. 2006 p.594	1
	97	Maisch *et al*. 2006 p.594	1
	98	Maisch *et al*. 2006 p.594	0
	102	Maisch *et al*. 2006 p.594	0
	103	Maisch *et al*. 2006 p.594	1

Genus	Character	References and comments	Coding
Ichthyosaurus	6	Motani 2005*b* p.339 figure 1, p.340	From 1 to 0 and 1
	13	Maisch and Matzke 2000*a* p.137, p.140 Text-figure 4. The squamosal is found to be present in *Ichthyosaurus* contrary to previous descriptions (and does not participate in the upper temporal fenestra). Therefore, coding amended.	From 2 to 1
Leptonectes	3	McGowan and Milner 1999 p.765 Text-figure 3; Maisch and Matzke 2003*c* p.118; Maisch and Reisdorf 2006 p.497, p.499 figure 4	0 and 1
	6	Maisch and Matzke 2003*c* p.119; Maisch and Reisdorf 2006 p.499	0
Leptonectes	7	Maisch and Matzke 2003*c* p.119 figure 2, p.120. The nasal reaches parietal on the left side but not on the right. This shows variation in one individual and so has been coded for both states.	0 and 1
	13	Maisch and Matzke 2003*c* p.119 figure 2; Maisch and Reisdorf 2006 p.499 figure 4	1
	15	Maisch and Matzke 2003*c* p.119 figure 2	0
	16	Maisch and Matzke 2003*c* p.117	1
	19	Maisch and Matzke 2003*c* p.119 figure 2	2
	21	Maisch and Matzke 2003*c* p.119 figure 2B, p.121 figure 4A, p.122	1
	22	Maisch and Matzke 2003*c* p.123	1
	23	Maisch and Matzke 2003*c* p.121	1
	26	Maisch and Reisdorf 2006 p.500	2
	39	Maisch and Matzke 2003*c* p.124 states that the largest tooth crown is 18mm long. Using the photos and scale bars on p.120, the skull width is estimated to be between 165 and 225mm which gives tooth to skull ratios of 0.08 to 0.11 and, therefore, a coding of 0. However, McGowan and Motani (2003 p.75) states that the Leptonectidae ratio is less than 0.05, a coding of 1. Therefore, coding amended to represent both character states.	From 1 to 0 and 1
	55	McGowan and Milner 1999 p.762 states that the humerus is "widely expanded distally", a coding of 1. When Motani's coding of 0 was investigated, it appears to be incorrect. McGowan and Motani 2003 (p.75) states that a "widely expanded distally" humerus is diagnostic of the genus and this is pictured on p.76 (figure 72). Therefore, coding amended from 0 to 1.	From 0 to 1

Genus	Character	References and comments	Coding
	59	McGowan and Milner 1999 p.766	From 1 to 1 and 2
Maiaspondylus	1	Maxwell and Caldwell 2006 p.1046 Text-figure 1B	2
	37	Maxwell and Caldwell 2006 p.1048-9	0
	38	Maxwell and Caldwell 2006 p.1046	0
	52	Maxwell and Caldwell 2006 p.1048	2
	53	Maxwell and Caldwell 2006 p.1048	2
Maiaspondylus	54	Maxwell and Caldwell 2006 p.1048	0
	55	Maxwell and Caldwell 2006 p.1048	0
	56	Maxwell and Caldwell 2006 p.1048	1
	57	Maxwell and Caldwell 2006 p.1048	0
	62	Maxwell and Caldwell 2006 p.1050 Text-figure 6	2
	63	Maxwell and Caldwell 2006 p.1050 Text-figure 6	2
	66	Maxwell and Caldwell 2006 p.1045 Plate 1(5); p.1050 Text-figure 6. Coded as ? despite a coding of 1 in Maxwell 2010 (character 25) as the intermedium is broken.	?
	67	Maxwell and Caldwell 2006 p.1048	0
	69	Maxwell and Caldwell 2006 p.1050 Text-figure 6	1
	70	Maxwell and Caldwell 2006 p.1050 Text-figure 6	1
	72	Maxwell and Caldwell 2006 p.1050 Text-figure 6	1
	74	Maxwell and Caldwell 2006 p.1050 Text-figure 6	1
	78	Maxwell and Caldwell 2006 p.1050 Text-figure 6	1
	97	Maxwell and Caldwell 2006 p.1047	1
	98	Maxwell and Caldwell 2006 p.1048	0
	99 / 100	Maxwell and Caldwell 2006 p.1047. Isolated vertebrae have been allocated to regions of the vertebral column using knowledge of vertebrae facet types in other ichthyosaurs. Therefore, it would not be reliable to code the facet types of the vertebrae in each region using these specimens.	?
Mixosaurus	23	Jiang *et al.* 2005*a* p.870; Jiang *et al.* 2006 p.63, p.69 Appendix 2	From 1 to 0 and 1

Genus	Character	References and comments	Coding
(previously M. cornalianus)	32	Jiang *et al.* 2006 p.63 figure 4	1
	36	Jiang *et al.* 2005*a* p.870, p.876, p.882 Appendix; Jiang *et al.* 2006 p.69 Appendix 2	0 and 1
	37	Jiang *et al.* 2005*a* p.870, p.876	From 0 to 0 and 2
	39	Jiang *et al.* 2006 p.69 Appendix 2	From 1 to 0 and 1
Mixosaurus (previously M. cornalianus)	45	Jiang *et al.* 2006 p.64	From 1 to 1 and 2
	59	Jiang *et al.* 2006 p.64	From 0 to 0 and 1
Ophthalmosaurus	3	Maisch and Matzke 2000*b* p.9 states that Motani (1999*b*) coded this incorrectly.	From 1 to 0
Phalarodon (previously Mixosaurus atavus)	4	Schmitz *et al.* 2004 p.148; Jiang *et al.* 2006 p.69 Appendix 2	From 1 to 0 and 1
	32	Maisch and Matzke 2001 p.1143, p.1149 Text-figure 6	1
	35	Maisch and Matzke 2001 p.1133; Schmitz *et al.* 2004 p.151; Jiang *et al.* 2007 p.604	0
	37	Schmitz *et al.* 2004 p.151, p.152	From 2 to 0 and 2
	38	Jiang *et al.* 2007 p.604	From 0 to 0 and 2
	42	Schmitz *et al.* 2004 p.151	1
	46	Schmitz *et al.* 2004 p.154	0
	47	Schmitz *et al.* 2004 p.154; Text-figure 5	0
	48	Schmitz *et al.* 2004 Text-figure 5	0
	82	Schmitz *et al.* 2004 p.154 (with Wiman 1910 Plate VI figures 1 and 2)	1
	83	Schmitz *et al.* 2004 p.154	1
	84	Schmitz *et al.* 2004 p.154 (with Wiman 1910 Plate VI figure 2)	0

Genus	Character	References and comments	Coding
	85	Schmitz *et al.* 2004 p.154	0
	86	Schmitz *et al.* 2004 p.154	1
	87	Schmitz *et al.* 2004 p.154 (with Wiman 1910 Plate VI figures 1 and 2)	0
	88	Schmitz *et al.* 2004 p.154 (with Wiman 1910 Plate VI figure 2)	0
	89	Schmitz *et al.* 2004 p.154	0
	90	Schmitz *et al.* 2004 p.154 (with Wiman 1910 Plate VI figure 2)	0
	91	Schmitz *et al.* 2004 p.154 (with Wiman 1910 Plate VI figure 2)	0
	92	Schmitz *et al.* 2004 p.154 (with Wiman 1910 Plate VI figure 2)	0
Phalarodon (previously Mixosaurus atavus)	93	Schmitz *et al.* 2004 p.154 (with Wiman 1910 Plate VI figures 1 and 2)	1
	94	Schmitz *et al.* 2004 p.152	0
	97	Schmitz *et al.* 2004 p.154 (with Wiman 1910 Plate VI figure 1)	1
	98	Jiang *et al.* 2006 p.69 Appendix 2	1
	99	Schmitz *et al.* 2004 p.153	0
	100	Schmitz *et al.* 2004 p.157	1
	102	Schmitz *et al.* 2004 p.153	1
	103	Schmitz *et al.* 2004 p.154	1
Platypterygius	2	Kear 2005 p.587 figure 1	From 0 to 0 and 1
	3	Kear 2005 p.589	From 1 to 0 and 1
	7	Kear 2005 p.592	From 1 to 0 and 1
	21	Kear 2005 p.595, p.596 figure 7A	1
	22	Kear 2005 p.595; Kolb and Sander 2009 p.163	1
	27	Kear 2005 p.599	0
	28	Kear 2005 p.587 figure 1	1
	29	Kear 2005 p.602; Kolb and Sander 2009 p.163	1

Genus	Character	References and comments	Coding
	35	Kear 2001 p.388 figure 1B, p.389; Kear 2005 p.616; Kolb and Sander 2009 p.168. Kolb and Sander state that Kuhn observed a replacement tooth inside the pulp cavity of another tooth in 1946 but that the specimen can no longer be found. As this observation cannot be verified, it seems more prudent to not use it for coding. Indeed, Motani did not code this character despite being aware of Kuhn's paper. However, the more recent work by Kear shows that resorption pits are present which indicates replacement teeth were appearing outside the pulp cavity of the predecessor, which leads to a coding of 0.	0
Platypterygius	36	Kear 2005 p.616 states that there is no infolding of dentine in broken sections of teeth, which disagrees with this coding. However, absence in some teeth does not mean absence in all and so is not necessarily conclusive. Therefore, coding not amended.	No change
	49	Kolb and Sander 2009 p.174	From 3 to 2 and 3
	66	Kolb and Sander 2009 p.181	From 1 to 0 and 1
	73	Kolb and Sander 2009 p.180 Text-figure 16. The right forefin shows no extra digit between digits 4 and 5. Note the extra digit shown in the diagram is actually anterior to digit 2 and so does not apply to this character.	0
	94	Kolb and Sander 2009 p.169	1
	95	Kolb and Sander 2009 p.170	1
	99	Kolb and Sander 2009 p.169	1
	100	Kolb and Sander 2009 p.170	1
Qianichthyosaurus	1	Nicholls *et al*. 2002 p.759, p.761 figure 3; Maisch *et al*. 2008 p.260, p.263 figure 3	1
	2	Nicholls *et al*. 2002 p.759, p.761 figure 3; Maisch *et al*. 2008 p.260, p.263 figure 3	1
	3	Nicholls *et al*. 2002 p.759, p.761 figure 3; Maisch *et al*. 2008 p.260, p.263 figure 3	0
	5	Nicholls *et al*. 2002 p.759, p.761 figure 3; Maisch *et al*. 2008 p.260, p.263 figure 3	0
	6	Maisch *et al*. 2008 p.263 figure 3	0
	7	Maisch *et al*. 2008 p.263 figure 3	0
	8	Nicholls *et al*. 2002 p.759, p.761 figure 3; Maisch *et al*. 2008 p.260, p.263 figure 3	1

Genus	Character	References and comments	Coding
	9	Nicholls *et al*. 2002 p.761 figure 3; Maisch *et al*. 2008 p.260-1, p.263 figure 3. Note that Maisch *et al.* re-interpreted the postorbital region of the Nicholls *et al.* specimen. However, in both interpretations, the postfrontal appears to have a postero-lateral process.	1
	10	Maisch *et al*. 2008 p.260, p.263 figure 3	1
	11	Nicholls *et al*. 2002 p.761 figure 3; Maisch *et al*. 2008 p.258 figure 1, p.261	1
Qianichthyosaurus	12	Nicholls *et al*. 2002 p.761 figure 3; Maisch *et al*. 2008 p.261. The postorbital interpretation of Nicholls *et al*. has been superseded by Maisch *et al*. 2008. However, the Maisch paper does not give a definitive coding for this character.	?
	13	Maisch *et al*. 2008 p.263 figure 3	1
	14	Maisch *et al*. 2008 p.258 figure 1, p.261	1
	16	Maisch *et al*. 2008 p.260, p.261	1
	17	Maisch *et al*. 2008 p.261	1
	20	Maisch *et al.* 2008 p.258 figure 1, p.263 figure 3	1
	24	Nicholls *et al*. 2002 p.761 figure 3; Maisch *et al*. 2008 p.258 figure 1	1
	27	Maisch *et al*. 2008 p.262	1
	30	Maisch *et al*. 2008 p.258 figure 1C, p.262	0
	31	Nicholls *et al*. 2002 p.760; Maisch *et al*. 2008 p.258 figure 1C, p.262	1
	32	Nicholls *et al*. 2002 p.760, p.761 figure 3; Maisch *et al*. 2008 p.262 figure 2, p.264	1
	33	Nicholls *et al*. 2002 p.761 figure 3	0
	34	Maisch *et al*. 2008 p.259	1
	35	Maisch *et al*. 2008 p.263	0
	37	Nicholls *et al*. 2002 p.761	0
	38	Li 1999 p.1330; Nicholls *et al*. 2002 p.761	0
	52	Nicholls *et al*. 2002 p.762	2
	53	Nicholls *et al*. 2002 p.762	2
	54	Nicholls *et al*. 2002 p.762	0
	55	Nicholls *et al*. 2002 p.762	0
	57	Nicholls *et al*. 2002 p.762 figure 4	0
	58	Nicholls *et al*. 2002 p.762 figure 4	1

Genus	Character	References and comments	Coding
	59	Nicholls *et al*. 2002 p.762	1
	60	Li 1999 p.1332; Nicholls *et al*. 2002 p.762	0
	61	Nicholls *et al*. 2002 p.762	0
	62	Nicholls *et al*. 2002 p.762	1
	63	Li 1999 p.1332; Nicholls *et al*. 2002 p.762	0
	64	Nicholls *et al*. 2002 p.762 figure 4	0
Qianichthyosaurus	65	Li 1999 p.1332; Nicholls *et al*. 2002 p.762 figure 4	0 and 1
	66	Nicholls *et al*. 2002 p.762 figure 4	1
	67	Nicholls *et al*. 2002 p.762	1
	68	Nicholls *et al*. 2002 p.762	3
	69	Nicholls *et al*. 2002 p.762 figure 4	1
	71	Nicholls *et al*. 2002 p.762 figure 4, p.763	1
	72	Li 1999 p.1332; Nicholls *et al*. 2002 p.762	0
	73	Nicholls *et al*. 2002 p.762	0
	74	Motani 1999*a*	1
	75	Nicholls *et al*. 2002 p.762 figure 4	0
	76	Nicholls *et al*. 2002 p.762	0
	77	Nicholls *et al*. 2002 p.762 figure 4, p.763	1
	78	Nicholls *et al*. 2002 p.762 figure 4	1
	80	Nicholls *et al*. 2002 p.762	2
	81	Nicholls *et al*. 2002 p.762	1
	83	Nicholls *et al*. 2002 p.762	1
	84	Nicholls *et al*. 2002 p.762	0
	85	Nicholls *et al*. 2002 p.762	0
	86	Nicholls *et al*. 2002 p.762 figure 5	0
	87	Nicholls *et al*. 2002 p.762 figure 5	0
	88	Li 1999 p.1332; Nicholls *et al*. 2002 p.762 figure 5	0
	89	Nicholls *et al*. 2002 p.762 figure 5, p.763	1
	90	Nicholls *et al*. 2002 p.762 figure 5, p.763	0
	91	Li 1999 p.1332; Nicholls *et al*. 2002 p.762 figure 5	0

Genus	Character	References and comments	Coding
	92	Nicholls *et al*. 2002 p.762 figure 5, p.763	1
	93	Nicholls *et al*. 2002 p.762 figure 5	2
	95	Li 1999 p.1330; Nicholls *et al*. 2002 p.761	1
Qianichthyosaurus	96	Nicholls *et al*. 2002 p.760 figure 1, p.761 states there is a tail bend but that there is inadequate preparation to see any wedge shaped vertebrae. The tail bend is deemed inconclusive, as it could be an artefact of preservation, and so has not been coded.	?
	97	Li 1999 p.1332; Nicholls *et al*. 2002 p.761	1
	99	Nicholls *et al*. 2002 p.761	1
	100	Li 1999 p.1332; Nicholls *et al*. 2002 p.761	1
	102	Nicholls *et al*. 2002 p.761	0
Shastasaurus	6	Merriam 1902 Plate 12; Maisch 2000 p.6 figure 1	0
	7	Merriam 1902 Plate 12; Maisch 2000 p.6 figure 1	0
	8	Merriam 1902 p.84, Plate 12; Maisch 2000 p.6 figure 1, p.10	1
	9	Merriam 1902 Plate 12; Maisch 2000 p.6 figure 1, p.11	1
	10	Merriam 1902 Plate 12; Maisch 2000 p.6 figure 1, p.10	1
	11	Merriam 1902 p.84; Maisch 2000 p.6 figure 1, p.11. Both discuss a posterior process of the postorbital but this is only exposed as a consequence of supratemporal weathering and would not normally be visible in external lateral view.	1
	12	Maisch 2000 p.6 figure 1 gives the impression that the postorbital reaches the upper temporal fenestra. However, p.11 states that it only "probably just reaches" it, which is inconclusive.	?
	13	Merriam 1902 Plate 12; Maisch 2000 p.6 figure 1	1
	14	Maisch 2000 p.8	1
	15	Merriam 1902 Plate 12	1
	16	Maisch 2000 p.9	1
	19	Merriam 1902 Plate 12	1
	22	Maisch 2000 p.12	1
	24	Merriam 1902 Plate 12; Maisch 2000 p.6 figure 1	1

Genus	Character	References and comments	Coding
	25	Maisch 2000 p.5, p.6 figure 1	0
	26	Merriam 1902 Plate 13; Maisch 2000 p.7 figure 2	2
	27	Maisch 2000 p.7 figure 2, p.12	1
Shastasaurus	28	Merriam 1902 Plate 13; Maisch 2000 p.7 figure 2	1
	30	Maisch 2000 p.7 figure 2	0
	31	Sander 1997 p.23; Maisch 2000 p.13	1
	36	Sander 1997 p.30	1
	38	Sander 1997 p.30	0
	44	Maisch 2000 p.7 figure2	1
	46	Merriam 1902 Plate 12	0
	47	Merriam 1902 Plate 12	1
	48	Merriam 1902 Plate 12	1
	49	Merriam 1902 p.77	2
	52	Merriam 1902 Plate 11 figure 1	1
	53	Motani 1999*a* p.31 Table 1	1
	54	Merriam 1902 p.80, Plate 11 figure 1; McGowan 1994 p.175	1
	55	Merriam 1902 p.80	0
	56	Motani 1999*a* p.31 Table 1	0
	57	Merriam 1902 Plate 11	0
	59	Merriam 1902 Plate 11 figure 1	1
	60	Merriam 1902 Plate 11 figure 1	1
	61	Merriam 1902 p.81	1
	62	Merriam 1902 Plate 11 figure 1	2
	63	Merriam 1902 Plate 11 figure 1	1
	64	Merriam 1902 Plate 11 figure 1	1
	84	Sander 1997 p.35 figure 7	1
	85	Sander 1997 p.35 figure 7	0
	97	Merriam 1902 Plate 8 figure 5; Sander 1997 p.32	1
	99	Merriam 1902 Plate 8 figure 1, Plate 12; Sander 1997 p.31	1
	102	Merriam 1902 Plate 9; Sander 1997 p.31 figure 5	0

Genus	Character	References and comments	Coding
Shonisaurus	5	Nicholls and Manabe 2004 p.840 notes that a fragment of nasal bone includes the edge of the external naris. This is a coding 0 and, therefore, would lead to a coding of 0 and 1 for this genus. On investigation of the coding of 1 (Motani 1997 p.93; Motani 1999*b* p.485), it appears that it is based on a controversial specimen which some authors apply to a different genus (Shastasaurus). Here I have assumed Motani's interpretation that it is a Shonisaurus and, therefore, the coding should be both 0 and 1.	From 1 to 0 and 1
	45	Nicholls and Manabe 2004 p.842	2
	99	Nicholls and Manabe 2004 p.842	1
	105	Nicholls and Manabe 2004 p.842 discusses that no specimens of this taxon are well enough preserved to confirm this coding.	From 1 to ?
Stenopterygius	6	Motani 2005*b* p.340	From 1 to 0 and 1
	7	Motani 2005*b* p.340	From 1 to 0 and 1
	39	Motani's coding for this character was 0&2, but there was no character state 2 described. Character 7 of Maisch and Matzke 2000*b* is identical to this character (p.13) and Stenopterygius has been given a coding of 0 (p.155). Therefore, this coding has been amended to just 0.	From 0 and 2 to 0
Suevoleviathan	1	Maisch 2001*a* p.149 Abbildung 2	From 2 to 0 and 2
	3	Maisch 2001*a* p.149 Abbildung 2, p.152 Abbildung 3. Also see Maisch and Matzke 2000*b* which states that this character is variable intragenerically.	0 and 1
	13	Maisch 2001*a* p.149 Abbildung 2, p.152 Abbildung 4	1
	30	Maisch 2001*a* p.155	0
	31	Maisch 2001*a* p.154	1
Utatsusaurus	13	Maisch and Matzke 2000*b* p.10 state that in their opinion preservation is insufficient to be certain about this character. However, as there is no detailed explanation, Motani's (1999*b*) coding has not been amended.	No change

Genus	Character	References and comments	Coding
Utatsusaurus	23	Maisch and Matzke 2000*b* p.10 state that in their opinion preservation is insufficient to be certain about this character. However, as there is no detailed explanation, Motani's (1999*b*) coding has not been amended.	No change
	36	Jiang *et al.* 2005*a* p.882 Appendix; Jiang *et al.* 2006 p.69 Appendix 2	1
Xinminosaurus	35	Jiang *et al*. 2008 p.1317	0
	37	Jiang *et al*. 2008 p.1317	2
	38	Jiang *et al*. 2008 p.1317	1
	40	Jiang *et al*. 2008 p.1317	1
	46	Jiang *et al*. 2008 p.1317	0
	54	Jiang *et al*. 2008 p.1317	0
	58	Jiang *et al*. 2008 p.1317 figure 3	1
	59	Jiang *et al*. 2008 p.1317 figure 3	0
	60	Jiang *et al*. 2008 p.1317 figure 3	0
	61	Jiang *et al*. 2008 p.1317	0
	62	Jiang *et al*. 2008 p.1317 figure 3	1
	63	Jiang *et al*. 2008 p.1317 figure 3	0
	64	Jiang *et al*. 2008 p.1317 figure 3	0
	65	Jiang *et al*. 2008 p.1317 figure 3	0
	66	Jiang *et al*. 2008 p.1317 figure 3, p.1318	0
	67	Jiang *et al*. 2008 p.1317 figure 3	1
	68	Jiang *et al*. 2008 p.1317 figure 3	0
	69	Jiang *et al*. 2008 p.1317 figure 3	0
	70	Jiang *et al*. 2008 p.1317 figure 3, p.1318	1
	71	Jiang *et al*. 2008 p.1317 figure 3	0
	72	Jiang *et al*. 2008 p.1317 figure 3	0
	73	Jiang *et al*. 2008 p.1317 figure 3	0
	74	Motani 1999*a*	1
	75	Jiang *et al*. 2008 p.1317 figure 3	0
	76	Jiang *et al*. 2008 p.1317 figure 3	0
	77	Jiang *et al*. 2008 p.1318	0

Genus	**Character**	**References and comments**	**Coding**
Xinminosaurus	78	Jiang *et al*. 2008 p.1317 figure 3	1
	88	Jiang *et al*. 2008 p.1317 figure 4	0
	90	Jiang *et al*. 2008 p.1317 figure 4, p.1318	0
	91	Jiang *et al*. 2008 p.1317 figure 4	0
	92	Jiang *et al*. 2008 p.1317 figure 4	0
	93	Jiang *et al*. 2008 p.1317 figure 4	1
	95	Jiang *et al*. 2008 p.1317	2
	96	Jiang *et al*. 2008 p.1317	1
	103	Jiang *et al*. 2008 p.1317	1

APPENDIX S3. Character descriptions from Motani (1999*b*). No new characters were added but characters 5, 9, 18 and 84 have been amended, as discussed in the main text.

1. Premaxilla posterior end: concave and the dorsal process is longer than the ventral (0); pointed, scarcely entering the external naris (1); concave and the ventral process is longer than the dorsal (2).
2. Maxilla dorsal lamina: absent (0); present (1).
3. Maxilla/external naris contact: present (0); absent (1).
4. External naris orientation: dorso-lateral (0); lateral, scarcely visible in dorsal view (1).
5. Nasal/external naris contact: present (0); absent (1).
6. Wide contact between nasal/postfrontal: absent (0); present (1).
7. Nasal/parietal contact lateral to frontal: absent (0); present (1).
8. Prefrontal/postfrontal contact: absent, the dorsal margin of the orbit being formed by the frontal (0); present, eliminating the frontal from the dorsal margin of the orbit (1).
9. Postfrontal postero-lateral process: absent (0); present (1).
10. Postfrontal participation in upper temporal fenestra: absent (0); present (1).
11. Postorbital shape: triradiate (0); lunate, without posterior process (1).
12. Postorbital participation in upper temporal fenestra: present (0); absent (1).
13. Squamosal participation in upper temporal fenestra: present (0); absent (1); squamosal absent (2).
14. Anterior terrace of upper temporal fenestra: absent (0); present, but small, reaching the posterior part of the frontal anteriorly (1); present, and large, reaching the nasal anteriorly (2).
15. Frontal widest position: located posteriorly (0); at nasal suture (1).
16. Sagittal eminence: absent (0); present but small, involving only the parietal (1); present and large, involving the parietal, frontal, and nasal (2).
17. Parietal ridge: absent (0); present (1).
18. Parietal supratemporal process: short (0); long (1); parietal and supratemporal separated by an additional skull bone (2).
19. Right and left parietals' anterior processes: contacting each other anteriorly, eliminating frontal from pineal foramen (0); narrowly separated anteriorly, forming parietal fork, and frontal dorsally visible along the pineal foramen (1); widely open, resulting in absence of clear fork (2).
20. Supratemporal posterior slope: absent (0); present (1).
21. Supratemporal posterior ridge: absent (0); present (1).
22. Supratemporal ventral process: absent (0); present (1).
23. Jugal/quadratojugal dorsal contact: absent (0); present (1).

24. Jugal shape: triradiate (0); lunate, or J-shaped (1).
25. Cheek orientation: mostly lateral (0); largely posterior (1).
26. Pterygoid, transverse flange: antero-lateral (0); postero-lateral (1); not well defined (2).
27. Interpterygoidal vacuity: present (0); absent, or extremely reduced (1).
28. Ectopterygoid: present (0); absent (1).
29. Basioccipital peg: clearly present (0); absent or extremely reduced (1).
30. Basioccipital extracondylar area: wide (0); reduced to a narrow band of concavity (1).
31. Basioccipital condyle: flat or slightly concave (0); hemispherical (1).
32. Angular lateral exposure: extensive, at least as high and anteriorly as surangular exposure (0); much smaller than surangular exposure (1).
33. Overbite: absent or slight (0); clearly present (1).
34. Snout extremely slender: no (0); yes (1).
35. Replacement teeth: appear outside the pulp cavity of the predecessor (0); inside (1).
36. Plicidentine: absent (0); present (1).
37. Tooth horizontal section: circular (0); disto-medially compressed (1); laterally compressed (2).
38. Posterior tooth crown: conical (0); rounded (1); flat (2).
39. Tooth size relative to the skull width: normal (over 0.1) (0); small (below 0.05) (1).
40. Maxillary tooth row: single (0); multiple (1).
41. Upper dental groove: present throughout jaw margin (0); only present anteriorly (1); absent (2).
42. Lower dental groove: present throughout jaw margin (0); only present anteriorly (1); absent (2).
43. Bony fixation of teeth: present (0); absent (1).
44. Pterygoidal teeth: present (0); absent (1).
45. Interclavicle shape: cruciform (0); triangular (1); T-shaped (2).
46. Scapula antero-dorsal margin: fan-shaped (0); emarginated (1); straight (2).
47. Scapular blade shaft: absent (0); present at least proximally (1).
48. Scapular axis and glenoid facet orientations: nearly parallel (0); at 60 degrees or more (1).
49. Coracoid facet on scapula: scapula and coracoid fused (0); absent (1); equal or smaller than glenoid facet of scapula (2); twice as large as glenoid facet (3).
50. Ossified sternum: absent (0); present (1).
51. Ossified cleithrum: present (0); absent (1).
52. Humerus distal articular facets: not terminal (0); terminal, radial facet being larger than ulnar facet (1); terminal, two facets being nearly equal (2).

53. Humerus anterior flange: absent (0); present and complete (1); present but reduced proximally (2).
54. Humerus relative width exclusive of anterior flange: much longer than wide (0); nearly squarish (1).
55. Humerus, distal and proximal ends, exclusive of anterior flange: nearly equal (0); distal end wider than proximal end (1).
56. Ridge on humerus plate-like: no (0); yes (1).
57. Humerus antero-distal facet for sesamoid: absent (0); present (1).
58. Propodial + epipodial versus manus length: propodial + epipodial longer (0); manus longer (1).
59. Radius peripheral 'shaft': complete or nearly complete (0); notch or largely reduced (1); absent (2).
60. Radius contiguous 'shaft': complete or nearly complete (0); notch or largely reduced (1); absent (2).
61. Radius L/W ratio: longer than wide (0); wider than long (1).
62. Ulna peripheral 'shaft': complete or nearly complete (0); notch or largely reduced (1); absent (2).
63. Ulna contiguous 'shaft': complete or nearly complete (0); notch or largely reduced (1); absent (2).
64. Radius/ulna relative size: nearly equal (0); radius much larger than ulna (1).
65. Radiale, anterior notch: absent (0); preaxially present (1).
66. Ulnare/intermedium relative size: ulnare larger than intermedium (0); intermedium larger than ulnare (1); intermedium lost (2).
67. Manual pisiform: present (0); absent (1).
68. Mc I peripheral 'shaft': complete or nearly complete (0); notch or largely reduced (1); absent (2); mc I not ossified (3).
69. Mc III 'shaft': present (0); absent (1).
70. Mc V peripheral 'shaft': complete or nearly complete (0); absent (1); mc V not ossified (2).
71. Manual digit 2 distal elements peripheral 'shaft': complete (0); largely reduced or notch (1); absent (2).
72. Manual accessory digit VI: absent (0); present (1).
73. Manual digit S4-5: absent (0); present (1).
74. Manual centralia: present (0); absent (1).
75. Manual anterior sesamoid e, and the digit distal to it: absent (0); present (1).
76. More than one extra anterior digit: absent (0); present (1).
77. Maximum phalangeal count: five or less (0); seven or more (1).
78. Interdigital separation: present (0); absent (1).
79. Forelimb/hindlimb ratio: nearly equal or hind longer (0); forelimb longer but less than twice as hindlimb (1); forelimb longer twice as much as hindlimb (2).
80. Iliac blade shape: (0) with thick shaft; (1) plate-like; (2) narrow and styloidal.
81. Iliac antero-medial prominence: (0) present; (1) absent.
82. Thyroid fenestra: absent (0); one median opening (1); two openings, being medially separated (2).

83. Ischium-pubis fusion in adults: complete (0); absent (1); present only medially (2); present medially and laterally (3).
84. Pubis, obturator foramen: completely enclosed in pubis (0); mostly in pubis but open on one side (1); part of obturator fossa (2); no foramen between the ischium and pubis (3).
85. Pubis, styloidal or plate-like: plate-like (0); styloidal (1).
86. Pubis/ischium relative length: nearly equal or ischium slightly larger than pubis (0); pubis twice as large as ischium (1).
87. Ischium, styloidal or plate-like: plate-like (0); styloidal (1).
88. Tibia and fibula: in contact or closely placed with each other (0); widely separated from each other (1).
89. Pes digit 1: present (0); absent (1).
90. Tibia L/W ratio: longer than wide (0); wider than long (1).
91. Tibia contiguous 'shaft': complete or nearly complete (0); absent (1).
92. Tibia peripheral 'shaft': complete or nearly complete (0); notch or largely reduced (1); absent (2).
93. Fibula posterior extent: not fixed, fibula being mobile relative to femur (0); much posterior to femur (1); about the same level as femur (2).
94. Atlantal pleuro centrum: separate from axis (0); fused with axis (1).
95. Presacral count: 30 or less (0); between 40 and 50 (1); 55 or more (2).
96. Caudal peak: absent (0); present (1).
97. Posterior dorsal centra shape: cylindrical (0); discoidal (1).
98. Mid-caudal centra height change: gradual decrease (0); increase (1); sudden decrease (2).
99. Cervical bicipital rib facet: absent (0); present (1).
100. Posterior-dorsal bicipital rib facet: absent (0); present, at least near pelvic girdle (1).
101. Antero-dorsal rib facets: confluent with anterior facet in at least some centra (0); not confluent in any of the centra (1).
102. Anterior dorsal neural spine: normal (0); narrow, high, and straight (1).
103. Neural spine anticlination in tail: absent (0); present (1).
104. Sacral ribs: two, distinguishable (0); not distinguishable (1).
105. Posterior gastralia: present (0); absent (1).

APPENDIX S4. The amended data matrix, showing taxa in rows and characters in columns.

	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	35
Petrolacosaurus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	?	0	0	0	0	0	?
Utatsusaurus	0	1	0	0	0	0	0	0	1	1	1	0	0	1	0	0	0	1	0	1	1	0	0	1	0	0	1	1	?	?	?	1	0	0	0
Grippia	0	1	0	0	0	0	0	0	1	1	1	0	1	1	0	0	0	1	0	?	?	?	0	1	0	0	?	?	?	?	?	1	0	?	0
Parvinatator	?	1	0	?	0	?	?	0	?	?	1	?	?	?	?	?	?	?	?	?	?	?	?	1	?	?	?	?	?	?	?	?	?	?	?
Chaohusaurus	?	?	?	?	?	0	0	?	?	1	?	?	?	?	?	?	?	?	0	?	?	?	1	1	?	2	1	?	?	?	?	1	0	1	?
Cymbospondylus	0	1	0	1	0	1	0	1	1	0&1	1	0&1	1	1&2	0	0&1	0	2	0&1	1	?	0	0&1	1	0	2	0&1	1	?	?	0	1	0	0	0
Mixosaurus	1	1	0	1	0	0	0	1	1	1	1	1	1	2	0	2	1	0	1	1	?	?	0&1	1	?	?	1	?	?	?	1	1	0	1	?
Phalarodon	1	1	0	0&1	0	0	0	1	1	1	1	1	1	2	0	2	1	0	1	1	1	1	1	1	0	2	1	1	?	?	?	1	?	?	0
Xinminosaurus	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	0
Besanosaurus	?	0	0	?	?	?	?	?	?	?	1	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	1	?	?	?
Shastasaurus	?	?	?	?	?	0	0	1	1	1	1	?	1	1	1	1	?	?	1	?	?	1	?	1	0	2	1	1	?	0	1	?	?	?	?
Shonisaurus	0	?	?	?	0&1	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	0	1	?	?	?	0
Callawayia	?	1	0&1	?	0	1	0	1	1	1	1	0	1	2	1	1	1	0	2	?	?	?	?	?	?	?	?	?	?	0	1	1	0	0	0
Guizhouichthyosaurus	0	1	0	0	0	1	0	1	1	1	1	0	1	1	1	1	1	?	1	?	1	?	0	1	?	2	0	?	?	?	?	1	?	0	?
Califomosaurus	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Toretocnemus	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	1	?	?	?	?	?	?	?	1	?	?	?
Qianichthyosaurus	1	1	0	?	0	0	0	1	1	1	1	?	1	1	?	1	1	?	?	1	?	?	?	1	?	?	1	?	?	0	1	1	0	1	0
Hudsonelpidia	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	0	?	?	?	?	?	?	?	?	0	?
Macgowania	2	0	?	1	?	?	?	1	1	?	1	1	?	?	?	?	?	?	?	?	?	?	?	1	0	?	?	?	?	?	?	1	0	0	?
Suevoleviathan	0&2	0	0&1	1	0	1	?	1	1	1	1	1	1	0	1	1	1	0	1	1	?	?	1	1	0	?	?	?	?	0	1	1	0	0	?
Temnodontosaurus	2	0	1	1	0	1	1	1	1	1	1	1	1	0&1	1	1	1	0&1	1	1	1	1	1	1	0	2	0	1	0	0	1	1	0	0	1
Leptonectes	2	0	0&1	1	0	0	0&1	1	1	1	1	1	1	0	0	1	1	0	2	1	1	1	1	1	1	2	0	?	?	0	1	1	0	1	?
Excalibosaurus	?	0	?	1	0	?	?	1	1	?	1	1	?	0	?	?	?	?	?	?	?	?	?	1	1	?	?	?	?	?	?	1	1	1	?
Eurhinosaurus	2	0	1	1	0	?	0	1	1	1	1	1	?	0	?	0	1	0	?	1	?	?	1	1	1	?	?	?	?	0	1	1	1	1	?
Ichthyosaurus	2	0	1	1	0	0&1	0	1	1	1	1	1	1	0	1	1	1	0	2	1	1	1	1	1	0	2	0	1	0	0	1	1	0	0	1
Stenopterygius	2	0	0&1	1	0	0&1	0&1	1	1	1	1	1	1	0	1	1	1	0	2	1	1	1	1	1	0	2	0	1	?	0	1	1	0	0	?
Brachypterygius	2	0	1	1	0	?	?	1	1	?	1	1	?	0	?	?	?	?	?	?	?	?	1	?	0	?	?	?	1	1	1	0	0	0	?
Ophthalmosaurus	2	0	0	1	0	1	0	1	1	1	1	1	1	0	1	0	1	0	2	1	1	1	1	1	0	2	0	1	1	1	1	0	0	0	1
Aegirosaurus	2	0	1	?	0	1	0	1	1	1	1	1	1	?	0	1	?	?	2	1	?	?	1	1	0	?	?	?	?	1	?	0	0	0	?
Caypullisaurus	2	0	1	1	0	?	?	?	?	?	1	1	1	?	?	?	?	?	2	?	?	?	1	1	0	?	0	?	?	1	?	0	0	0	?
Platypterygius	2	0&1	0&1	1	0	1	0&1	1	1	1	1	1	2	0	1	1	1	0	2	1	1	1	1	1	0	2	0	1	1	1	1	0	0	0	0
Maiaspondylus	2	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?

	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70
Petrolacosaurus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Utatsusaurus	1	1	0	1	0	0	0	0	0	0	0	0	0	1	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	1
Grippia	1	1	1	1	1	0	0	0	1	?	0	0	0	1	?	1	1	1	0	1	0	0	1	0	0	0	0	0	0	0	1	0	2	0	1
Parvinatator	1	1	0	0	0	?	?	?	?	?	?	?	?	1	?	?	?	?	?	0	?	0	0	0	0	0	0	0	0	0	?	0	1	0	?
Chaohusaurus	1	0&1	1	?	1	?	?	?	1	0	0	0	0	1	0	1	1	1	0	1	?	0	1	0	0	0	0	0	0	0	1	0	2	0	1
Cymbospondylus	1	0	0	0	0	?	0,1&2	0	1	?	1	0	0	1	0	1	1	1	0&1	0&1	0	0	?	0	0	0	1&2	0	0	0	?	?	?	0	1
Mixosaurus	0&1	0&2	1	0&1	0	0	0	0	1	1&2	0	0	0	1	0	1	1	1	0	1	0	0	1	0&1	0	0	2	0	0	0	1	0	2	0	1
Phalarodon	1	0&2	0&2	0	0	?	1	0	1	1	0	0	0	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Xinminosaurus	?	2	1	?	1	?	?	?	?	?	0	?	?	?	?	?	?	?	0	?	?	?	1	0	0	0	1	0	0	0	0	1	0	0	1
Besanosaurus	1	0	0	?	?	?	?	?	?	?	0	0	0	2	?	?	1	1	1	0	?	?	1	1	1	0	2	2	0	?	?	?	?	1	?
Shastasaurus	1	?	0	?	?	?	?	?	1	?	0	1	1	2	?	?	1	1	1	0	0	0	?	1	1	1	2	1	1	?	?	?	?	?	?
Shonisaurus	1	0	0	?	?	2	2	0	?	2	0	1	1	2	?	?	1	1	1	0	0	0	?	2	0	0	2	0	1	0	?	?	3	?	?
Callawayia	?	0	0	0	?	0	?	1	?	?	2	1	1	2	?	?	1	?	0&1	0&1	?	0	1	1&2	1	1	2	1&2	1	1	1&2	0&1	3	1	?
Guizhouichthyosaurus	1	0	?	?	?	?	?	1	?	?	0	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Californosaurus	?	0	?	?	?	?	?	?	?	?	0	0	0	3	?	?	2	2	1	0	?	?	?	1	0	0	1	0	0	1	1	1	3	?	?
Toretocnemus	1	0	0	0	0	0	?	1	?	?	?	?	?	2	?	?	2	1	0	?	?	0	?	1	0	0	2	0	0	1	1	1	3	1	2
Qianichthyosaurus	?	0	0	?	?	?	?	?	?	?	?	?	?	?	?	?	2	2	0	0	?	0	1	1	0	0	1	0	0	0&1	1	1	3	1	?
Hudsonelpidia	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	2	2	0	1	?	0	1	2	1&2	1	2	1&2	0	0	1	?	3	1	1
Macgowania	1	0	0	0	0	0	0	?	?	?	2	1	0	3	?	1	2	2	0	0	?	0	1	1	1&2	1	2	1&2	0	1	1	1	3	1	1
Suevoleviathan	1	0	0	0	?	?	0	?	?	?	2	1	0	3	0	1	2	2	0	1	0	0	1	2	2	1	2	2	0	1	1	1	3	1	1
Temnodontosaurus	1	0	0	0	0	0	0	1	1	2	2	1	0	3	0	1	2	2	0	1	0	0	1	1&2	2	1	2	2	0	0	1	1	3	1	2
Leptonectes	1	0	0	0&1	0	0	0	1	1	2	2	1	0	3	0	1	2	2	0	1	0	0	1	1&2	1&2	0&1	2	1&2	0	0&1	1	1	3	1	1
Excalibosaurus	1	0	0	1	0	0	0	1	1	?	2	1	0	3	0	1	2	2	0	1	0	0	1	1	2	1	2	2	0	1	1	1	3	1	2
Eurhinosaurus	1	0	0	1	0	0	0	1	1	2	2	1	0	3	0	1	2	2	0	1	0	0	1	2	2	1	2	2	0	1	1	0	3	1	1
Ichthyosaurus	1	0	0	0	0	0	0	1	1	2	2	1	0	3	0	1	2	2	0	0	0	0	1	2	2	1	2	2	0	0	0	0&1	3	1	1
Stenopterygius	1	0	0	0	0	0	0	1	1	2	2	1	0	3	0	1	2	2	0	1	0	0	1	1	2	1	2	2	0	1	1	0	3	1	1
Brachypterygius	1	0	0	0	0	0	0	1	1	2	2	1	?	?	?	?	2	2	0	0	1	0	1	2	2	1	2	2	0	0	1	0	3	1	1
Ophthalmosaurus	1	0	0	?	0	0	0	1	1	2	2	1	0	3	0	1	2	2	0	0	1	1	1	2	2	1	2	2	0	0	1	0	3	1	1
Aegirosaurus	?	?	?	?	?	?	?	?	?	2	?	?	?	?	?	?	2	2	0	0	1	0	1	2	2	1	2	2	0	0	1	0	3	1	1
Caypullisaurus	?	?	?	?	?	?	?	?	?	2	2	1	0	3	?	?	2	2	0	0	1	1	1	2	2	1	2	2	0	0	1	0	3	1	1
Platypterygius	1	0	0	0	0	0	0	1	1	?	?	1	0	2&3	?	?	2	2	0	0	1	0&1	1	2	2	1	2	2	0	0	0&1	0	3	1	1
Maiaspondylus	?	0	0	?	?	?	?	?	?	?	?	?	?	?	?	?	2	2	0	0	1	0	?	?	?	?	2	2	?	?	?	0	?	1	1

	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105
Petrolacosaurus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	?
Utatsusaurus	0	0	0	1	0	0	0	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	1	0	1	1	0	0	0	0	0	0	1	0	0
Grippia	0	0	0	1	0	0	0	1	?	?	?	?	1	0	0	?	?	?	?	?	?	?	?	?	?	?	0	?	1	1	?	0	?	?	0
Parvinatator	0	0	0	1	0	0	1	1	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Chaohusaurus	0	0	?	1	0	0	?	1	1	?	?	?	?	0	0	0	0	0	0	0	0	0	1	?	1	1	0	0	?	?	?	0	1	?	0
Cymbospondylus	?	?	?	?	0	0	?	1	?	1	1	1	1	0	0	0	0	0	?	0	0	0	1	0	2	1	1	0	1	0	0	0	1	?	0
Mixosaurus	0	0	0	1	0	0	1	1	1	1	?	1	1	0	0	1	0	0	0	0	0	0	1	?	1	1	1	1	1	1	0	1	1	1	0
Phalarodon	?	?	?	?	?	?	?	?	?	?	?	1	1	0	0	1	0	0	0	0	0	0	1	0	?	?	1	1	0	1	?	1	1	?	?
Xinminosaurus	0	0	0	1	0	0	0	1	?	?	?	?	?	?	?	?	?	0	?	0	0	0	1	?	2	1	?	?	?	?	?	?	1	?	?
Besanosaurus	?	?	?	?	?	?	?	1	?	1	1	?	?	1	0	0	0	0	?	?	0	0	1	?	2	?	1	0	1	?	0	?	?	?	1
Shastasaurus	?	?	?	?	?	?	?	?	?	?	?	?	?	1	0	?	?	?	?	?	?	?	?	?	?	?	1	?	1	?	?	0	?	?	?
Shonisaurus	?	?	0	1	0	0	?	?	1	1	1	?	1	1	0	0	0	0	?	1	0	0	1	?	2	?	1	0	1	0	?	?	?	?	?
Callawayia	1	0	0	1	0	0	1	1	?	1	1	1	1	2	0	0	0	0	1	0	0	0	2	0	2	?	1	0	1	0	0	0	0	?	?
Guizhouichthyosaurus	?	?	?	?	?	0	?	?	?	1	?	?	?	?	?	?	?	?	?	?	?	?	?	?	2	1	1	0	?	?	?	0	1	?	?
Californosaurus	?	?	?	1	?	?	?	1	?	1	0	1	?	2	0	0	0	?	?	0	0	0	1	?	1	1	1	2	?	?	1	0	?	1	?
Toretocnemus	1	0	0	1	0	0	1	1	?	2	?	1	1	0	0	0	0	0	1	0	0	0	2	?	?	?	?	?	?	1	?	?	?	?	?
Qianichthyosaurus	1	0	0	1	0	0	1	1	?	2	1	?	1	0	0	0	0	0	1	0	0	1	2	?	1	?	1	?	1	1	?	0	?	?	?
Hudsonelpidia	2	1	0	1	0	0	1	1	?	2	0	?	1	2	1	0	0	?	0	0	0	1	1	?	?	?	1	?	?	?	?	1	?	?	?
Macgowania	1	1	0	1	0	0	1	1	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	0	?	?	?
Suevoleviathan	2	1	1	1	0	0	1	1	1	1	0	2	1	2	1	0	1	0	1	1	1	1	2	?	1	1	1	2	1	1	1	0	?	1	1
Temnodontosaurus	1&2	0	0	1	0	0	1	1	1	2	1	2	2	2	1	0	1	0&1	1	1	1	1	2	1	1	1	1	2	1	?	1	0	?	1	?
Leptonectes	2	0	0	1	0	0	1	1	2	2	1	2	2&3	2	1	0	1	1	1	1	1	1	2	1	1	1	1	2	1	1	1	0	?	1	?
Excalibosaurus	2	0	0	1	0	0	1	1	?	?	?	?	?	2	?	?	?	?	?	?	?	?	?	?	1	1	1	?	?	1	?	?	?	?	?
Eurhinosaurus	2	0	0	1	0	0	1	1	1	2	1	2	1&2	2	1	0	1	1	1	1	1	1	2	1	1	1	1	2	1	1	1	0	?	1	?
Ichthyosaurus	2	1	0	1	0	0	1	1	2	2	1	2	1&2	2	1	0	1	0	1	1	1	2	2	1	1	1	1	2	1	1	1	0&1	0&1	1	1
Stenopterygius	2	1	1	1	0	0	1	1	2	2	1	2	3	2	1	0	1	0	1	1	1	1	2	1	1	1	1	2	1	1	1	0	0&1	1	1
Brachypterygius	2	1	0	1	1	0&1	1	1	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	1	?	?	1	?	1	1	0	?	?	?	?
Ophthalmosaurus	2	1	0	1	1	0	1	1	2	2	1	2	3	2	1	0	1	0	1	1	1	2	2	1	1	1	1	2	1	1	1	0	?	1	?
Aegirosaurus	2	1	0	1	1	0	1	1	2	2	?	0	3	3	1	0	1	0	1	1	1	2	2	?	1	1	1	?	?	?	?	0	?	?	?
Caypullisaurus	2	1	0	1	1	1	1	1	?	?	?	?	?	?	1	?	?	0	?	0	1	2	2	1	1	?	1	?	?	1	?	0	?	?	?
Platypterygius	2	1	0	1	1	1	1	1	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	1	1	1	1	2	1	1	?	0	?	?	?
Maiaspondylus	?	1	?	1	?	?	?	1	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	1	0	?	?	?	?	?	?	?