Appendix S1: Complete list of characters and modifications to the data matrix of RC07, with
 reports of new observations of specimens.

3 The names, the abbreviations and the order of all characters and their states are 4 unchanged from RC07 unless a change is explained. We renumbered the characters we did 5 not delete from 1 to 277, so the character numbers do not match those of RC07. However, 6 merged characters retain the abbreviations of all their components: PREMAX 1-2-3 (our 7 character 1) consists of the characters PREMAX 1, PREMAX 2 and PREMAX 3 of RC07, 8 while MAX 5/PAL 5 (our ch. 22) is assembled from MAX 5 and PAL 5 of RC07. We did not 9 add any characters, except for splitting state 1 of INT FEN 1 into the new state 1 of INT FEN 1 (ch. 84) and states 1 and 2 of the new character MED ROS 1 (ch. 85), undoing the merger 10 of PIN FOR 1 and PIN FOR 2 (ch. 91 and 92) and splitting state 0 of TEETH 3 into the new 11 12 state 0 of TEETH 3 (ch. 183) and the entire new character TEETH 10 (ch. 190). A few characters have additional states or are recoded in other ways. Deleted characters are retained 13 14 here, together with the reasons why we deleted them and the changes we made to their scores.

All multistate characters mention in their names whether they are ordered, unordered,
 or treated according to a stepmatrix.

Taxa are by default mentioned in the same order as in the matrix, at least within the same paragraph.

In the interest of making our scoring decisions transparent, the taxa we have added as separate OTUs are mentioned in cases where their scores could be controversial or, of course, when we report previously unknown scores for them based on pers. obs. of specimens. Their names are preceded by an asterisk; the names of taxa that are not included (but mentioned for comparison) are marked with two asterisks.

Similarly, scores we have decided not to change are mentioned in cases where they could be controversial. Lack of mention implies lack of change from RC07.

"Broiliellus" is *B. brevis* throughout; other species, including the type species *B. texensis*, were not considered (as explained in Material and methods: Treatment of OTUs:
Taxa added as parts of existing OTUs).

30 1. PREMAX 1-2-3: Caudodorsal process of premaxilla: broad, low, indistinct (0); alary 31 process (vaguely triangular, not occupying entire available mediolateral width at its 32 base) (1); moderately tall, vaguely rectangular, or acutely triangular but occupying the 33 entire mediolateral width between the nares and the median suture at its base (2); 34 narrow and long, along the sagittal plane or parasagittal (3) (unordered). Within state 3, 35 the mediolateral position of the process is not considered, because it probably depends on the 36 width of the premaxilla.

This character changes states from 0 to 1 in the ontogeny of *Apateon gracilis* (Schoch & Fröbisch, 2006); we have tried to take this into account when scoring OTUs known only from immature or paedomorphic individuals.

40 RC07 treated this character complex as three separate characters: PREMAX 1, "Premaxillary alary process: absent (0); present (1)"; PREMAX 2, "Premaxilla alary process shor-41 42 ter than wide (0) or as long as/longer than wide (1)"; and PREMAX 3, "Premaxilla alary 43 process less than (0) or at least one-third as wide as premaxilla (1)". Not only are PREMAX 2 44 and PREMAX 3 inapplicable when PREMAX 1 has state 0; they do not (even together) cover 45 the diversity of shapes of the contact between premaxilla and nasal seen in the taxon sample. 46 Accordingly, we have replaced all three characters by ch. 26 of Marjanović & Laurin (2009), 47 itself based on ch. 2 of Marjanović & Laurin (2008) and the work of Good & Wake (1992).

48 *Crassigyrinus* and *Microbrachis* were scored for PREMAX 2 and PREMAX 3 by 49 RC07 in spite of being also scored PREMAX 1(0), which, as mentioned, made PREMAX 2 and PREMAX 3 inapplicable. Some OTUs were scored for the latter two characters in spite of
 being also scored PREMAX 1(?), which had the same effect.

52 State 0 occurs in Eusthenopteron (Jarvik, 1967; Brazeau & Ahlberg, 2006), 53 Panderichthys (Vorobyeva & Schultze, 1991), Ventastega (Ahlberg et al., 2008), 54 Acanthostega (Clack, 2007), Ichthyostega (Clack & Milner, 2015: fig. 8), Whatcheeria 55 (Lombard & Bolt, 1995), Baphetes and Megalocephalus (Beaumont, 1977), Eucritta (Clack, 56 2001 – it looks like 2 in the reconstruction, but the photo strongly suggests the pieces of bone 57 in question are median rostrals rather than processes of the premaxilla), Chenoprosopus 58 (Langston, 1953), Cochleosaurus (Sequeira, 2004), Neldasaurus (Chase, 1965), Caerorhachis 59 (Ruta, Milner & Coates, 2002 – though 1 and 2 would also be more or less defensible scores), Echerpeton (Smithson, 1985, though this is somewhat arguable), Proterogyrinus (Holmes, 60 61 1984), Archeria (Holmes, 1989), Discosauriscus (Klembara & Ruta, 2005a), Keraterpeton, Batrachiderpeton, Ptvonius and Sauropleura (Bossy & Milner, 1998), Ariekanerpeton 62 63 (Laurin, 1996b; Klembara & Ruta, 2005a) and Utegenia (Laurin, 1996c; Klembara & Ruta, 64 2004a). We have further assigned state 0 to the frogs Notobatrachus (Báez & Nicoli, 2004), Vieraella (Báez & Basso, 1996) and *Liaobatrachus (Dong et al., 2013): their so-called alary 65 processes are entirely ventral to the nares and are laterally bordered by a neomorphic fenestra 66 67 that is more or less confluent with the naris on the same side.

68 Colosteus and Greererpeton are here tentatively scored 1 (Smithson, 1982; Hook, 69 1983; see Bolt & Lombard, 2010, for grounds for caution). State 1 further occurs in Isodectes (Sequeira, 1998), Trimerorhachis (Schoch & Milner, 2013), Balanerpeton (Milner & 70 71 Sequeira, 1994), Dendrerpetidae (Holmes, Carroll & Reisz, 1998), Eryops, Acheloma (Polley 72 & Reisz, 2011 – although it is arguably a special case), Ecolsonia (Berman, Reisz & Eberth, 73 1985), Amphibamus (Schoch, 2001), Doleserpeton (Bolt, 1969; Sigurdsen & Bolt, 2010), 74 Platyrhinops (Clack & Milner, 2010), Micromelerpeton (arguably borderline to state 3: 75 Schoch, 2009), Apateon (Schoch & Fröbisch, 2006), Karaurus (Ivachnenko, 1978: fig. 1; D. 76 M. and M. L., pers. obs. of unnumbered MNHN cast of PIN 2585/2), Dolichopareias 77 (Andrews & Carroll, 1991), Capetus (Sequeira & Milner, 1993) and, perhaps surprisingly, 78 *Utaherpeton (Carroll, Bybee & Tidwell, 1991: fig. 6.1, 7).

79 State 2 occurs in *Tulerpeton* (as far as can be told from the isolated premaxilla + 80 vomer; Lebedev & Clack, 1993), Crassigyrinus (Clack, 1998), Albanerpetidae, Eocaecilia (Jenkins, Walsh & Carroll, 2007), Pholiderpeton attheyi (Panchen, 1972), Anthracosaurus 81 82 (Clack, 1987a), Pholiderpeton scutigerum (Clack, 1987b), Bruktererpeton (Boy & Bandel, 83 1973), Gephyrostegus (Carroll, 1970; Klembara et al., 2014), Seymouria (Laurin, 1996a; see Marjanović & Laurin [2009: Electronic Supplementary Material 1] for discussion), Capto-84 rhinus (Fox & Bowman, 1966; Heaton, 1979), Petrolacosaurus (Reisz, 1981), Westlothiana 85 86 (Smithson et al., 1994), Batropetes (Carroll, 1991; Glienke, 2013), Tuditanus, Pantylus, Asa-87 phestera, Saxonerpeton, Hapsidopareion, Micraroter, Pelodosotis, Cardiocephalus, Hylople-88 sion and Odonterpeton (CG78), Rhynchonkos (CG78; Szostakiwskyj, Pardo & Anderson, 89 2015), Microbrachis (Vallin & Laurin, 2004), Stegotretus (Berman, Eberth & Brinkman, 90 1988), Diceratosaurus, Diplocaulus, Diploceraspis, Scincosaurus, Adelogyrinus, Silvanerpe-91 ton (Ruta & Clack, 2006) and Tseajaia (Moss, 1972).

State 3 occurs in *Phonerpeton* (Dilkes, 1990: fig. 3), *Eoscopus* (Daly, 1994), *Valdo- triton* (Evans & Milner, 1996), *Diadectes* (Berman, Sumida & Martens, 1998), *Limnoscelis*(Reisz, 2007; Berman, Reisz & Scott, 2010), *Lethiscus* (Pardo et al., 2017) and *Orobates*(Berman et al., 2004).

Unknown (but not scored as such by RC07) in *Edops* (Romer & Witter, 1942 – the
area is reconstructed in MCZ 1378: D. M., pers. obs.), *Leptorophus* and *Schoenfelderpeton*(Boy, 1986, 1987), *Triadobatrachus* (Roček & Rage, 2000), *Solenodonsaurus* (Laurin &
Reisz, 1999), *Kotlassia* (Bulanov, 2003), *Paleothyris* (Carroll, 1969b), *Adelospondylus*

102 (Warren, 2007), Pederpes (Clack & Finney, 2005); also unknown in *Gerobatrachus (Marjanović & Laurin, 2009: Electronic Supplementary Material 1). 103 104 Euryodus is polymorphic, possessing states 0 and 2 (CG78). 105 Brachydectes has state 1 or 2 (Wellstead, 1991; Pardo & Anderson, 2016). 106 Oestocephalus (specimen drawings in Carroll, 1998a) and Phlegethontia (Anderson, 107 2007a) have state 2 or 3. 108 *Acanthostomatops is polymorphic, in at least one case (Witzmann & Schoch, 2006a: 109 fig. 3D) showing states 1 and 2 on different sides of the same individual. 110 States 1 and 3 occur in "large adults" of *Glanochthon (Schoch & Witzmann, 2009b: 111 fig. 2). 112 The premaxillae of **Ouasicaecilia* are unknown, but the nasals make state 3 113 impossible (Pardo, Szostakiwskyj & Anderson, 2015); we have thus scored state 0, 1 or 2. 114 115 2. PREMAX 4: Premaxilla with flat, expanded anteromedial dorsal surface and 116 elongated along its lateral margin but not along its medial margin, when observed in 117 dorsal aspect: absent (0); present (1). This character is a case of non-additive binary coding; 118 it is likely that dividing state 0 (which is defined only as everything that is not state 1) into 119 several states would reveal further phylogenetic signal. 120 State 0 is present in Ventastega (Ahlberg, Lukševičs & Lebedev, 1994). We have kept 121 it for Acanthostega, Ichthyostega and the colosteids because the anteromedial surface is 122 probably not "expanded", although the lateral margin is much longer than the medial one (Clack, 2007; Bolt & Lombard, 2010; Porro, Rayfield & Clack, 2015; Clack & Milner, 2015); 123 124 the same holds for *Elginerpeton (Ahlberg, 1995). 125 State 1 is, however, present in *Phlegethontia* (Anderson, 2007a). 126 This character is invisible in **Saharastega*; there are so many fractures that each of 127 them could be a suture (D. M., pers. obs. of MNN MOR 73). 128 129 3. PREMAX 7: Ratio of maximum width of both premaxillae together to maximum 130 width of skull roof: ≥ 0.5 (0); |0.5-0.4| (1); |0.4-0.3| (2); |0.3-0.2| (3); < 0.2 (4) (ordered). The wording of this character, but not its scores, changed substantially between Ruta, Coates 131 132 & Quicke (2003) and RC07. Ruta, Coates & Quicke (2003) put it as follows: 133 "PREMAX 7. Premaxillae more (0) or less than (1) two-thirds as wide as skull. This 134 is a modified version of one of Gauthier et al.'s (1988b) characters, found ubiquitously among 'reptiliomorphs', and which characterizes also several lepospondyls and some primitive 135 136 lissamphibians (e.g. Eocaecilia; Carroll, 2000). Narrow premaxillae, even in stem-amniotes 137 showing broad and spade-shaped snouts (e.g. Discosauriscus; Klembara, 1997), contrast with 138 the broad premaxillae of temnospondyls and several stem-tetrapods." 139 Compare RC07:

"PREMAX 7. Premaxillae more (0) or less than (1) two-thirds as wide as skull table.
The total width of the conjoined premaxillae is measured as the distance between their
lateralmost extremities; the total skull table width is between the lateral extremities of the
suspensoria."

Thus, the 2007 version described the width of the skull, but called it "skull table width". This appears to be yet another instance of the constant confusion of the terms "skull roof" and "skull table" by RC07 (see main text). However, we have measured the total width of the premaxillae ("between their lateralmost extremities") and the maximum width of the skull roof ("between the lateral extremities of the suspensoria") in all taxa in this matrix (Data S5); it turns out that a ratio of 0.67 or more **does not occur in the original or the expanded**

(Andrews & Carroll, 1991), Urocordylus (Bossy & Milner, 1998), Leptoropha & Microphon

(Bulanov, 2003 – known to be 0 in juvenile skulls, but this could be ontogenetic), Ossinodus

100

taxon sample – except in *Caerorhachis* (Ruta, Milner & Coates, 2002), which was scored as
unknown in RC07. Only 11 OTUs even reach a ratio of 0.5. Moreover, the correlation
between the scores by RC07 and the ratios we have calculated is quite low (Appendix-Table
1), and it does not improve if we boldly interpret "two-thirds" as "one-third" (which would
give state 0 to 65 of the 127 measurable OTUs).

Because Ruta, Coates & Quicke (2003) claimed that this character carried phylogenetic signal, we did not want to simply delete it as parsimony-uninformative. We therefore speculated that the change from "skull" to "skull table" may in this case really have been a correction and measured the width of the skull table (see main text and legend to Data S5; including "tabular horns") in all taxa in this matrix as well. Indeed, 50 of 129 measurable OTUs have a ratio of two-thirds or more, but the correlation between the ratios we have found and the scores by RC07 remains extremely low (Data S5).

Except for a few cases of missing data, RC07 assigned state 1 to all amniotes, diadectomorphs, "microsaurs", seymouriamorphs, anthracosaurs, *Silvanerpeton, Gephyrostegus*, *Diplocaulus, Diploceraspis* and finally *Eocaecilia* (mentioned in the quote above), and state 0 to all the rest. It appears to us that they did not measure most OTUs at all, but instead scored them after presumed close relatives – which would be an example of circular logic, because those presumptions of relationship are the very hypotheses that their phylogenetic analyses aimed to test. We have therefore entirely discarded the original scores and state definitions.

169 Regardless of whether the skull table or the entire skull roof is measured, this 170 character is continuous; the question thus arises of how best to divide it into states, and 171 whether to choose the table or the whole roof. Concerning the second question, we have 172 arbitarily chosen the whole roof in order to conform to the definition by RC07 and the name 173 of the 2003 version of the character. The ideal solution to the first question would be stepmatrix gap-weighting (Wiens, 2001) as used by Marjanović & Laurin (2008), but PAUP* 174 only allows 32 states, while our matrix has 128 measurable OTUs with 122 different values 175 176 (so that arbitrary binning and averaging would have to be performed), and even with "only" 177 32 states the calculation time would skyrocket. The character lacks large morphological gaps 178 except toward the extremes, and it seems clear that the existing small gaps are artefacts of 179 taxon sampling because the taxa we have added have filled many (Appendix-Table 1; Data 180 S5). We have arbitrarily created a state for each interval of 0.1, with the two OTUs above 0.6 181 (Caerorhachis, Crassigyrinus) and the two below 0.1 (Diplocaulus, Diploceraspis) merged 182 into the neighboring bins to avoid making a near-uninformative state in Caerorhachis and 183 Crassigyrinus, and a near-uninformative state correlated with the famous boomerang shape of 184 the skull in *Diplocaulus* and *Diploceraspis*.

185 The ratios, sources, and state changes are presented in Appendix-Table 1; they and our 186 measurements are contained in Data S5.

Baphetes is polymorphic: *B. kirkbyi* has state 1 (Beaumont, 1977: fig. 21), *B. orientalis* changes from state 1 to state 0 in ontogeny (Beaumont, 1977: fig. 25; Milner, Milner & Walsh, 2009).

*Saharastega is too poorly preserved to measure, but states 0 and 4 can still be
excluded (D. M., pers. obs. of MNN MOR 73): the squished skull roof was something like 28
cm wide, the minimum width across both premaxillae is about 7 cm, the maximum about 12
cm, corresponding to ratios of 0.25 to 0.43 – adding further margins of error, we have scored
state 1, 2 or 3.

The skull roof width of **Archaeovenator* has not been reconstructed, but the ratio of premaxillary width to skull table width is 0.225 (Data S5; Reisz & Dilkes, 2003); it follows that the ratio of premaxillary width to skull roof width must have been 0.225 or lower, meaning states 3 or 4.

4

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Appendix-Table 1: Ratios of premaxillary width to skull roof width, and changes to the scores of character 3 (PREMAX 7). Taxa underlain in blue were scored 0 by RC07, taxa underlain in yellow were scored 1, and the remainder were scored as unknown or have been added by us; the latter are marked with an asterisk. Abbreviation: *Ph., Pholiderpeton.* See Data S5 and its legend for more information.

OTU	Ratio	New	Measured in:	
	(rounded)	score		
Brachydectes	0.780	0	Pardo & Anderson, 2016: fig. 4B	
Caerorhachis	0.689	0	Ruta, Milner & Coates, 2002	
Crassigyrinus	0.620	0	Clack, 1998	
Phlegethontia	0.569	0	Anderson, 2007a	
Ventastega	0.568	0	Ahlberg et al., 2008	
Cochleosaurus	0.556	0	Schoch & Milner, 2014: fig. 13D	
*Spathicephalus	0.544	0	Beaumont & Smithson, 1998: fig. 5	
*Erpetosaurus	0.541	0	Milner & Sequeira, 2011	
Eryops	0.535	0	Schoch & Milner, 2014: fig. 3C	
Dendrerpetidae	0.533	0	Dendrysekos: Schoch & Milner, 2014: fig. 17C	
Karaurus	0.508	0	Ivachnenko, 1978	
Edops	0.491	1	Schoch & Milner, 2014: fig. 13A	
Chenoprosopus	0.484	1	Schoch & Milner, 2014: fig. 13E	
Capetus	0.479	1	Sequeira & Milner, 1993	
*Konzhukovia	0.479	1	Gubin, 1991: drawing 6a	
Albanerpetidae	0.477	1	Celtedens: McGowan, 2002	
Orobates	0.469	1	Kissel, 2010: fig. 32B	
Balanerpeton	0.462	1	Schoch & Milner, 2014: fig. 17A	
Amphibamus	0.462	1	Schoch & Milner, 2014: fig. 30	
*Llistrofus	0.456	1	Bolt & Rieppel, 2009	
*Pholidogaster	0.452	1	Panchen, 1975	
Eucritta	0.446	1	Clack, 2001: fig. 8	
Ptyonius	0.446	1	Bossy & Milner, 1998	
*Sclerocephalus	0.445	1	Schoch & Witzmann, 2009a	
*Mordex	0.445	1	Schoch & Milner, 2014: fig. 32A	
*Micropholis	0.443	1	Schoch & Rubidge, 2005: fig. 3B	
Vieraella	0.440	1	Báez & Basso, 1996: fig. 6, 7	
Eoscopus	0.432	1	Daly, 1994: fig. 3	
Doleserpeton	0.430	1	Sigurdsen & Bolt, 2010	
Trimerorhachis	0.427	1	Schoch & Milner, 2014: fig. 20A	
*Acanthostomatops	0.426	1	Witzmann & Schoch, 2006a	
*Nigerpeton	0.419	1	Steyer et al., 2006	
Apateon	0.417	1	Schoch & Fröbisch, 2006: fig. 1D	
*Iberospondylus	0.411	1	Laurin & Soler-Gijón, 2006: fig. 1A; left side	
			approximately doubled	
Platyrhinops	0.408	1	Clack & Milner, 2010: fig. 9	
Panderichthys	0.407	1	Vorobyeva & Schultze, 1991	
Greererpeton	0.402	1	Smithson, 1982	
Lethiscus	0.402	1	J. Pardo, pers. comm. 2017	
Ichthyostega	0.404	1	Clack & Milner, 2015: fig. 8	
*Palatinerpeton	0.399	2	Boy, 1996: fig. 3	

Saxonerpeton	0.395	2	CG78: fig. 22			
*Glanochthon	0.392	2	Schoch & Witzmann, 2009b: fig. 2A			
			approximately doubled			
Eocaecilia	0.386	2	Jenkins, Walsh & Carroll, 2007			
Diadectes	0.385	2	Kissel, 2010: fig. 36B			
Valdotriton	0.377	2	Evans & Milner, 1996			
Phonerpeton	0.375	2	Dilkes, 1990: fig. 1			
*Deltaherpeton	0.370	2	Bolt & Lombard, 2010: fig. 2; left premaxilla			
			doubled, otherwise right side approximately			
			doubled			
*Gerobatrachus	0.370	2	estimated from Anderson et al., 2008a: fig. 2b			
Acanthostega	0.368	2	Porro, Rayfield & Clack, 2015			
*Cheliderpeton	0.366	2	Werneburg & Steyer, 2002			
Westlothiana	0.365	2	Smithson et al., 1994			
Isodectes	0.365	2	Schoch & Milner, 2014: fig. 20E			
Megalocephalus	0.362	2	Beaumont, 1977: fig. 8			
*Liaobatrachus	0.360	2	Dong et al., 2013			
Gephyrostegus	0.360	2	Klembara et al., 2014			
Asaphestera	0.358	2	CG78: fig. 7			
*Carrolla	0.355	2	Maddin, Olori & Anderson, 2011			
Acheloma	0.348	2	Polley & Reisz, 2011			
*Pangerpeton	0.346	2	estimated from Wang & Evans, 2006			
Ecolsonia	0.344	2	Berman, Reisz & Eberth, 1985: fig. 5A			
Micromelerpeton	0.341	2	Boy, 1995: fig. 8A			
Solenodonsaurus	0.339	2	Danto, Witzmann & Müller, 2012; maximum			
			possible width of premaxilla estimated			
*Saharastega	0.339	2	Damiani et al., 2006			
*Chroniosaurus	0.335	2	Clack & Klembara, 2009			
Silvanerpeton	0.333	2	Ruta & Clack, 2006			
Rhynchonkos	0.330	2	CG78: fig. 63			
Microphon	0.328	2	Bulanov, 2003: fig. 22			
Broiliellus	0.327	2	Carroll, 1964			
Eoherpeton	0.326	2	Panchen, 1975			
Schoenfelderpeton	0.325	2	Boy, 1986: fig. 13			
Colosteus	0.322	2	Hook, 1983			
Anthracosaurus	0.321	2	Clack, 1987a			
*Lydekkerina	0.320	2	Hewison, 2007: fig. 30			
Seymouria	0.317	2	Laurin, 1996a			
Keraterpeton	0.314	2	Bossy & Milner, 1998			
Paleothyris	0.313	2	Carroll, 1969b: fig. 4B			
Micraroter	0.313	2	CG78: fig. 56			
Ossinodus	0.309	2	Warren, 2007			
*Palaeoherpeton	0.306	2	Panchen, 1964			
Sauropleura	0.306	2	Bossy & Milner, 1998			
Oestocephalus	0.306	2	Anderson, 2003b			
Pelodosotis	0.304	2	CG78: fig. 48			
Euryodus	0.304	2	CG78: fig. 37			
*Tungussogyrinus	0.304	2	Werneburg, 2009			
Ph. attheyi	0.299	3	Panchen, 1972			

Discosauriscus	0.299	3	Klembara et al., 2006	
Leptorophus	0.298	3	Boy, 1986: fig. 4	
Pederpes	0.298	3	Clack & Finney, 2005	
Limnoscelis	0.298	3	Kissel, 2010: fig. 13A ¹	
Eusthenopteron	0.293	3	Clack, 2007	
Microbrachis	0.292	3	Vallin & Laurin, 2004	
Batropetes	0.291	3	Glienke, 2013: fig. 2	
*Caseasauria	0.290	3	Eothyris: Reisz, Godfrey & Scott, 2009	
*Archegosaurus	0.289	3	Witzmann, 2006: fig. 5	
Scincosaurus	0.289	3	Milner & Ruta, 2009	
Proterogyrinus	0.277	3	Holmes, 1984	
*Utaherpeton	0.272	3	Carroll, Bybee & Tidwell, 1991	
Stegotretus	0.271	3	Berman, Eberth & Brinkman, 1988: fig. 10B	
Hyloplesion	0.271	3	CG78: fig. 89B	
Ph. scutigerum	0.271	3	Clack, 1987b	
Ariekanerpeton	0.271	3	Klembara & Ruta, 2005a	
*Crinodon	0.268	3	CG78: fig. 11	
Captorhinus	0.266	3	Fox & Bowman, 1966: fig. 3	
Urocordylus	0.262	3	Bossy & Milner, 1998	
Neldasaurus	0.254	3	Schoch & Milner, 2014: fig. 20C	
Notobatrachus	0.252	3	Báez & Nicoli, 2004	
Diceratosaurus	0.250	3	Bossy & Milner, 1998	
Utegenia	0.250	3	Klembara & Ruta, 2004a	
Bruktererpeton	0.246	3	estimated based on Boy & Bandel, 1973: fig. 7	
Tseajaia	0.245	3	Berman, Sumida & Lombard, 1992: fig. 11	
Tuditanus	0.240	3	Carroll & Baird, 1968: fig. 9	
*Karpinskiosaurus	0.240	3	Klembara, 2011	
Petrolacosaurus	0.238	3	Berman, Sumida & Lombard, 1992: fig. 11	
Cardiocephalus	0.235	3	CG78: fig. 69	
*Pseudophlegethontia	0.233	3	Anderson, 2003b: fig. 3	
*Australerpeton	0.228	3	Eltink et al., 2016: fig. 5	
Archeria	0.227	3	Holmes, 1989	
*Chelotriton	0.226	3	Marjanović & Witzmann, 2015: fig. 7	
*Neopteroplax	0.222	3	Romer, 1963: fig. 3	
Kotlassia	0.216	3	Bulanov, 2003: fig. 30	
*Bystrowiella	0.203	3	Witzmann & Schoch, 2017: fig. 15C	
*Sparodus	0.193	4	Carroll, 1988	
*Platyoposaurus	0.193	4	Gubin, 1991: drawing 3a	
Odonterpeton	0.188	4	CG78: fig. 99B	
Batrachiderpeton	0.153	4	Bossy & Milner, 1998	
Pantylus	0.149	4	Romer, 1969: fig. 1	
Diplocaulus	0.091	4	Olson, 1951: pl. 5B left side doubled	
Diploceraspis	0.077	4	Beerbower, 1963: fig. 2	

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¹ A line drawing identical to Berman, Reisz & Scott (2010: fig. 3A), but slightly more convenient to measure.

4. PREMAX 8: Anteriormost surface of premaxilla oriented obliquely, so that mouth
opens subterminally: absent (0); present (1).

Ventastega (Ahlberg, Lukševičs & Lebedev, 1994) and *Lethiscus* (Anderson, Carroll
& Rowe, 2003; Pardo et al., 2017) have state 0.

215 *Panderichthys* is famous for having a subterminal mouth (state 1; e.g. Brazeau &
216 Ahlberg, 2006). This condition has also been reconstructed for *Ichthyostega* (Clack & Milner,
217 2015: fig. 8).

218 Unknown in *Edops* (Romer & Witter, 1942; D. M., pers. obs. of MCZ 1378).

Although we have kept the score of 1 for *Batropetes*, this seems to be a very weak case (Glienke, 2013, 2015).

Conversely, while the premaxillae of **Quasicaecilia* are unknown, the nasals themselves are recurved so that the nostrils opened on the ventral side of the snout (Pardo, Szostakiwskyj & Anderson, 2015); the mouth was inevitably subterminal, so we have scored state 1.

225

226 5. PREMAX 9: Maxilla in ventral view more or less limited to toothrow (0); contributes 227 to the palate labial to the choana for at least twice the width of the toothrow (1). The 228 original wording was: "Shelf-like contact between premaxilla and maxilla occurring mesial to 229 marginal tooth row on palate and extending medially for at least twice the width of such a 230 row: absent (0); present (1)", but it took us a long time to understand this wording. - From here on, RC07 consistently wrote "mesial" (toward the jaw symphysis, along the curvature of 231 232 the jaw) when they were clearly aiming at "medial" (toward the sagittal plane) and actually 233 meant "lingual" (toward the tongue, at 90° to the curvature of the jaw - caudal at the 234 symphysis, medial around the jaw joints).

Ventastega (Ahlberg, Lukševičs & Lebedev, 1994), most likely *Amphibamus* (Schoch
& Milner, 2014: fig. 30B; implicitly Daly, 1994), Albanerpetidae (McGowan, 2002, Venczel
& Gardner, 2005) and *Lethiscus* (Anderson, Carroll & Rowe, 2003) have state 0. We also
continue to consider the tiny teeth of frogs, which create a wide palatal contribution not only
labial to the choana, but along the entire length of the maxilla, as state 0, and have therefore
kept the scores of *Notobatrachus* and *Vieraella*.

241

Orobates has state 0 (Nyakatura et al., 2015: digital reconstruction).

In *Ossinodus* (Warren, 2007), the contribution of the maxilla to the palate lateral of the choana is easily twice as wide as the toothrow (not counting the very large caniniforms) at the caudal end of the choana (at the mediolateral suture to the palatine), but only about once as wide at the rostral end (at the suture to the premaxilla). We count this as state 1.

We have scored state 0 for **Perittodus* and **Aytonerpeton* after Clack et al. (2016: matrix).

248

249 6. TEC 1: Anterior tectal: present (0); absent (1). We follow Panchen (1967), Beaumont 250 (1977), Clack (1998) and RC07 in considering the septomaxilla homologous to the lateral rostral rather than the anterior tectal, because the septomaxilla lies caudal and/or ventral to the 251 252 naris, like the lateral rostral and unlike the dorsally positioned anterior tectal (contra 253 Sigurdsen & Green, 2011: supp. inf.), though we would like to point out that this question has 254 received disquietingly little attention in the literature. Clack et al. (2012a) presented a 255 phylogenetic, arguably scenario-based argument for the reduction and complete loss of the 256 lateral rostral and for the homology of anterior tectal and septomaxilla. We fear that this 257 question cannot be decided without new material, because at the moment the seeming 258 disappearance of the anterior tectal, the seeming disappearance of the lateral rostral, and the 259 seeming appearance of the septomaxilla are optimized as happening in indistinguishable 260 places in the tree – we need more fossil noses from the Late Devonian and the Mississippian. A good candidate for possessing both an anterior tectal and a septomaxilla is **Aytonerpeton*, but this is currently unclear and requires further study, if not further specimens (see below).

263 State 0 is almost certainly present in *Ventastega* (Ahlberg, Lukševičs & Lebedev, 264 1994).

The condition is unknown in *Colosteus* and *Greererpeton* (Bolt & Lombard, 2010), in *Whatcheeria* (Lombard & Bolt, 1995) and in *Batropetes* (Glienke, 2013, 2015).

Phonerpeton was scored as unknown in RC07. Although many sutures are difficult or
impossible to find in AMNH 7150 or MCZ 2313, there is no evidence for an anterior tectal in
either of them; in particular, the margins of both nares are undamaged in both skulls (D. M.,
pers. obs.). We have therefore scored state 1 for *Phonerpeton*.

271

State 1 is likewise present in *Lethiscus* (Pardo et al., 2017).

Due to the argument above, we have scored the mystery bone of **Ymeria* as the septomaxilla, so that the presence of the anterior tectal is unknown.

274 In *Pholidogaster, Panchen (1975) reconstructed state 1 with confidence. However, of 275 the two specimens, the type (which exposes the dorsal surface) has undergone compression and shearing (Panchen, 1975: 614; Bolt & Lombard, 2010), including but not limited to 276 277 disruption by the tusks on the dentary and the palatine (Panchen, 1975: fig. 11; Bolt & 278 Lombard, 2010) which could have obscured the distinction between a break and a suture 279 between the nasal, the anterior tectal and/or the prefrontal (the nasal-prefrontal suture is shown in fig. 11 as having an unusual shape and running in part in a lateral-line groove on the 280 281 strongly ornamented snout). The referred specimen is only exposed in ventral view and 282 heavily damaged medial to the septomaxilla (Panchen, 1975: fig. 13). Given that the only 283 illustrations (other than fig. 12, a not very large photograph of the type skull) are thick-lined line drawings, restudy of both specimens will be necessary – and perhaps insufficient – to 284 285 resolve this and related issues. In short, we have joined the skepticism of Bolt & Lombard 286 (2010) and scored this character as unknown.

Panchen (1964) thought that anterior tectals were present in **Palaeoherpeton*; we follow his later assessment (Panchen, 1972: 287) that these areas were in fact part of the lacrimals and have therefore scored state 1.

We accept the inference of Ahlberg (1995) that a slot on the premaxilla of **Elginerpeton* is the sutural surface for the anterior tectal, and have therefore scored state 0.

The septomaxilla identified in **Aytonerpeton* by Clack et al. (2016) is clearly an anterior tectal; we have scored state 0.

295 7. SPTMAX 1-2: Septomaxilla with exposure on skull surface (0), wholly inside nostril 296 (1), absent (2) (unordered). RC07 had deleted the character SPTMX 1 of Ruta, Coates & 297 Quicke (2003), which concerned the presence of the septomaxilla; SPTMX 2 was 298 "Septomaxilla a detached ossification inside nostril: no (0); yes (1)". We have assigned state 2 299 only to taxa of which many articulated skulls are known; otherwise we have interpreted ab-300 sence as possible post-mortem loss or incomplete preparation (as cautioned by RC07) and 301 scored it as partial uncertainty (state 1 or 2). Nonetheless, state 2 is present in Acanthostega 302 (Ahlberg, Lukševičs & Lebedev, 1994; Clack, 1994a, 2002, 2003b; Clack et al., 2012a; by 303 implication Porro, Rayfield & Clack, 2015), Microbrachis (no evidence of a septomaxilla in 304 100 inspected specimens: Olori, 2015), apparently Lethiscus (Pardo et al., 2017) and Phlege-305 thontia (Anderson, 2002, 2007a) as well as in Notobatrachus, from which no septomaxilla has 306 been reported despite the enormous number of known and superbly preserved individuals 307 (Báez & Basso, 1996; Báez & Nicoli, 2004, 2008); Acanthostega was scored SPTMAX 2(0) 308 by RC07, the others as unknown. - We have also assigned state 2 to the added OTU 309 *Sclerocephalus (Schoch & Witzmann, 2009a).

Panderichthys (Vorobyeva & Schultze, 1991), Baphetes (judging from the presence of 310 311 dermal ornament on the septomaxilla: Milner, Milner & Walsh, 2009), Trimerorhachis (Mil-312 ner & Schoch, 2013), Eocaecilia (Jenkins, Walsh & Carroll, 2007), Gephvrostegus (apparently: Klembara, 2014: fig. 5B) and Seymouria (Laurin, 1996a; Klembara et al., 2005) show state 313 314 0. While the septomaxilla is not preserved in Batropetes, Glienke (2013: 79) confidently 315 reconstructed state 0 for this taxon as well, "owing to the premaxilla and the naris" (and 316 presumably the prefrontal).

317 We have tentatively kept state 0 for *Ichthyostega* under the assumption that the lateral 318 rostral identified by Jarvik (1996) was correctly identified as such and is homologous to the 319 septomaxilla (see above); but we caution that it has not been found again (Clack & Milner, 320 2015).

321 Romer & Witter (1942) stated very explicitly that *Edops* has state 0. However, 322 assuming that both they and D. M. (pers. obs.) have traced the sutures in MCZ 1378 correctly, 323 the sculpture on the septomaxilla is much lower and finer than that on the rest of the skull 324 roof, and the surface lies on a more ventral level, bounded by a sharp vertical step formed by 325 the maxilla and the lacrimal (the margin of the nasal, which most likely participated, is not 326 preserved). This constitutes state 1. - The same condition occurs in *Pholidogaster (Panchen, 327 1975: 617).

328 Acheloma shows state 1 (Dilkes & Reisz, 1987). Phonerpeton, on the other hand, has 329 state 0 (D. M., pers. obs. of the type specimen, MCZ 1419).

330 State 1 is present in Doleserpeton (Sigurdsen & Bolt, 2010) as well as 331 Hapsidopareion, Micraroter and Rhynchonkos (CG78).

332 Following Clack & Milner (2010), we assign state 1 or 2 to Eoscopus and 333 *Platyrhinops*.

334 While Colosteus and Greererpeton have been reconstructed as possessing state 2 335 (Smithson, 1982; Hook, 1983), they should rather be scored as unknown (Bolt & Lombard, 2010). 336

337 **Acanthostomatops* is apparently polymorphic, showing states 0 and 1 (illustrations in 338 Witzmann & Schoch, 2006a). It is possible that this is ontogenetic, as state 0 is seemingly 339 only found in the largest specimens, but the sample size is probably not large enough to tell. 340

We have tentatively scored state 0 for *Ymeria as explained for TEC 1.

The septomaxilla identified in *Aytonerpeton by Clack et al. (2016) is clearly an 341 342 anterior tectal (see TEC 1 immediately above). Whether a septomaxilla is or was present is 343 unclear: the caudoventral rim of the naris is damaged, and a fragment bounded by the naris, 344 the anterior tectal, the lacrimal and the maxilla may or may not be the septomaxilla, as may be 345 the continuation of the maxilla in the naris (no sutures are visible anywhere in the 346 supplementary video).

347

348 8. NAS 1: Paired nasals: absent (0); present (1). We interpret this character as referring to 349 identifiable nasals as separate bones; Eusthenopteron and Panderichthys have a "postrostral 350 mosaic" (now state 84(0)) which contains several candidates for nasal homologues, so we 351 have scored them as unknown, unlike Diplocaulus and Diploceraspis, in which nasals are 352 definitely absent according to published descriptions.

353 Ventastega has state 1 (Lukševičs, Ahlberg & Clack, 2003, Ahlberg et al., 2008). 354 Bulanov (2003: fig. 30) reconstructed state 1 for Kotlassia; judging from the text (p. S53), this 355 appears to be correct.

356 Although there is evidence of nasals in *Palatinerpeton, the sagittal suture of the 357 dorsal side of the skull is entirely unknown (Boy, 1996), so we cannot tell if the presumed 358 nasals were fused and have scored *Palatinerpeton as unknown.

State 0 is present in *Panderichthys* (whichever bones actually are the nasals: Vorobyeva & Schultze, 1991), *Ventastega* (Ahlberg et al., 2008), *Microbrachis* (Vallin & Laurin, 2004), *Hyloplesion* (CG78), *Lethiscus* (Pardo et al., 2017), *Oestocephalus* (Carroll, 1998a; Anderson, 2003a) and *Phlegethontia* (Anderson, 2007a). Bulanov (2003: fig. 30) reconstructed state 0 for *Kotlassia*; judging from the text (p. S53), this appears to be correct.

11

State 0 is furthermore plesiomorphic for Albanerpetidae, as far as can be reconstructed from the fact that it occurs in both species of *Celtedens* (McGowan, 2002) as well as in *Albanerpeton pannonicum* (Venczel & Gardner, 2005). Only *A. inexpectatum* shows state 1 (Estes & Hoffstetter, 1976), if that reconstruction is even correct (Venczel & Gardner, 2005); 1 is the state RC07 ascribed to Albanerpetidae as a whole. Unfortunately, no other albanerpetids preserve nasals.

The state of this character is unknown in *Adelospondylus*, *Adelogyrinus* and *Dolichopareias* (Andrews & Carroll, 1991) and *Leptoropha* (Bulanov, 2003).

374

375 10. NAS 5: Narial margins of nasals parallel to each other and to the sagittal plane (0), at 376 an angle (so that, if extended as straight lines, they would meet rostral to the snout) (1). 377 The original wording, "Nasals broad plates delimiting most of the posterodorsal and me[d]ial 378 margins of nostrils and with lateral margins diverging abruptly in their anterior portions: 379 absent (0), present (1)", describes a combination of three characters: the length/width ratio of 380 the nasals (possibly correlated to the length-width ratio of the snout and thus probably to the 381 nasal/frontal length ratio, NAS 2, as well as the nasal/parietal length ratio, NAS 6), the 382 relative position of nasals and external nares (plausibly correlated to the position and shape of 383 the nasal-premaxilla suture, PREMAX 1-2-3), and the character described here.

384 This character is inapplicable when the nasal does not participate in the narial margin. 385 This is the case in Acanthostega, Ichthvostega and *Avtonerpeton, where the anterior tectal intervenes, in *Proterogyrinus* (Holmes, 1984), which has a premaxilla-lacrimal suture instead, 386 387 and possibly in Colosteus, Greererpeton and *Pholidogaster (Smithson, 1982; Hook, 1983; 388 Bolt & Lombard, 2010; see above under TEC 1 - ch. 6), in which the narial region is poorly 389 preserved and the premaxilla and the prefrontal or the anterior tectal may meet instead of the 390 nasal and the naris. The state of this character is furthermore unknown in Westlothiana (Smithson et al., 1994), Tuditanus (CG78) and Lethiscus (Wellstead, 1982; Anderson, Carroll 391 392 & Rowe, 2003).

393 State 0 is found contrary to RC07 in *Phonerpeton* (D. M., pers. obs. of AMNH 7150 394 and MCZ 2313), and *Ptyonius* (Bossy & Milner, 1998). We also assign state 0 to 395 *Phlegethontia* (Anderson, 2007a), where the margins form an extremely small angle, to 396 **Nigerpeton*, where in the best-preserved snout (Sidor, 2013) the left nasal only contributes to 397 the rostral margin of the naris, while the right naris forms a symmetric mediolateral notch in 398 the right nasal.

399 State 1 is almost ubiquitous, being found in Crassigyrinus (Clack, 1998), Whatcheeria 400 (Bolt & Lombard, 2000), Baphetes (adult) and Megalocephalus (Beaumont, 1977), Eucritta 401 (Clack, 2001), Chenoprosopus (Langston, 1953), Isodectes (Sequeira, 1998), Trimerorhachis 402 (Milner & Schoch, 2013), Dendrerpetidae (Holmes, Carroll & Reisz, 1998), Eryops (Sawin, 403 1941), Broiliellus (Carroll, 1964; Schoch, 2012), Eoscopus (Daly, 1994), Micromelerpeton 404 (though the least paedomorphic morphotype is somewhat borderline: Boy, 1995), Albaner-405 petidae (Venczel & Gardner, 2005), Eocaecilia (Jenkins, Walsh & Carroll, 2007), Caerorha-406 chis (Ruta, Milner & Coates, 2002), Eoherpeton (though this is not entirely clear: Panchen, 407 1975; Smithson, 1985), Archeria (Holmes, 1989), Pholiderpeton atthevi (Panchen, 1972), 408 Anthracosaurus (Clack, 1987a), Pholiderpeton scutigerum (Clack, 1987b), Bruktererpeton 409 (Boy & Bandel, 1973: pl. 8), Gephvrostegus (Carroll, 1970; Klembara et al., 2014), Soleno410 donsaurus (Danto, Witzmann & Müller, 2012: fig. 8A), Kotlassia (Bulanov, 2003: S53, S54), 411 Discosauriscus, Ariekanerpeton, Microphon and Utegenia (Bulanov, 2003, 2014; Klembara 412 & Ruta, 2004a, 2005a), Diadectes (Berman, Sumida & Lombard, 1992; Berman, Sumida & 413 Martens, 1998), Limnoscelis (Fracasso, 1983; Berman, Reisz & Scott, 2010), Captorhinus (Fox & Bowman, 1966; Heaton, 1979), Paleothyris (perhaps a bit borderline; Carroll, 1969b), 414 415 Petrolacosaurus (Reisz, 1981), Batropetes (Carroll, 1991; Glienke, 2013), Pantylus, Asaphestera, Saxonerpeton, Hapsidopareion, Micraroter, Pelodosotis, Rhynchonkos, Cardio-416 417 cephalus, Euryodus, Microbrachis, Hyloplesion and Odonterpeton (CG78; Vallin & Laurin, 418 2004; Szostakiwskyj, Pardo & Anderson, 2015), Stegotretus (Berman, Eberth & Brinkman, 419 1988), Brachydectes (Wellstead, 1991; Pardo & Anderson, 2016), Acherontiscus (Carroll, 420 1969a), Adelogyrinus and Dolichopareias (Andrews & Carroll, 1991), Batrachiderpeton 421 (Bossy & Milner, 1998), Diceratosaurus (Jaekel, 1903; A. C. Milner, 1980; Bossy & Milner, 422 1998), Oestocephalus (Carroll, 1998a), Capetus (Sequeira & Milner, 1993), apparently Oro-423 bates (Berman et al., 2004), Pederpes (Clack & Finney, 2005), Silvanerpeton (Ruta & Clack, 424 2006), and Tseajaia (Moss, 1972; Berman, Sumida & Lombard, 1992).

425

426 11. NAS 6: Parietal/nasal length ratio less than (0) or greater than 1.45 (1).

State 1 is known to occur in *Panderichthys* (no matter which of the candidates are in
fact the nasals: Clack, 2007), *Trimerorhachis* (Milner & Schoch, 2013), *Amphibamus* (Milner,
1982; Schoch & Milner, 2014), *Eocaecilia* (Jenkins, Walsh & Carroll, 2007), *Karaurus*(Ivachnenko, 1978), *Batropetes* (Glienke, 2013), *Asaphestera*, *Saxonerpeton*, *Cardiocephalus*and *Euryodus* (CG78), and *Brachydectes* (Wellstead, 1991; Pardo & Anderson, 2016).
Bulanov (2003: fig. 30) further reconstructed state 1 for *Kotlassia*; judging from the text (p.
S53), this appears to be correct.

Westlothiana is polymorphic: it shows state 1 on the left and (as scored by RC07) state 0 on the right side of the type specimen (Smithson et al., 1994). *Discosauriscus pulcherrimus* has state 0 as scored by RC07 (Klembara, 1997: fig. 33), while *D. austriacus* has state 1 (Klembara, 1997: fig. 27; Klembara et al., 2006: fig. 4C); we have accordingly scored polymorphism for *Discosauriscus*.

Unknown in *Stegotretus* (Berman, Eberth & Brinkman, 1988), *Acherontiscus* (Carroll,
1969a), *Adelospondylus*, *Adelogyrinus* and *Dolichopareias* (Andrews & Carroll, 1991);
inapplicable to *Phlegethontia*, where the parietals are absent (Anderson, 2002, 2007a).
Unknown and likely borderline in **Pholidogaster* (Panchen, 1975).

442 443

444 12. PREFRO 1: Separately ossified prefrontal: present (0); absent (1).

445 State 0 is present in *Ventastega* (Ahlberg, Lukševičs & Lebedev, 1994); we follow 446 Ascarrunz et al. (2016) in also scoring it for *Triadobatrachus*.

In **Palaeoherpeton* the sutures between the prefrontal, lacrimal and jugal have not been traced (Panchen, 1964); given the sutures to the postfrontal and the quadratojugal, we presume that if any of these bones was absent, that was the lacrimal (LAC 1(?)), so we have scored state 0 of the present character and also of PREFRO 7 while leaving the other PREFRO characters as unknown.

452 Similarly, the region where the suture between prefrontal and lacrimal would be 453 expected is not preserved in **Neopteroplax* (Romer, 1963: fig. 1); we have again concluded 454 that the presence of the lacrimal is unknown. Even so, however, **Neopteroplax* has PREFRO 455 2(0).

456 We have scored **Aytonerpeton* as unknown because the supplementary video of Clack 457 et al. (2016) hints that the supposed nasal may be composed of the nasal and the prefrontal. 458 460 [...] in dorsal aspect. 461 State 0 is present in *Ventastega* (Ahlberg et al., 2008). 462 Colosteus has state 0 regardless of how the prefrontal is reconstructed (Hook, 1983; 463 Bolt & Lombard, 2010). Greererpeton, however, does just reach state 1 even if a large 464 anterior tectal is assumed, so that it was scored correctly in RC07 in any case (Bolt & 465 Lombard, 2010). If the prefrontal is correctly identified as such, Triadobatrachus must share state 0 466 467 (Ascarrunz et al., 2016: fig. 12). 468 State 1 is found in Acanthostega (Porro, Rayfield & Clack, 2015), Eocaecilia (Jenkins, 469 Walsh & Carroll, 2007), Gephyrostegus (Klembara et al., 2014) and Solenodonsaurus (Danto, 470 Witzmann & Müller, 2012) as well as in Glienke's (2013, possibly also 2015) reconstructions 471 of Batropetes. 472 The adult specimen of Baphetes orientalis has state 0 on the left but state 1 on the 473 right side (Beaumont, 1977: fig. 25), making Baphetes polymorphic. 474 Albanerpeton pannonicum, the only albanerpetid that can be scored with confidence, 475 just barely reaches state 1 (Venczel & Gardner, 2005), so we ascribe this state to 476 Albanerpetidae as a whole. 477 Unknown in Lethiscus due to insufficient preservation (Pardo et al., 2017). 478 *Beivanerpeton is always close to the cutoff point, but at least one specimen has state 479 0 on the left and state 1 on the right side (Gao & Shubin, 2012: fig. 2); we have scored it as 480 polymorphic. 481 *Australerpeton is polymorphic, sometimes within an individual (Eltink et al., 2016: 482 fig. 2–5). 483 We have assigned state 1 to **Quasicaecilia* by measuring along the curve formed by 484 the orbit (Pardo, Szostakiwskyj & Anderson, 2015: fig. 3A). In strict rostrocaudal terms, the 485 prefrontal is about as long as it could be without extending dorsal to the nostril, and it is not as 486 short as it could be. 487 The stippled lines in Anderson (2003a: fig. 3A) are justified by Pardo et al. (2017: ext. 488 data fig. 4, video) to the extent of making state 1 very probable for **Coloraderpeton*. 489 490 14. PREFRO 3: Antorbital portion of prefrontal forming near-equilateral triangular 491 lamina: absent (0); present (1). State 0, which unites a wide range of different states, may 492 have to be split to reveal more phylogenetic signal. 493 State 0 is present in Ventastega (Ahlberg, Lukševičs & Lebedev, 1994) and 494 Solenodonsaurus (Danto, Witzmann & Müller, 2012) as well as in the most mature specimens 495 of Micromelerpeton (Schoch, 2009b; fig. 2b). 496 State 1 is documented in Ichthyostega (a larger version perhaps: Clack & Milner, 497 2015: fig. 8), Balanerpeton (arguably: Milner & Sequeira, 1994), Phonerpeton (Dilkes, 1990; 498 D. M., pers. obs. of AMNH 7150 and MCZ 2313), Kotlassia (Bulanov, 2003: fig. 30), Disco-499 sauriscus (both species, though sometimes borderline: Klembara, 1997), and Ariekanerpeton 500 (Klembara & Ruta, 2005a), and makes a surprise appearance in *Lethiscus* (Pardo et al., 2017: 501 extended data fig. 1a, b, 3b). 502 Baphetes is best scored as unknown because of its antorbital fenestrae. Even so, 503 however, the shape of the rostral end of the prefrontal only allows state 0 in Megalocephalus 504 (Beaumont, 1977) and *Spathicephalus (Smithson et al., 2017: fig. 3C). 505 *Eucritta* is polymorphic, sometimes within the same individual (Clack, 2001: fig. 6). 506 The condition is unknown in Valdotriton (Evans & Milner, 1996), Westlothiana 507 (Smithson et al., 1994) and Tseajaia (Moss, 1972; Berman, Sumida & Lombard, 1992). 13

13. PREFRO 2: Prefrontal less than (0) or more than (1) three times longer than wide

*Acanthostomatops is polymorphic, sometimes within the same individual (Witzmann
 & Schoch, 2006a). This may be at least partly ontogenetic, in that state 0 is only found in
 large individuals, but these same individuals are sometimes polymorphic.

512 deleted PREFRO 6: Prefrontal/premaxilla suture: absent (0); present (1).

State 0 is present in *Ventastega* (Ahlberg et al., 2008).

514 Unknown in *Colosteus* and *Greererpeton* (Bolt & Lombard, 2010; see above under 515 TEC 1 – ch. 6) as well as *Adelospondylus* (Andrews & Carroll, 1991). We have also scored 516 *Diplocaulus* as unknown, because it lacks nasals (see NAS 1 above) that would separate the 517 prefrontals from the premaxillae – just like *Diploceraspis*, which was already scored as 518 unknown.

519 State 1 is possibly present in *Albanerpeton inexpectatum*, but absent in *A. pannonicum* 520 and in *Celtedens* (Venczel & Gardner, 2005). According to Gardner, Evans & Sigogneau-521 Russell (2003), *Albanerpeton* and *Celtedens* are sister-groups; the condition in the sister-522 group to the clade formed by both, *Anoualerpeton*, is unknown. We consequently infer that 523 state 0 is the plesiomorphy for Albanerpetidae and have scored Albanerpetidae as possessing 524 state 0.

525 This reduces the distribution of state 1 to *Acherontiscus*, which is very fragmentarily 526 preserved (Carroll, 1969a); even accepting that *Acherontiscus* has state 1, the character is 527 parsimony-uninformative in the original taxon sample, so we have deleted it. This also 528 relieves us from worrying about correlation with PREFRO 8 (see below) – PREFRO 6(1) is 529 probably impossible without PREFRO 8(2) (which is unknown but likely in *Acherontiscus*).

530 State 1 is unambiguously present in **Utaherpeton* (Carroll, Bybee & Tidwell, 1991), 531 but, given the uncertainty in *Acherontiscus*, we have not reintroduced this character for the 532 analysis with added taxa, either as a character or as an additional state of PREFRO 8 (which 533 would then need a stepmatrix).

534535 15. PREFRO 7: Prefrontal without (0) or with (1) stout, lateral outgrowth.

536 State 0 is present in *Ventastega* (Ahlberg, Lukševičs & Lebedev, 1994), 537 *Triadobatrachus* (Ascarrunz et al., 2016: fig. 4, 12) and *Diploceraspis* (Beerbower, 1963).

538 State 1 is not limited to baphetids – *Karaurus* possesses a very clear case of it (Ivach-539 nenko, 1978; D. M. and M. L., pers. obs. of unnumbered MNHN cast of PIN 2585/2), and 540 *Acanthostega* has a small version (Porro, Rayfield & Clack, 2015).

541 We have scored **Spathicephalus* as polymorphic, although it is conceivable that the 542 observed distribution (*S. mirus*: 0; *S. marsdeni*: 1) is ontogenetic because the only known 543 specimen of *S. marsdeni* is half the size of that of *S. mirus* (Smithson et al., 2017).

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545 16. PREFRO 8: Caudal margin of external naris, including anterior tectal and 546 septomaxilla, formed by lacrimal/nasal contact (0) or maxilla/nasal contact (excluding 547 the lacrimal from the margin) (1); prefrontal entering nostril margin (2) (unordered). 548 The original wording was: "Prefrontal entering nostril margin: no (0); yes (1)." Now that we 549 have split state 0 to make explicit which conditions it represents, this character makes use of 550 the phylogenetic signal in the difference between the new states 0 and 1. We count the 551 anterior tectal and the septomaxilla as part of the naris even if the latter lies entirely on the 552 skull surface (as the former always does); this way, correlation with TEC 1 and SPTMAX 2 553 can be avoided.

554 State 0 is present in *Ventastega* (Ahlberg et al., 2008) and *Micraroter* (CG78).

555 State 1 is rare outside of stereospondylomorphs (**Sclerocephalus*, **Cheliderpeton*, 556 **Archegosaurus*, **Konzhukovia*, **Lydekkerina* [polymorphic, see below], **Glanochthon*, 557 **Platyoposaurus*, **Australerpeton*), but occurs in other particularly long-snouted animals, 558 namely Megalocephalus (Beaumont, 1977), Chenoprosopus (Hook, 1993; Reisz, Berman & 559 Henrici, 2005), Neldasaurus (Chase, 1965; Boy, 1993; Milner & Schoch, 2013), Pholiderpe-560 ton atthevi (Panchen, 1972), *Nigerpeton (Steyer et al., 2006) and probably *Saharastega 561 (unless the lacrimal had a quite unusual shape: Damiani et al., 2006; D. M., pers. obs. of 562 MNN MOR 73). However, state 1 is also found in the distinctly short-snouted Microphon 563 gracilis (even though M. exiguus and M. arcanus retain state 0, so that we have scored 564 *Microphon* as polymorphic; Bulanov, 2003); outside the present taxon sample, it is shared by 565 many short-snouted amniotes, and the snout of *Sclerocephalus is not all that long either.

We have kept state 2 for *Acheloma*, *Phonerpeton* and *Ecolsonia* (and also scored it for **Mordex*); however, an indeterminate juvenile trematopid (Dilkes, 1993: fig. 4) shows state 0 instead. This implies that the naris only reached the prefrontal later during its allometric growth (NOS 3(2)), which in turn suggests that the OTUs with NOS 3(2) should be scored as unknown for the present character; in **Mordex*, however, state 2 is already seen in an aquatic larva (Werneburg, 2012a: fig. 14d).

572 Unknown in *Colosteus*; *Greererpeton* (like **Pholidogaster*) has state 0 or 2 (Bolt & 573 Lombard, 2010; see above under TEC 1 – ch. 6). *Pholiderpeton scutigerum* has state 0 or 1.

In *Eocaecilia* (Jenkins, Walsh & Carroll, 2007), *Diploceraspis* (Beerbower, 1963), and *Phlegethontia* (Anderson, 2002), the lacrimal is absent, but the prefrontal is present. We have scored them as possessing the observed state 2 or the impossible state 0 – state 1 would be possible but is not observed. The presence of a lacrimal is unknown in *Valdotriton*, but we have scored it the same way because the prefrontal does appear to have reached the naris, and the maxilla would have needed an extremely tall process to reach the nasal (Evans & Milner, 1996: compare p. 632 to fig. 6b).

581 The lacrimal is likewise absent and the prefrontal present in **Chelotriton*; we have 582 scored it as possessing the observed state 1 or the impossible state 0.

583 Glienke (2013) stated that Batropetes fritschi and B. niederkirchensis have state 2, and 584 reconstructed both of them accordingly (if only in stippled lines for *B. fritschi*). Glienke 585 (2015: ch. 5) scored all four species as having state 2 – but stated (p. 7) and illustrated (fig. 586 1D) that *B. palatinus* just barely has state 0, and made clear (p. 15) that neither the prefrontal 587 nor the lacrimal of *B. appelensis* are well enough known to rule out any of the three states. 588 Glienke (2015) found *B. appelensis* to be the sister-group of the other three species together, 589 and B. palatinus as the closest relative of B. fritschi; consequently, the plesiomorphic state of 590 Batropetes cannot be determined without an outgroup, and we have scored Batropetes as 591 possessing both state 0 and state 2.

592 A rather clear case of state 2 occurs in *Lethiscus* (Pardo et al., 2017: especially 593 extended data figure 3b).

594 **Lydekkerina* has states 0 and 1 (Jeannot, Damiani & Rubidge, 2006).

We have scored state 0 or 2 for **Aytonerpeton*.

595

596 Incidentally, as for a few other characters (see below), RC07: 94 claimed that this 597 character "shows no clear phylogenetic pattern". Yet, the distribution of its states is far from 598 chaotic. According to Analysis R4, state 2 is an autapomorphy of Holospondyli (reversed in 599 Lethiscus, Batropetes palatinus, *Quasicaecilia and the Batrachiderpeton-Diplocaulus-600 *Diploceraspis* clade, as well as Lissamphibia in those trees where it lies within Holospondyli); 601 a synapomorphy of *Mordex, Acheloma, Phonerpeton, and Ecolsonia, reversed in the clade of 602 all other dissorophoids; and a synapomorphy of Isodectes and *Erpetosaurus (reversed in 603 Trimerorhachis). Clearly isolated occurrences of state 2 are limited to Crassigyrinus and 604 Karaurus. In total, there are only 11–12 transitions to or from state 2 for 150 OTUs.

16

- deleted PREFRO 9: Prefrontal/maxilla suture rostral to lacrimal: absent (0); present (1).
 The original wording did not distinguish a suture rostral to the lacrimal from a suture caudal
 to it; the latter condition is covered by LAC 2, see below.
- 609 State 0 is present in *Ventastega* (Ahlberg et al., 2008).

610 Unknown in *Colosteus* and *Greererpeton* (Bolt & Lombard, 2010) as well as 611 *Adelospondylus* and *Dolichopareias* (Andrews & Carroll, 1991).

- This character is inapplicable when the lacrimal is absent (LAC 1(1) below) or unknown; this is the case in *Eocaecilia* (Jenkins, Walsh & Carroll, 2007) and *Valdotriton* (Evans & Milner, 1996).
- 615 The redefinition further confers state 0 on *Karaurus* (Ivachnenko, 1978) and 616 *Diplocaulus* (Bossy & Milner, 1998).
- 617 This leaves state 1 solely to, probably, *Adelogyrinus* (Andrews & Carroll, 1991). The
 618 character is therefore parsimony-uninformative; we have accordingly deleted it.
 619

620 17. PREFRO 10: Prefrontal contributes to more (0) or less than (1) half of orbit
621 anterome[d]ial margin. We interpret "anteromesial margin" as the rostromedial/rostrodorsal
622 quarter of the orbit margin; state 1 means that less than half of this quarter is contributed by
623 the prefrontal. This character has to be scored as unknown for all baphetoids except *Eucritta*624 because the antorbital fenestra occupies at least the other half of this quarter.

- State 0 is present in *Ventastega* (Ahlberg, Lukševičs & Lebedev, 1994), *Ecolsonia*(Berman, Reisz & Eberth, 1985), *Amphibamus* (Milner, 1982: fig. 3a; Daly, 1994: fig. 18), *Platyrhinops* (Clack & Milner, 2010), *Schoenfelderpeton* (Boy, 1987), *Eocaecilia* (Jenkins,
 Walsh & Carroll, 2007), *Karaurus* (Ivachnenko, 1978) and *Urocordylus* (Bossy & Milner,
 1998).
- 630 State 1 is found in *Ichthyostega* (Clack & Milner, 2015), *Greererpeton* (Smithson, 631 1982), *Proterogyrinus* (Holmes, 1984), *Westlothiana* (Smithson et al., 1994), *Micraroter* and 632 *Hyloplesion* (CG78) and *Diploceraspis* (Beerbower, 1963). It also appears to be reached in 633 **Spathicephalus* (Smithson et al., 2017: fig. 3C).
- *Apateon* is polymorphic, sometimes within the same individual (Schoch & Milner,
 2008; Fröbisch & Schoch, 2009b). So is *Diplocaulus* (Bossy & Milner, 1998).

Unknown or borderline in *Eoscopus* (appears to be exactly borderline: Daly, 1994: fig. *Micromelerpeton* (Schoch, 2009b: fig. 2b), *Leptorophus* (Boy, 1987), *Valdotriton* (Evans & Milner, 1996), *Pholiderpeton scutigerum* (Clack, 1987b), *Bruktererpeton* (Boy & Bandel, 1973), *Lethiscus* (reconstructed as borderline: J. Pardo, pers. comm.; Pardo et al., 2017: ext. data fig. 3b, c, suggest state 0, but may not be in strict lateral view) and **Nigerpeton* (state 1 cannot be excluded: D. M., pers. obs. of MNN MOR 70).

- 642
- 643 18. LAC 1: Separately ossified lacrimal: present (0); absent (1).
- 644 *Eocaecilia* has state 1 (Jenkins, Walsh & Carroll, 2007), as does *Diploceraspis* 645 (Beerbower, 1963).
- 646The condition in Valdotriton (Evans & Milner, 1996) and Westlothiana (Smithson et647al., 1994) is unknown.
- 648

649 19. LAC 2: Contact between lacrimal and orbit (0); prefrontal contacts jugal or maxilla
650 at its orbital margin (1). We have added a mention of the maxilla to state 1 so that *Karaurus*,
651 which lacks jugals, can be scored (as having state 1).

This character is inapplicable when the lacrimal is missing, e.g. in *Eocaecilia* (see LAC 1 above). It is further inapplicable when the orbit has a large rostroventral extension that separates the jugal from the prefrontal, in other words, in OTUs with state ORB 3/LAC 5(2) – the baphetoids. Similarly, we have scored *Isodectes* and *Micromelerpeton* as unknown, where

- the lateral exposure of the palatine (state MAX 5/PAL 5(2)) is so long as to reach the
 prefrontal, excluding the lacrimal from the orbit margin entirely (Sequeira, 1998; Schoch,
 2009b: fig. 2b).
- 659 State 0 is now known in *Ossinodus* (Warren, 2007) and appears to be preserved in 660 *Kotlassia* (Bulanov, 2003: fig. 30).
- 661 The condition is unknown in *Proterogyrinus* (Holmes, 1984) as well as in 662 *Adelospondylus*, *Adelogyrinus* and *Dolichopareias* (Andrews & Carroll, 1991).
- 663 664

Crassigyrinus has both states, sometimes within the same individual (Clack, 1998).

- 665 20. LAC 4: Lacrimal without (0) or with (1) dorsome[d]ial digitiform process. Because 666 this process lies at the orbit margin, state 1 is impossible when the lacrimal does not 667 participate in the orbit margin; we have accordingly scored this character as unknown in all 668 taxa that have or may have state LAC 2(1), as well as in all baphetoids due to their antorbital 669 emargination.
- 670 We have further scored *Tseajaia* as unknown (Moss, 1972; Berman, Sumida & 671 Lombard, 1992; D. M., pers. obs. of CM 38033).
- 672 State 0 is now known in *Brachydectes* (Pardo & Anderson, 2016) and *Ossinodus*673 (Warren, 2007) and appears to be preserved in *Kotlassia* (Bulanov, 2003: fig. 30).
- 674 State 1 is documented in Albanerpetidae (Venczel & Gardner, 2005), *Pelodosotis* 675 (CG78) and probably borderline in *Microbrachis* (Vallin & Laurin, 2004).
- 676 *Colosteus* (Hook, 1983) is polymorphic. So is *Trimerorhachis*, where *T. insignis* has 677 state 1 but the other species all have state 0 (Milner & Schoch, 2013); this potentially 678 contradicts the finding by Milner & Schoch (2013) that *T. insignis* lacks autapomorphies. 679
- 680 LAC 5 is merged with ORB 3, see below.
- 681

deleted LAC 6: Portion of lacrimal lying anteroventral to orbit abbreviated: absent (0);
present (1). RC07 explained this character as follows: "In several lepospondyls (as well as in
some temnospondyls), the antorbital part of the lacrimal is considerably foreshortened,
regardless of relative snout proportions[,] and barely extends for one fourth of its total length
anteroventral to the orbit."

687 Despite this statement, and a similar one by Ruta, Coates & Quicke (2003: 307) which 688 names several lepospondyls as having state 1, state 0 is instead present in all "lepospondyls", 689 including Acherontiscus and the adelogyrinids, according to all sources. Usually the entire 690 lacrimal lies rostral to the orbit; even in small, large-eyed animals like Doleserpeton (Sigurd-691 sen & Bolt, 2010; correctly scored 0 in RC07), Batropetes (Carroll, 1991; Glienke, 2013, 692 2015). Microbrachis (Vallin & Laurin, 2004) and the urocordylids (Bossy, 1976), more than 693 half of it does. With state 0 occurring even in Acheloma (Bolt, 1974; Dilkes & Reisz, 1987; 694 arguably Olson, 1941) and Phonerpeton (Dilkes, 1990, 1993; D. M., pers. obs. of USNM 695 437796 and MCZ 2313), state 1 does not occur in this matrix at all despite having been 696 scored for 18 OTUs in RC07; this makes the character parsimony-uninformative, so we have 697 deleted it.

- In the future, this character could be made informative by redefining it to describe how much of the ventral margin of the orbit the lacrimal forms, that is, how far the lacrimal extends caudally rather than rostrally to the rostral margin of the orbit. If redefined in such a way, however, this character would have to be merged with MAX 5/PAL 5 (see below).
- 702

703 21. MAX 3-9: Caudal end of maxilla lying caudal to caudal margin of orbit (0), between
704 caudal margin of orbit and caudal margin of vomer (1), at the same level as the caudal

end of the vomer or rostral to it (2) (ordered). This character is ordered because potentially
 continuous characters should be ordered (Wiens, 2001; Grand et al., 2013).

RC07 used two separate characters, MAX 3 having the caudal margin of the orbit and MAX 9 the caudal margin of the vomer as the threshold. We have merged them because half of the states of these characters predicted each other – except in *Brachydectes* (see below), the vomer never extends caudal to the orbit, which means that MAX 3(0) predicted MAX 9(0), while MAX 9(1) required MAX 3(1).

State 0 occurs in *Cochleosaurus* (Sequeira, 2004), *Eocaecilia* (Jenkins, Walsh & Carroll, 2007), *Bruktererpeton* (Boy & Bandel, 1973), *Gephyrostegus* (most likely: Klembara et al., 2014) and *Lethiscus* (Pardo et al., 2017). We have also scored it for *Triadobatrachus*: although the caudal ends of the preserved fragments of the maxillae lie rostral of the caudal ends of the orbitotemporal fenestrae, they lie well caudal of the caudal margins of the largest possible eyes that would fit into the fenestrae (Ascarrunz et al., 2016: fig. 4, 12, 3D model 1).

State 1 is seen in *Batropetes* (Glienke, 2013, 2015) and most likely *Solenodonsaurus* (Danto, Witzmann & Müller, 2012). We have also scored it for *Brachydectes* where the caudal ends of orbit and maxilla variably coincide or nearly so (apparently independently of ontogeny – J. Pardo, pers. comm. – so that fig. 4A and 4C of Pardo & Anderson, 2016, represent different individuals), while the vomer has unusual caudal processes that extend farther caudal than both the orbit and the maxilla (Pardo & Anderson, 2016: fig. 4C).

Westlothiana has states 0 or 1 (Smithson et al., 1994). The same is the best score for Albanerpetidae (Venczel & Gardner, 2005: fig. 4, 8) and **Saharastega* (D. M., pers. obs. of MNN MOR 73). In several specimens of **Liaobatrachus*, however, the eyes themselves are preserved (Dong et al., 2013), so that its orbitotemporal fenestra does not prevent us from scoring state 0.

The maxillae of **Quasicaecilia* are unknown. State 0 is nonetheless ruled out by the fact that the jaw articulation lay well rostral of the caudal margin of the orbit; we have scored state 1 or 2.

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22. MAX 5/PAL 5: Ventral margin of the orbit formed by: lacrimal-jugal, prefrontal-733 734 jugal or lacrimal-postorbital suture (0); maxilla (1); lateral exposure of the palatine (2) 735 (unordered). This is another merger of two characters that partly predicted each other. State 0 736 includes cases where the mentioned suture is rostroventral to the orbit, so that the entire 737 ventral margin is formed by the jugal alone. It also includes the unique condition of 738 Trimerorhachis (excluding ?T. sandovalensis), where the jugal (let alone the maxilla and the palatine) is excluded from the orbit margin by a long lacrimal-postorbital suture (Milner & 739 740 Schoch, 2013); making this condition a state of its own would be pointless, because it is 741 unique, and would necessitate a stepmatrix for this character, so we have kept the score of 0 742 for Trimerorhachis.

When the jugal is absent (see JUG 1 below: *Triadobatrachus*, *Brachydectes*, **Beiyanerpeton*), state 0 and 1 cannot be distinguished; when the palatine is absent (see VOM 5-10/PAL 8/PTE 10-12-18/INT VAC 1 below: *Oestocephalus*; *Phlegethontia* as already scored by RC07), states 1 and 2 cannot be distinguished; when both are absent (*Karaurus*, *Valdotriton*, *Notobatrachus*, ?*Vieraella*, **Liaobatrachus*, **Pangerpeton*, **Chelotriton*), this character is entirely inapplicable.

Apateon was scored as showing state 1 in RC07, but acquired state 2 after metamorphosis, judging from the one known adult specimen of *A. gracilis* (Schoch & Fröbisch, 2006); we have scored state 2. *Schoenfelderpeton* was given state 1 or 2 by RC07; we have scored it (and also **Tungussogyrinus*) as unknown because the jugal does not (yet) extend to the region ventral to the orbit in the first place in the known specimens. Among albanerpetids, only *Albanerpeton pannonicum* can be scored with confidence; it shows state 0. The dorsal margin of the maxilla is similar enough in all albanerpetids that Venczel & Gardner (2005) consider it likely that the same state prevailed throughout Albanerpetidae.

- 758 State 0 further occurs in *Ossinodus* (Warren, 2007).
 - Rhynchonkos has state 1 (Szostakiwskyj, Pardo & Anderson, 2015).

Sigurdsen & Green (2011: appendix 2) stated that this character was unknown in
 Amphibamus; Schoch & Milner (2014: fig. 30A), however, showed state 2 in a new
 reconstruction based in part on Schoch's personal observations. We have therefore tentatively
 scored state 2.

764 Acheloma dunni is a special case, in that (Polley & Reisz, 2011) the palatine and the 765 ectopterygoid are exposed laterally (like in state 2) but do not participate in the orbit margin, being separated from the latter by a very long lacrimal-jugal suture (state 0). We have kept its 766 767 score of 0, not least because A. cumminsi lacks a lateral exposure of the palatine altogether 768 (Polley & Reisz, 2011), but caution that this may be ontogeny- or size-related: perhaps, as the 769 orbit shrinks in relation to the rest of the skull, state 2 would generally turn into state 0 and 770 leave such a lateral exposure of the palatine that does not participate in the orbit margin. This 771 idea may be supported by the fact that in *Phonerpeton* (already scored as polymorphic), AMNH 7150 shows state 2 on the left side but possibly reaches state 0 on the right (Dilkes, 772 773 1990: fig. 3; D. M., pers. obs.).

- *Caseasauria has states 0 and 1 (*Eothyris* has state 1, *Oedaleops* has state 0, and the
 condition in *Eocasea* is unknown: Reisz, Godfrey & Scott, 2009; Reisz & Fröbisch, 2014).
- 23. MAX 6: Maxillary arcade closed (0) or open (1) posteriorly. In state 1, the orbit is open
 (caudo)ventrally; (caudo)ventrally open temporal fenestrae as in *Oestocephalus* and most
 likely **Coloraderpeton* do not prevent state 0.
 - State 0 appears to be preserved in *Kotlassia* (Bulanov, 2003: fig. 30).

781 *Schoenfelderpeton* is now scored as unknown (like **Tungussogyrinus*), because the 782 observed condition (state 1) is likely due to paedomorphosis, if not indeed larval age of the 783 known individuals. This is based on the ontogeny of its close relative *Apateon*.

Brachydectes, in contrast, is now scored as possessing state 1; from what is known of the ontogeny of this "lepospondyl", there is no evidence it would ever have reached state 0 (Pardo & Anderson, 2016). The jugal and the quadratojugal bones are lacking entirely (see JUG 1 and QUAJUG 1 below).

Notobatrachus reigi has state 0 (Báez & Nicoli, 2008). As the jugal and the
quadratojugal are absent in *N. degiustoi* (Báez & Nicoli, 2008), and the caudal end of the
maxilla is not received by the palatine as it is in *Brachydectes*, we interpret the open maxillary
arcade of *N. degiustoi* as inapplicable and have scored *Notobatrachus* as possessing state 0.
Unknown in *Triadobatrachus* (all sources).

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794 24. MAX 7: Dorsal margin of maxilla forming distinct dorsal 'step': no (0); yes (1).

State 1 is not confined to pantylids – it occurs in *Broiliellus* (Carroll, 1964: fig. 9B) and *Doleserpeton* (Sigurdsen & Bolt, 2010) as well as some but not all specimens of **Glanochthon* (Schoch & Witzmann, 2009b). Surprisingly, it is also found in **Pholidogaster* (Panchen, 1975: fig. 15) and **Neopteroplax* (Romer, 1963: fig. 4 – less well visible in fig. 1), even though both have state MAX 8(0) and in the former the entire maxilla lies ventral to the nostril; these cases show that this character is independent from MAX 8.

801 **Platyoposaurus* shows a borderline condition (Gubin, 1991: drawing 3) that we have 802 also counted as state 1. We have further counted the condition in **Erpetosaurus*, where the nares lie so far dorsomedial that the maxillae, which have state MAX 8(0), have a long
 dorsomedial process to reach their ventrolateral margin (Milner & Sequeira, 2011).

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806 25. MAX 8: Dorsal margin of maxilla: low compared to naris and/or septomaxilla (0); tall and rounded (1); distinct process (2) (unordered). The original wording mentions an 807 808 "approximately rectangular flange", which is called "subrectangular" in the next sentence; 809 such a condition does not occur in the taxon sample (except arguably **Iberospondylus*) – the 810 dorsal process (if present) is always rounded and/or triangular to varying degrees. 811 Furthermore, there were unambiguous mistakes in the scoring - Triadobatrachus was scored 812 as possessing the (sub)rectangular process even though the whole region is unknown. Rather 813 than jettisoning this character, we have coded the states that we see in the sampled taxa. The 814 character is unordered because intermediates between 1 and 2 as well as directly between 0 815 and 2 exist, see below.

816 State 0: Eusthenopteron, Panderichthys and Acanthostega (Long & Gordon, 2004; 817 Porro, Rayfield & Clack, 2015), Ventastega (Ahlberg, Lukševičs & Lebedev, 1994; Ahlberg et al., 2008), Ichthyostega (Ahlberg, Clack & Blom, 2005), Colosteus (Hook, 1983), Greerer-818 819 peton (Smithson, 1982), Crassigyrinus (Clack, 1998), Whatcheeria (Lombard & Bolt, 1995), 820 Baphetes and Megalocephalus (Beaumont, 1977), Edops (Romer & Witter, 1942; D. M., pers. obs. of MCZ 1378), Chenoprosopus (Hook, 1993), Isodectes (Sequeira, 1998), Trimerorha-821 822 chis (Case, 1935; Milner & Schoch, 2013), Balanerpeton (Milner & Sequeira, 1994), Dend-823 rerpetidae (A. R. Milner, 1980, 1996; Godfrey, Fiorillo & Carroll, 1987; Holmes, Carroll & 824 Reisz, 1998), Eryops (Sawin, 1941), Acheloma (Bolt, 1974), Ecolsonia (Berman, Reisz & 825 Eberth, 1985), Broiliellus (Carroll, 1964; Schoch, 2012), Eoscopus (Daly, 1994; Hutten-826 locker, Small & Pardo, 2007), Platyrhinops (Schoch, 2002: fig. 4), Micromelerpeton (Boy, 827 1995), Eocaecilia (Jenkins, Walsh & Carroll, 2007), Caerorhachis (Ruta, Milner & Coates, 828 2002), Eoherpeton (Panchen, 1975; Smithson, 1985), Proterogyrinus (Holmes, 1984), Ar-829 cheria (Holmes, 1989), Pholiderpeton atthevi (Panchen, 1972), Anthracosaurus (Panchen, 830 1977), Pholiderpeton scutigerum (Clack, 1987b), Bruktererpeton (Boy & Bandel, 1973), Ge-831 phyrostegus (Brough & Brough, 1967), Solenodonsaurus (Laurin & Reisz, 1999), Kotlassia 832 (Bulanov, 2003), Discosauriscus (Klembara, 1993, 1997; Klembara et al., 2006, 2007), 833 Seymouria (Laurin, 2000; Klembara et al., 2005), Diadectes (Berman, Sumida & Lombard, 834 1992; Berman, Sumida & Martens, 1998), Limnoscelis (Romer, 1946; Berman, Reisz & Scott, 835 2010), Captorhinus (Heaton, 1979), Paleothyris (Carroll, 1969b), Petrolacosaurus (Reisz, 836 1981), Westlothiana (Smithson et al., 1994), all "microsaurs" (CG78; Berman, Eberth & 837 Brinkman, 1988; Caroll, 1991; Glienke, 2013, 2015; Szostakiwskyj, Pardo & Anderson, 838 2015) except Pantylus (which has state 2: Romer, 1969; CG78), Brachydectes (Wellstead, 839 1991: Pardo & Anderson, 2016). Acherontiscus (Carroll, 1969a). Dolichopareias (Andrews & 840 Carroll, 1991), all "nectrideans" (Jaekel, 1903: pl. II; Moodie, 1912; Bossy & Milner, 1998; 841 Milner & Ruta, 2009) except Diploceraspis (unknown because the skull is so flattened and it 842 is not clear if maxilla and lacrimal are separate: Beerbower, 1963), Lethiscus (Pardo et al., 843 2017), Oestocephalus (Carroll, 1998a), Phlegethontia (Anderson, 2002), Ariekanerpeton 844 (Laurin, 1996b; Klembara & Ruta, 2005a), Capetus (Sequeira & Milner, 1993), Orobates 845 (Berman et al., 2004), Pederpes (Clack & Finney, 2005), Silvanerpeton (Ruta & Clack, 2006), 846 Tseajaia (Moss, 1972; D. M., pers. obs. of CM 38033) and Utegenia (Laurin, 1996c; Klem-847 bara & Ruta, 2004a).

State 1: *Cochleosaurus* (Sequeira, 2004: fig. 8A), *Phonerpeton* (Dilkes, 1990; D. M.,
pers. obs. of AMNH 7150 – counting the orbit and the lateral exposure of the palatine rather
than the caudodorsal expansion of the naris), *Karaurus* (Ivachnenko, 1978), *Leptoropha* and *Microphon* (Bulanov, 2003), *Ossinodus* (Warren, 2007), arguably **Iberospondylus* (Laurin &
Soler-Gijón, 2006) and apparently **Mordex* (Werneburg, 2012a: fig. 17b); a surprise

appearance occurs in **Aytonerpeton* (Clack et al., 2016: fig. 4 and especially supplementary
video 2).

State 2: *Doleserpeton* (Sigurdsen & Bolt, 2010), *Apateon* (Werneburg, 1991: fig. 2, 5), *Leptorophus* (somewhat uncertain: Boy, 1986), *Schoenfelderpeton* (Boy, 1986),
Albanerpetidae where codable, though close to state 0 (unknown in *Celtedens*: McGowan,
2002; unique condition in *Anoualerpeton priscum*: Gardner, Evans & Sigogneau-Russell,
2003: fig. 3D₁), *Pantylus* (Romer, 1969; CG78), *Notobatrachus* (like Albanerpetidae: Estes &
Reig, 1973; Báez & Nicoli, 2004).

Unknown: *Eucritta* (Clack, 2001 – the fossils are so crushed and split through the bone that the photo, the specimen drawing, the reconstruction, and the text do not really cooperate), *Adelospondylus* and *Adelogyrinus* (Andrews & Carroll, 1991).

We have scored *Neldasaurus* as possessing state 0 or 1 because of its intermediate condition (Chase, 1965). *Amphibamus* is scored the same way based on Schoch (2001: fig. 4), because illustrations of its skull in lateral view do not seem to exist. *Vieraella* is likewise partially uncertain (Estes & Reig, 1973; Báez & Basso, 1996).

Valdotriton has state 1 or 2 ("The maxillae bear facial processes of uncertain size":
Evans & Milner, 1996: 632).

- Because *Eothyris* has state 1 on the right and state 2 on the left side (Reisz, Godfrey &
 Scott, 2009; D. M., pers. obs. of MCZ 1161), we have scored polymorphism for *Caseasauria.
 All three states occur in **Glanochthon* (Schoch & Witzmann, 2009b: fig. 2).
- 873

874 26. FRO 1: Frontal unpaired (0) or paired (1).

875 State 0 is a very rare condition in this matrix. It is called 0 instead of 1 because RC07 876 assigned it to the outgroup (Eusthenopteron), but the large unpaired bone in the "snout 877 mosaic" is just one of several possibilities for homologues of the frontals. (It is reminiscent of 878 the "pineal plate" of stem-gnathostomes.) Judging from the fontanelle of Ventastega (Ahlberg 879 et al., 2008) and Acanthostega (Clack, 2003b; Porro, Rayfield & Clack, 2015), it is at least as 880 probable that the large median bone disappeared and lacks a homologue in limbed vertebrates 881 (except possibly the sporadic interfrontal/interfrontonasal, see IFN 1 below), while one of the 882 bone pairs lateral to it is homologous to the frontals. We have accordingly scored 883 *Eusthenopteron* as unknown.

State 1 is present in *Ventastega* (Lukševičs, Ahlberg & Clack, 2003; Ahlberg et al.,
2008).

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887 27. FRO 2: Frontals shorter than parietals (0), approximately equal in length (1), or
888 longer than parietals (2) (ordered). We have exchanged states 1 and 2 to make it possible to
889 order this continuous character. In part, it appears, RC07 had already done that in the matrix
890 but not in the character list.

State 1 or 2 is present in *Ventastega* (Ahlberg et al., 2008). We have also scored state 1
or 2 for *Crassigyrinus*: state 1 is present in the reconstruction by Clack (1998), which has the
postfrontals meeting each other between the frontals and the parietals – given the stippled
lines and poor preservation of the skull surface, we do not feel confident about this.

The frontals become longer in the ontogeny of *Apateon*; adults have state 2 as already scored (Schoch & Fröbisch, 2006). For this reason, we have scored *Leptorophus* as having state 1 or 2, and *Schoenfelderpeton* as unknown.

Neldasaurus (Chase, 1965, though arguably borderline), Broiliellus (Carroll, 1964;
Schoch, 2012), Pantylus (Romer, 1969; CG78), Adelogyrinus (Andrews & Carroll, 1991),
Diceratosaurus, Diplocaulus and Ptyonius (Bossy & Milner, 1998) and Diploceraspis
(Beerbower, 1963) show state 0.

902State 1 is found in *Trimerorhachis* (Milner & Schoch, 2013), *Micromelerpeton*903(Schoch, 2009b: fig. 2b) and *Eocaecilia* (Jenkins, Walsh & Carroll, 2007).

Acanthostega (Clack, 2007; Porro, Rayfield & Clack, 2015), Ichthyostega (Clack &
Milner, 2015: fig. 8), Saxonerpeton, Pelodosotis and Rhynchonkos (CG78; Szostakiwskyj,
Pardo & Anderson, 2015: fig. 1), Sauropleura (Bossy, 1976, Bossy & Milner, 1998) and
Lethiscus (Wellstead, 1982) show state 2.

908 The condition of *Pholiderpeton scutigerum* (Clack, 1987b), *Dolichopareias* (Andrews 909 & Carroll, 1991) and *Ossinodus* (Warren, 2007) is unknown.

910 States 0 and 1 are reconstructed for different albanerpetids (Venczel & Gardner, 911 2005); we have scored both states. Both also seem to occur in different species of *Batropetes* 912 (Glienke, 2013, 2015), where neither is clearly plesiomorphic.

States 1 and 2 are both found in *Balanerpeton* (left vs. right side: Milner & Sequeira,
1994) and *Platyrhinops* (Clack & Milner, 2010) as well as **Mordex* (usually left vs. right
side: Werneburg, 2012a); in all of these cases we have scored polymorphism.

Complete frontals and parietals are apparently seldom found in the same specimen of
*Branchiosaurus; the largest ones where both seem to be preserved in full have state 1
(Werneburg, 2012a).

920 28. FRO 4: Prefrontal/postfrontal suture (0); frontal contributes to orbit margin (1). 921 State 0 was originally called "Frontal excluded from [...] orbit margin"; we have defined it 922 more precisely and scored the character as inapplicable when the pre- and/or the postfrontal is 923 absent, which is the case in Albanerpetidae, Karaurus, Triadobatrachus, Valdotriton, Brachy-924 dectes, Notobatrachus and Vieraella in the original taxon sample. However, because the 925 aïstopod "postorbital" may be an ontogenetic fusion product of postorbital and postfrontal 926 (Anderson, Carroll & Rowe, 2003: fig. 9B), we have scored the aïstopods: Lethiscus has state 927 1 (J. Pardo, pers. comm.; although the lateral process on the frontal mentioned by Pardo et al., 928 2017, but absent from their figures, appears not to exist, the frontal has a long contribution to 929 the orbit margin), Oestocephalus has state 0 as already scored (Anderson, 2003a), and Phlege-930 thontia has state 1 (Anderson, 2002, 2007a).

931 The condition is furthermore unknown in *Pholiderpeton scutigerum* (Clack, 1987b).

932 *Ventastega* (Ahlberg et al., 2008) shows state 0, as does *Asaphestera* (CG78).

933 *Trimerorhachis* is polymorphic (Milner & Schoch, 2013).

Apateon dracyi has state 0; but because Schoch & Milner (2008) and Fröbisch &
Schoch (2009b) found this to be an unambiguous reversal within *Apateon*, we have kept the
score of 1 for *Apateon*. Among branchiosaurids, state 0 does occur in **Tungussogyrinus*(Werneburg, 2009) and **Branchiosaurus* (Schoch & Milner, 2008; Werneburg, 2012a).

938 Klembara et al. (2014) have documented state 0 in *Gephyrostegus*.

CG78 reconstructed state 1 in *Saxonerpeton*. It is not evident why they did so, however; the drawings of the specimens do not indicate either state, and the skull table is not mentioned in the text at all. We have kept its score as unknown. Similarly, we have changed the score of *Odonterpeton* to unknown because CG78 reconstructed state 0 on the left but state 1 on the right side, mentioned in the text that the right postfrontal is not preserved, and included a specimen drawing that does not clarify the situation.

It is possible (Sumida, Pelletier & Berman, 2014) that *Oedaleops* is polymorphic, specifically that some specimens show state 0 rather than the state 1 preserved in others (Reisz, Godfrey & Scott, 2009; Sumida, Pelletier & Berman, 2014). For the time being, we have ignored this and scored only state 1 for *Caseasauria; state 1 is seen in *Eothyris* (Reisz, Godfrey & Scott, 2009), and the condition in *Eocasea* is unknown. The smallest specimen of **Acanthostomatops* probably has state 1, but all others clearly show state 0 (Witzmann & Schoch, 2006a), so we have scored *Acanthostomatops* as possessing state 0, even though this character does not show ontogenetic variation elsewhere.

The holotype of **Konzhukovia vetusta* is polymorphic, with the left side showing state 0 and the right side state 1 (Gubin, 1991: drawing 6a).

955 Like Brachydectes (see above), *Beiyanerpeton possesses prefrontals but lacks 956 postfrontals; yet, the frontal does not contribute to the orbit margin, because the prefrontals 957 contact processes of the parietals that look as if the postfrontals had fused to the parietals. 958 This intriguing condition is common in extant salamanders, yet absent in Karaurus and, as far 959 as known, all other Mesozoic salamanders except *Beiyanerpeton (ch. 61 of Gao & Shubin, 960 2012) – Valdotriton has the processes, but they may not have reached the prefrontals (Evans 961 & Milner, 1996: fig. 6b); for this reason, and because it is restricted to a single OTU in the 962 original taxon sample, we have refrained from coding this condition as a third state of the 963 present character. *Beivanerpeton is scored as unknown.

964 One specimen of **Platyoposaurus* has state 1 on the right side (Gubin, 1991: 34). We 965 have counted this as polymorphism.

967 29. FRO 5: Coossified frontal and parietal (frontoparietal bone): absent (0); present (1).

Ventastega has state 0 (Ahlberg et al., 2008).

There is no evidence of a preserved frontal or a preserved rostral edge of a parietal in **Sparodus* (D. M., pers. obs. of NHMW 1899/0003/0006); the "frontal" in the mirrored fig. 1A of Carroll (1988) is the right prefrontal, as is already clear by comparison to the left side of the same figure. The most defensible score is therefore "?", contra Carroll (1988).

974 30. FRO 6: Frontal anterior margin deeply wedged between nasal posterolateral margins
975 for at least 1/3 of the length of the nasals: absent (0); present (1). We interpret state 1 as
976 meaning that both frontals together form such a wedge.

Ventastega has state 0 (Ahlberg et al., 2008), as do *Adelospondylus*, *Adelogyrinus* and *Dolichopareias* (Andrews & Carroll, 1991) and *Lethiscus* (Pardo et al., 2017). Although *Limnoscelis* has a conspicuous wedge, it has state 0 as well (Berman, Reisz & Scott, 2010:
fig. 3); *Gephyrostegus*, too, does not reach state 1 (Klembara et al., 2014).

981 State 1 is found in *Acanthostega* (Porro, Rayfield & Clack, 2015), Albanerpetidae 982 (Venczel & Gardner, 2005) and *Phlegethontia* (Anderson, 2007a).

Danto, Witzmann & Müller (2012) followed RC07 in scoring *Solenodonsaurus* as possessing state 1, but, according to their figures, the wedge is shallow or absent (as far as it is not obscured by the strong interdigitation). We have assigned state 0 to it.

986The only known skull of *Westlothiana* is polymorphic, showing state 0 on the left and9871 on the right side (Smithson et al., 1994).

In *Sauropleura pectinata*, state 1 (which was scored in RC07) was not quite reached: although a long wedge is present, the nasals participate in the extreme elongation of the tip of the snout. Because this elongation is autapomorphic, we have kept state 1 for *Sauropleura*, as found in *S. scalaris* (both known ontogenetic stages) and *S. bairdi* (Bossy & Milner, 1998: fig. 53A–D, 58A, 72A, 73A).

*Glanochthon is polymorphic (Schoch & Witzmann, 2009b: fig. 2).

In **Palaeoherpeton* (Panchen, 1964: fig. 11), state 1 is reached on the right side but not on the left, even though the suture on the left side runs rostromedial to caudolateral as well; we have scored polymorphism.

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998 31. PAR 1: Supratemporal/postparietal suture (0); parietal/tabular suture (1). This
999 character is inapplicable when any of these bones are missing. RC07 did not specify state 0

1000 (calling the character "Parietal/tabular suture: absent (0); present (1)"), leading them to score 1001 many cells in ways predictable from other cells.

1002 Megalocephalus is polymorphic: state 1 is found on the right side of the holotype, 1003 state 0 everywhere else (Beaumont, 1977: 52).

1004 The supratemporal is missing, as far as known, in all albanerpetids (except possibly 1005 **Shirerpeton), as well all "lepospondyls" except the following, which all have state 1 (as already scored for all except the last two): Westlothiana (Smithson et al., 1994), Ptyonius and 1006 1007 Sauropleura (Bossy & Milner, 1998), Lethiscus (Pardo et al., 2017) and Oestocephalus 1008 (Anderson, 2003a: fig. 3C).

By comparison with Oestocephalus, *Coloraderpeton and to a lesser degree Lethiscus 1009 1010 (Anderson, 2003a; Pardo et al., 2017) it seems evident that the supposed right supratemporal 1011 of *Pseudophlegethontia (Anderson, 2003b) is the process of the parietal that contacts the 1012 tabular. (On the left side, however, the bone dorsomedial of the squamosal probably is a 1013 supratemporal; we have scored it as such in the next and other characters below.) The 1014 supposed postfrontal may well belong to the parietal, too, for the same reasons. We have 1015 scored state 1 of the present character. 1016

1017 2/POSFRO 3/INTEMP 1/SUTEMP 32. PAR 1: Intertemporal present (0): 1018 supratemporal/postfrontal contact (1); parietal/postorbital contact, supratemporal 1019 present (2); parietal/postorbital or parietal/squamosal contact, supratemporal absent 1020 (3); tabular/postfrontal contact, supratemporal absent (4) (stepmatrix). Four redundant 1021 characters have been merged: no known limbed vertebrate that has an intertemporal (INTEMP 1(1) in the original) lacks a supratemporal (SUTEMP 1(0)); states 1 through 3 track 1022 gradual shrinking of the supratemporal (its rostral end reaches the postfrontal in state 1, but 1023 1024 not in state 2, and in states 3 and 4 the bone is entirely absent); all states other than 0 are 1025 impossible when the intertemporal is present; and a parietal-postorbital contact (states 2 and 1026 3, originally PAR 2(1)) is impossible when the supratemporal is too large (states 0 and 1) as 1027 well as when the tabular contacts the postfrontal (state 4, originally POSFRO 3(1)). The 1028 stepmatrix for this character is Appendix-Table 2.

1029 Whenever there is an intertemporal, it contacts the postfrontal and the supratemporal, 1030 separating the parietal and the postorbital. The only possible exception is the right side of one 1031 specimen of Greererpeton (Smithson, 1982): it has a tiny extra bone that could be an atavistic 1032 reappearance of the intertemporal (even though a long parietal-postorbital contact is present) or a pathological neomorph; see various "branchiosaurs" for supposed occurrences of such 1033 1034 phenomena (Boy, 1972). We have therefore scored *Greererpeton* as possessing state 2 of this 1035 character (and as unknown for the INTEMP characters, see below).

1036 Mentioning the squamosal in state 3 accounts for *Eocaecilia*, which is unique in this 1037 matrix in combining absence of the postorbital with presence of the tabular and the postfrontal. Taxa that lack not only the supratemporal but also the tabular and/or postfrontal 1038 1039 (Acherontiscus, Adelogyrinidae, Odonterpeton, Brachydectes, modern amphibians other than 1040 *Eocaecilia*, *Phlegethontia* and **Quasicaecilia*) are scored as having state 3 or 4.

1041 State 0 is present in Panderichthys (Vorobyeva & Schultze, 1991) and in Ventastega (Lukševičs, Ahlberg & Clack, 2003; Ahlberg et al., 2008). 1042 1043

Solenodonsaurus has state 1 according to Danto, Witzmann & Müller (2012).

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The condition of Dolichopareias is wholly unknown (Andrews & Carroll, 1991).

1045 Although the description of this character does not quite fit Lethiscus or Oestocepha-1046 lus, where the parietal laterally participates in the margin of the temporal fenestra and a single 1047 bone occupies the places where the postfrontal and the postorbital would be expected, we 1048 have kept state 2 for both: in Oestocephalus, the supratemporal and/or the "postfrontal" would 1049 have to be extremely long and narrow to meet each other along the unusually elongate parietal 1050 (Anderson, 2003b: fig. 2, 3C); in *Lethiscus*, the parietal even has a wide lateral flange 1051 between the caudal margin of the "postorbital" and the rostral margin of the supratemporal 1052 (Wellstead, 1982; Pardo et al., 2017), so that the latter two bones would again need to have 1053 highly unusual shapes to meet each other if the temporal fenestra were absent. – Much the 1054 same holds for **Coloraderpeton* (Anderson, 2003a; Pardo et al., 2017), which we have also 1055 scored 2.

- 1056 To account for its possible intertemporal, we have scored *Ossinodus* as showing state 1057 0 or 2.
- 1058 **Spathicephalus* is polymorphic, with state 1 in *S. marsdeni* and state 2 in *S. mirus* 1059 (Smithson et al., 2017).
- 1060 **Pseudophlegethontia* has state 0, 1 or 2 following the argument under the preceding 1061 character.
- 1062
- 1063 For Analysis EB, this character is split as follows:
- PAR 2/POSFRO 3: Postfrontal contacts supratemporal or tabular (0); parietal contacts
 postorbital or squamosal (1). Inapplicable when the intertemporal is present, and also when
 the tabular or the postfrontal is absent.

1067 INTEMP 1/SUTEMP 1: Intertemporal and supratemporal present (0); intertemporal 1068 absent, supratemporal present (1); both absent (2) (ordered).

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1070Appendix-Table 2: Stepmatrix for character 32 (PAR 2/POSFRO 3/INTEMP10711/SUTEMP 1).

1	0	7	2	
-	~		_	

from \downarrow to \rightarrow	0	1	2	3	4
0	0	1	1	2	3
1	1	0	1	1	2
2	1	1	0	1	2
3	2	1	1	0	1
4	3	2	2	1	0

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33. PAR 4: Anterior margin of parietal lying in front of (0), level with (1), or behind (2)
orbit midlength (ordered). We have ordered this continuous character.

1077 Because of the orbitotemporal fenestra, batrachians (already done for *Karaurus* by 1078 RC07) are scored as having their observed state (corresponding to the clearly wrong assump-1079 tion that the entire orbitotemporal fenestra is homologous to the orbit) or higher. In the case of 1080 *Valdotriton*, this means a score as unknown.

1081 State 1 is present in *Ventastega* (Ahlberg et al., 2008) and arguably *Eryops* (D. M., 1082 pers. obs. of MCZ 1129).

1083State 2 is recorded in Albanerpetidae (Venczel & Gardner, 2005), Kotlassia (Bulanov,10842003), Brachydectes (Pardo & Anderson, 2016) and Ossinodus (Warren, 2007).

**Sparodus* is best scored as unknown, see FRO 5 above.

1086 **Archegosaurus* has state 1 on the left and state 2 on the right side in at least two 1087 individuals (Witzmann, 2006).

Even if the caudal angle of the left orbit (indenting the postorbital) is ignored as a taphonomic artefact, **Neopteroplax* reaches state 1 on the left side – quite likely not on the right, but most of the margin of the right orbit is not preserved – according to the specimen drawing (Romer, 1963: fig. 1) but not the reconstruction (fig. 3). While the text mentions dorsoventral compression, we cannot imagine what kind of rostrocaudal shear could be compatible with the specimen drawing; given the precedent of **Archegosaurus*, we have scored states 1 and 2 in order to avoid scoring just state 1 as a certainty. (There is currently no way of scoring "state 1 and possibly state 2".)

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1097 34. PAR 5: Anteriormost third of parietals not wider (0) or at least marginally wider (1) 1098 than frontals.

State 0 is present in *Ventastega* (Ahlberg et al., 2008), *Ichthyostega* (Jarvik, 1996;
Clack & Milner, 2015: fig. 8), *Cochleosaurus* (Sequeira, 2004), *Ecolsonia* (Berman, Reisz &
Eberth, 1985), *Broiliellus* (Carroll, 1964; Schoch, 2012), *Amphibamus* (Schoch, 2001), *Micromelerpeton* (Boy, 1995: fig. 8), *Apateon* (throughout its ontogeny: Schoch & Fröbisch,
2006), *Karaurus* (Ivachnenko, 1978), *Gephyrostegus* (Klembara et al., 2014), *Tuditanus, Sax- onerpeton* and *Hapsidopareion* (CG78), *Rhynchonkos* (Szostakiwskyj, Pardo & Anderson,
2015) and *Lethiscus* (Pardo et al., 2017).

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State 1 is found in Acanthostega (Porro, Rayfield & Clack, 2015).

1107 Dendrerpetidae is polymorphic: while *Dendrysekos* has state 1 as scored in RC07 1108 (Holmes, Carroll & Reisz, 1998), most or all specimens of *Dendrerpeton* (all species: A. R. 1109 Milner, 1980, 1996) have state 0. **Acanthostomatops* (Witzmann & Schoch, 2006a) and 1110 **Glanochthon* (Schoch & Witzmann, 2009b) are polymorphic as well. While only state 1 is 1111 known in the single individual of *Batropetes niederkirchensis* (Glienke, 2013: fig. 2), *B. frit*-1112 *schi* is polymorphic (Glienke, 2013: fig. 6), as is the reconstructed individual of *B. palatinus* 1113 because its two parietals have such different lengths (Glienke, 2015: fig. 1E).

Unclear and probably about equal in *Edops* (D. M., pers. obs. of MCZ 1378; the reconstruction by Romer & Witter [1942] just barely indicates state 1, but seems not to acknowledge a patch of reconstructed surface that probably covers at least part of the parietal/ postfrontal suture).

A (separate) parietal is absent in *Triadobatrachus* (see FRO 5 above), *Phlegethontia*,
 Notobatrachus and *Vieraella*; we have accordingly scored them as unknown.

1120 The state of **Pseudophlegethontia* depends on whether the supposed postfrontal 1121 belongs to the parietal (see ch. 31, PAR 1, above); we have scored it as unknown. 1122

35. PAR 6: Parietals more (0) or less (1) than two and a half times as long as wide each.
"Each" is added; we have interpreted it from the coding, which makes clear that this character
does not concern the combined widths of both parietals.

1126 *Brachydectes* is apparently polymorphic, with Permian specimens having state 1 and 1127 Carboniferous specimens reaching state 0 (Wellstead, 1991).

- **Sparodus* is probably borderline, but unknown, see FRO 5 above.
- *Lydekkerina is polymorphic (Jeannot, Damiani & Rubidge, 2006).

1131 36. PAR 7: **Squamosal participates in dorsal surface of skull roof: no (0); yes (1).** The 1132 original wording, "Parietal/squamosal suture extending in part onto the dorsal surface of the 1133 skull table: no (0); yes (1)", is not applicable to the vast majority of the taxon sample, because 1134 the parietal and the squamosal are separated by other bones; yet, all those OTUs were scored 1135 as possessing state 0. We therefore speculate that our wording, which can be applied to all 1136 taxa in this matrix, was intended.

1137 Skutschas & Martin (2011) suggested that state 1 results from fusion of the 1138 supratemporal to the squamosal. While it is not testable (except by phylogenetic bracketing) if 1139 this has happened in the extinct salamanders they had in mind (ontogenetic series are not 1140 known), state 1 occurs in several taxa in this matrix that retain a separate supratemporal. One 1141 example is *Ichthyostega* (Clack & Milner, 2015: fig. 8). Another is the one dendrerpetid skull 1142 that is not squished flat (Holmes, Carroll & Reisz, 1998) – which leaves us to suspect that

most small temnospondyls should actually be scored 1 as well, although we have remained 1143 1144 conservative and kept state 0 for all except Dendrerpetidae.

1145 Triadobatrachus is somewhat disarticulated and crushed flat, making it difficult to judge whether the parietal/squamosal contact was on the dorsal or the lateral side of the skull 1146 1147 roof; we have scored it as unknown.

1148 Captorhinus is borderline in that the parietal-squamosal suture forms the boundary 1149 between the skull table and the cheek (Heaton, 1979); unlike RC07, we have chosen to count 1150 this as state 0. State 0 is further present in Ventastega (Ahlberg et al., 2008), Paleothyris 1151 (Carroll, 1969b), Batropetes (Carroll, 1991; Glienke, 2013), Microbrachis (Olori, 2015) and 1152 Tseajaia (Moss, 1972). Under our reinterpretation of this character, state 0 is also found in 1153 Albanerpetidae (McGowan, 2002; Venczel & Gardner, 2005) and Notobatrachus (Estes & 1154 Reig, 1973; Báez & Nicoli, 2004).

We retain the score of Petrolacosaurus (Reisz, 1981) as possessing state 1 because we 1155 1156 consider the dorsally-facing supratemporal fenestrae to form part of the dorsal surface of the 1157 skull.

We assign state 1 to *Acanthostomatops because the squamosal extends medially 1158 1159 beyond the lateral margin of the supratemporal (Witzmann & Schoch, 2006a); the skull is 1160 apparently very flat, and illustrations (let alone reconstructions) in lateral view seem not to exist, but the supratemporal generally does not participate in the lateral skull surface. 1161

1163 37. PAR 8: Parietal/frontal suture strongly interdigitating: no (0); yes (1). 1164

State 0 is present in Ventastega (Ahlberg et al., 2008).

1165 Although "strongly" is not defined, we have scored Kotlassia as possessing state 0 1166 (Bulanov, 2003: fig. 30).

1167 Apateon has state 1 based on the largest metamorphic individual (Werneburg, 1991: fig. 5b). State 1 is further found in Baphetes (Milner, Milner & Walsh, 2009), Edops (Romer 1168 & Witter, 1942; D. M., pers. obs. of MCZ 1378), Trimerorhachis (Milner & Schoch, 2013), 1169 1170 Balanerpeton (Milner & Sequeira, 1994) and Diadectes (Berman, Sumida & Lombard, 1992; 1171 Berman, Sumida & Martens, 1998). We have further assigned state 1 to Gephyrostegus based 1172 on Klembara et al. (2014: especially fig. 1A, 5B).

- Batropetes is polymorphic (Glienke, 2013, 2015).
- Hapsidopareion probably qualifies for state 1 (CG78: fig. 13A), which we have 1174 1175 therefore scored.
- 1176 Unknown in Acanthostega (Porro, Rayfield & Clack, 2015).
 - Phlegethontia lacks parietals (Anderson, 2002), so we have scored it as unknown.

Assuming that the existing reconstructions of S. mirus are too schematic or thick-lined 1178 1179 to score this character, we have scored state 1 for *Spathicephalus based on S. marsdeni 1180 (Smithson et al., 2017: fig. 3C).

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1182 38. PAR 9: Parietal/postparietal suture strongly interdigitating: no (0); yes (1). RC07 1183 stated that "[t]here appears to be no clear phylogenetic signal associated with this character". 1184 It has at most 28 steps on the shortest trees from Analysis R4 (158 OTUs); state 1 is an 1185 autapomorphy of Temnospondyli except Eucritta (reversed in part of Colosteus, in Megalocephalus, Cochleosauridae, Eryops, Neldasaurus and in most dissorophoids, with a 1186 reappearance in *Gerobatrachus), of Archeria, of *Palaeoherpeton + *NSM 994 GF 1.1 + 1187 1188 *Neopteroplax, of Solenodonsaurus, Diadectes, *Caseasauria, Pantylus, Hyloplesion and 1189 *Keraterpeton*, and holds the aïstopod-urocordylid-adelospondyl clade together; it may also be homologous between *Sparodus, *Llistrofus and Brachydectes. 1190

1191 Kotlassia has state 0 (Bulanov, 2003: fig. 30); Eoscopus is somewhat borderline 1192 (Daly, 1994), but we prefer scoring it as sharing state 0.

1197 & Martens, 1998) and Limnoscelis (Reisz, 2007; Berman, Reisz & Scott, 2010), probably also 1198 *Saharastega (D. M., pers. obs. of MNN MOR 73). 1199 Unclear in Hapsidopareion (CG78: fig. 13A). 1200 This character is inapplicable to Odonterpeton because Odonterpeton lacks postparie-1201 tals, as explained in the next character. 1202 Assuming that the existing reconstructions of S. mirus are too schematic or thick-lined to score this character, we have scored state 1 for *Spathicephalus based on S. marsdeni 1203 1204 (Smithson et al., 2017: fig. 3C). *Bystrowiella has state 1 on the ventral side, but state 0, which we have scored, on the 1205 1206 dorsal side (Witzmann & Schoch, 2017: 716, fig. 2). 1207 1208 39. POSPAR 1-2: Postparietal(s) paired (0), single (1), or absent (2) (unordered). The two 1209 original characters, presence/absence of postparietals and absence/presence of median fusion 1210 of the postparietals, make each other inapplicable, so we have fused them. 1211 State 0 is present in Ventastega (Ahlberg et al., 2008). 1212 States 0 and 1 are known in Ichthyostega (Clack & Milner, 2015); in the absence of 1213 evidence on whether this could be ontogenetic, we have scored polymorphism. 1214 There is no evidence for postparietals in any albanerpetid, so we have scored 1215 Albanerpetidae as having state 2. 1216 Bruktererpeton has state 0 or 1 (Boy & Bandel, 1973). We have scored 1217 *Gerobatrachus the same way because it is not evident whether the sutured fragment close to 1218 the caudal end of the skull table belongs to the parietals or the postparietals. 1219 Odonterpeton was interpreted as possessing state 1 by CG78. However, the supposed 1220 suture between the left parietal and the postparietal consists of a discontinuous series of 1221 cracks (D. M., pers. obs. of USNM 4465+4467, the holotype). We have accordingly assigned 1222 state 2 to Odonterpeton and would like to use this opportunity to mention that fig. 98A and 1223 99A of CG78 differ from the specimen in other ways as well; they are idealized and 1224 simplified to the point of being unreliable. In particular, the suture between the right parietal 1225 and the "postparietal" has an additional curve to the left at its caudal end, so that the 1226 asymmetry between the parietals is considerably smaller than one would think. 1227 The condition is unknown in Adelogyrinus and Dolichopareias (Andrews & Carroll, 1228 1991). 1229 Although a stippled line indicates a suture in the reconstruction drawings of *Lethiscus* 1230 by Pardo et al. (2017), it is not apparent in the scan images or in Wellstead (1982); we have 1231 kept state 0 or 1 for the moment. 1232 As we have not seen the type specimen, we have trouble understanding the condition 1233 of *Tseajaia*: Moss (1972: 10) reported state 1, and his photos (pl. 1, 3) are compatible with 1234 this – if they show a suture, then that suture is much thinner than the others in that skull. 1235 Berman, Sumida & Lombard (1992: 490) said explicitly that Moss was wrong (reiterated by 1236 Berman, Reisz & Scott, 2010: 192) and presented another photo of the same skull (the holotype, UCMP 59012) which is much brighter, shows drastically narrower sutures, and 1237 1238 lacks a strong contrast between the suture between the postparietals and the other sutures. It 1239 looks like all sutures in that photo are enhanced in black ink, though. In the photo of UCMP 1240 59012 shown by Reisz (2007: pl. 26), the postparietals look very clearly separate. D. M. has 1241 seen CM 38033, a largely complete skeleton containing a complete skull illustrated by

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tes (Beaumont, 1977: fig. 25; Milner, Milner & Walsh, 2009), Edops (Romer & Witter, 1942; D. M., pers. obs. of MCZ 1378), Trimerorhachis (Milner & Schoch, 2013), Balanerpeton

(Milner & Sequeira, 1994), Diadectes (Berman, Sumida & Lombard, 1992; Berman, Sumida

State 1 occurs in Acanthostega (Clack, 2007; Porro, Rayfield & Clack, 2015), Baphe-

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Berman, Sumida & Lombard (1992: fig. 9-2, 10-2), but this does not help for this character,

1243 because the occipital region is preserved as tiny fragments and there is generally no safe way 1244 of distinguishing sutures from cracks in this specimen; indeed, Berman, Sumida & Lombard 1245 (1992: fig. 10-2) did not reconstruct the postparietal(s) of the skull of CM 38033, and while 1246 Reisz (2007) briefly described that skull, he did not mention this feature and did not illustrate 1247 it. Supported by Reisz (2007: pl. 26), we accept the more recent interpretation (Berman, 1248 Sumida & Lombard, 1992; Berman, Reisz & Scott, 2010) and have kept the score of Tseajaia 1249 as 0, unusual though this is for a diadectomorph (Reisz, 2007: 243, listed "single median 1250 postparietal" as an autapomorphy of Diadectomorpha; Berman, Reisz & Scott, 2010, repeated 1251 that the postparietal is single in *Limnoscelis*, Orobates and Diadectes as scored by RC07).

*Caseasauria is polymorphic: state 0 is found in *Eothyris* and *Eocasea*, state 1 in
 Oedaleops (Reisz, Godfrey & Scott, 2009; Reisz & Fröbisch, 2014).

Reisz & Dilkes (2003) were cautious, but we accept their argument for state 0 in **Archaeovenator.*

40. POSPAR 3-6: Dorsally exposed part of postparietals together less (0) or more than
four times as wide (mediolaterally) as long (1) or absent, postparietals entirely on occipital surface of skull (2) (ordered). We have fused two characters (POSPAR 3: size of dorsal
exposure; POSPAR 6: presence of dorsal exposure) that we consider parts of a single continuous character. The original wording had "postparietal" instead of "postparietals together", but
that does not remotely fit the original scores, so it was probably not intended.

- State 0 is present in Ventastega (Ahlberg et al., 2008), Ichthyostega (Clack, 2007), 1263 1264 Eucritta (Clack, 2001), Isodectes (Sequeira, 1998), Dendrerpetidae (Holmes, Carroll & Reisz, 1998), Eryops (D. M., pers. obs. of MCZ 1129), Acheloma (Polley & Reisz, 2011), Phonerpe-1265 ton (Dilkes, 1990), Ecolsonia (Berman, Reisz & Eberth, 1985), Platyrhinops (Clack & 1266 1267 Milner, 2010), Micromelerpeton (Schoch, 2009b: fig. 2b), Apateon, Leptorophus and Schoenfelderpeton (Schoch & Milner, 2008), Bruktererpeton (Boy & Bandel, 1973), probably Sole-1268 nodonsaurus (Danto, Witzmann & Müller, 2012), Discosauriscus (Klembara, 1997; Klemba-1269 1270 ra et al., 2006), Seymouria (Laurin, 1996a; Klembara et al., 2005), Microbrachis (Vallin & 1271 Laurin, 2004; Olori, 2015), Lethiscus (Wellstead, 1982; Pardo et al., 2017), and Ariekanerpe-1272 ton, Leptoropha and Microphon (Bulanov, 2003).
- 1273 State 1 is found in *Amphibamus* (Schoch & Milner, 2014: fig. 30B; possibly Daly, 1274 1994: fig. 18) and *Limnoscelis* (Reisz, 2007), and in *Diploceraspis* because of its "horns" 1275 (Beerbower, 1963).
- 1276 *Diadectes* possesses both state 0 (North American species: Berman, Sumida & 1277 Lombard, 1992) and state 1 (*D. absitus*: Berman, Sumida & Martens, 1998).
 - Saxonerpeton has state 1 (CG78: fig. 17).

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- 1279 *Hyloplesion* has state 2 (CG78; D. M., pers. obs. of NHMW 1983/82/54 and other 1280 NHMW specimens).
- 1281 *Pelodosotis* was scored POSPAR 3(0) and POSPAR 6(?) in RC07. Of these 1282 contradictory scores, the former is correct (CG78); *Pelodosotis* thus possesses state 0 of the 1283 present character.
 - Adelogyrinus and Dolichopareias have state 0 or 1 (Andrews & Carroll, 1991).
- Because the skull roof of **Gerobatrachus* is exposed in ventral view only, we have scored it as having state 0 or 1.

*Caseasauria shows both state 1 (in *Eothyris* and possibly *Eocasea*; Reisz, Godfrey &
Scott, 2009; Reisz & Fröbisch, 2014) and state 2 (*Oedaleops*; Reisz, Godfrey & Scott, 2009).

1290 41. POSPAR 4-8: Edge between the dorsal and the caudal surfaces of the skull lacking
1291 (0) or possessing (1) a caudal process in the midline. This is a fusion of two characters we
1292 deem not merely correlated but identical, with POSPAR 4 ("Postparietals without (0) or with

1293 (1) median lappets") meaning the combination of a caudal process with a vertical occipital 1294 surface and POSPAR 8 ("Postparietals without (0) or with (1) sinuous posterior ridge") the 1295 combination of a caudal process with an inclined occipital surface. (The difference between a 1296 vertical and an inclined surface is character POSPAR 7, see below.) Fitting this interpretation, 1297 POSPAR 8(1) was only scored for Micraroter and Pelodosotis, while POSPAR 4(1) was 1298 limited to Crassigyrinus, Whatcheeria, embolomeres other than Eoherpeton, and Ptyonius. -1299 Our wording makes the character applicable to taxa that lack postparietals; in particular, 1300 Triadobatrachus (all sources and pers. obs.) has state 0, and Batropetes has state 1 (Glienke, 1301 2013, 2015).

1302 *Crassigyrinus* in fact has a very clear case of state 0 (Panchen, 1985; Clack, 1998). We 1303 have also kept state 0 for *Micromelerpeton* and *Apateon* because this condition is seen in the 1304 most mature known specimens (Schoch, 2009b: fig. 2b; Schoch & Fröbisch, 2006).

1305 State 1 is present in Ventastega (Ahlberg et al., 2008), Balanerpeton (weakly: Milner & Sequeira, 1994), Dendrerpetidae (weakly: A. R. Milner, 1980, 1996; Holmes, Carroll & 1306 1307 Reisz, 1998), Platvrhinops (Clack & Milner, 2010), Eocaecilia (Jenkins, Walsh & Carroll, 2007), Diadectes (Berman, Sumida & Lombard, 1992; very weakly expressed in D. absitus, 1308 but present throughout [Berman, Sumida & Lombard, 1998]; see also Case, 1910), Asaphes-1309 1310 *tera* (where the caudal process comprises the entire caudal edge of the postparietal; CG78), Brachydectes (Pardo & Anderson, 2016: fig. 3D, 4B), Oestocephalus (Carroll, 1998a; Ander-1311 1312 son, 2003a), Capetus (Sequeira & Milner, 1993), Orobates (Berman et al., 2004), and Tseajaia (Moss, 1972; Berman, Sumida & Lombard, 1992; Reisz, 2007: pl. 26; D. M., pers. obs. 1313 1314 of CM 38033).

1315 *Solenodonsaurus* was scored POSPAR 4(?) but POSPAR 8(0) in RC07. The latter is 1316 correct according to Danto, Witzmann & Müller (2012).

1317 *Ossinodus* was scored in the same ways in RC07. Here, we have kept the question 1318 mark, because precisely that part of the postparietals is not preserved (Warren, 2007).

1319 State 1 is seen in a skull fragment referred to *Baphetes kirkbyi* (Beaumont, 1977: fig. 1320 20(*a*)); this area is damaged in the holotype of that species (Beaumont, 1977: fig. 18), but *B.* 1321 *orientalis* has state 0 (Beaumont, 1977: fig. 25), so we have scored polymorphism for 1322 *Baphetes*.

Likewise, *Sauropleura* is polymorphic: *S. scalaris* and *S. pectinata* have state 1, but *S. bairdi* shows state 0 (Bossy & Milner, 1998: fig. 53). **Micropholis* has both states as well
(Schoch & Rubidge, 2005: fig. 3).

1326 Probably unknown in *Kotlassia* (Bulanov, 2003: fig. 28–30); we have changed the 1327 score.

1328 Unclear in *Lethiscus* (Pardo et al., 2017).

1329Because of possible damage (D. M., pers. obs. of MNN MOR 70), we have scored1330*Nigerpeton as unknown.

1331Though damage makes MNN MOR 73 difficult to interpret (D. M., pers. obs.),1332*Saharastega most likely has state 0.

1333 1334 Gently rounded but present (state 1) in *Beiyanerpeton (Gao & Shubin, 2012: fig. 3).

- 1335 POSPAR 5 is merged with OPI 2, see below.
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42. POSPAR 7: Postparietals without (0) or with (1) posteroventrally sloping occipital
exposure. Only unusually low angles count as state 1; the occipital surface is almost never
perfectly vertical.

1340 State 0 is present in *Ventastega* (Ahlberg et al., 2008).

1341 State 1 occurs in *Limnoscelis* (Reisz, 2007; Berman, Reisz & Scott, 2010), *Oesto-*1342 *cephalus* (Carroll, 1998a; Anderson, 2003a) and *Orobates* (Berman et al., 2004).

- 1343 *Diadectes* is polymorphic (Berman, Sumida & Martens, 1998: 57).
- 1344 The condition is unknown in *Westlothiana* (Smithson et al., 1994).
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5 Adults of **Acanthostomatops* have state 0 (Witzmann & Schoch, 2006a).

43. POSPAR 9: Edge between the dorsal and the caudal surfaces of the skull without (0)
or with (1) broad, concave posterior emargination in the central bones. Our wording
makes the character applicable to taxa whose postparietals lie entirely on the occipital surface
(POSPAR 3-6(2)) or are absent (POSPAR 1-2(2)); namely, *Triadobatrachus* (all sources) has
state 0, while *Captorhinus* (Heaton, 1979) and *Batropetes* (Glienke, 2013, 2015) have state 1,
though *B. fritschi* may be considered borderline (Glienke, 2013).

1353 State 0 is present in *Ventastega* (Ahlberg et al., 2008). We have also assigned it to 1354 **Saharastega*, though damage makes MNN MOR 73 difficult to interpret (D. M., pers. obs.).

1355 According to RC07, state 1 is limited to "some" diplocaulids (i.e. all except 1356 Keraterpeton); however, other than in Captorhinus and Batropetes as mentioned above, it is 1357 also found in Ichthyostega (Clack & Milner, 2015: fig. 8), Edops (arguably borderline: D. M., pers. obs. of MCZ 1378), Trimerorhachis (Milner & Schoch, 2013), Dendrerpetidae (weakly: 1358 1359 A. R. Milner, 1980, 1996; Holmes, Carroll & Reisz, 1998), Acheloma (borderline: Polley & 1360 Reisz, 2011), Eoscopus (Daly, 1994), Discosauriscus (Klembara, 1997; Klembara et al., 2006), Seymouria (Laurin, 1996a: fig. 3A; Klembara et al., 2006), Diadectes (Berman, Sumi-1361 da & Lombard, 1992: fig. 1, 3), Limnoscelis (Romer, 1946; Fracasso, 1983; Reisz, 2007; Ber-1362 1363 man, Reisz & Scott, 2010), Brachydectes (Pardo & Anderson, 2016: fig. 4B), Oestocephalus 1364 (Carroll, 1998a; Anderson, 2003a), Ariekanerpeton (Klembara & Ruta, 2005a), Capetus (Sequeira & Milner, 1993), Orobates (marginally: Berman et al., 2004) and Ossinodus (Warren, 1365 2007), as well as in *Micropholis (Schoch & Rubidge, 2005), *Nigerpeton (D. M., pers. obs. 1366 1367 of MNN MOR 70) and *Sclerocephalus (only the type species, the only one considered here, and only in late ontogenetic stages: Schoch & Witzmann, 2009a). 1368

Although the reconstruction of *Baphetes kirkbyi* by Beaumont (1977: fig. 21) shows an almost straight margin as previously scored, the specimen drawings in the same work (fig. 1371 18, 20) clearly show state 1, which is also shown in both the specimen drawing and the 1372 reconstruction of *B. orientalis* (Beaumont, 1977: fig. 25).

- *Acanthostega* appears to be polymorphic (Porro, Rayfield & Clack, 2015: fig. 3E, 4B).
 So is *Megalocephalus* (Beaumont, 1977: fig. 10(*b*), 11(*a*)).
- 1375 *Eryops* is polymorphic, the broad-skulled morph having state 0 and the narrow-skulled 1376 morph, to which the holotype of the type species (*E. megacephalus*) belongs, having state 1 1377 (Werneburg, 2007a: figs. 6, 7). So is **Acanthostomatops* (Witzmann & Schoch, 2006a).

Microphon exiguus changes from state 0 to state 1 in ontogeny (Bulanov, 2003: fig.
1379 16, 19; 2014); only the "juvenile" stage of *M. gracilis* is known, so we cannot take its state 0
1380 at face value. We have therefore assigned state 1 to *Microphon*. Similarly, only the "juvenile"
1381 stage of *Leptoropha* is known, so we have scored it as unknown as well even though it shows
1382 the originally scored state 0.

- We have scored *Tseajaia* as unknown, because the state depends on the unclear position of the suture between postparietal and tabular. Moss (1972) located this suture lateral enough for state 1 to result, Berman, Sumida & Lombard (1992) preferred a more medial position that would cause state 0, and Reisz (2007: 245) simply said "the size of the tabular is uncertain in *Tseajaia*".
- 1388It seems fair to assign state 1 to *Karpinskiosaurus, although it is arguably borderline1389(Klembara, 2011).

1390 Of the **Cheliderpeton* specimens figured by Werneburg & Steyer (2002), the smallest 1391 and the largest have arguably borderline cases of state 1, while at least two others (fig. 1b, 6) 1392 clearly have state 0; we have scored **Cheliderpeton* as polymorphic. *Australerpeton is polymorphic (Eltink et al., 2016: fig. 2).

We have scored *Konzhukovia as having state 1, but it is arguably borderline (Gubin,

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1991).

1396 1397 44. POSPAR 10: Nasals not smaller (0) or smaller (1) than postparietals. 1398 State 0 is present in Ventastega (Ahlberg et al., 2008). Judging from their own figures, Danto, Witzmann & Müller (2012) miscoded this 1399 character in Solenodonsaurus, which clearly has state 0 (as scored by RC07), not 1: the nasals 1400 1401 have several times the area of the postparietals. 1402 State 1 occurs in Brachydectes (Pardo & Anderson, 2016: fig. 2E, 4B). 1403 1404 45. POSFRO 1: Separately ossified postfrontal: present (0); absent (1). 1405 In the aïstopods, a single bone occupies the area where the postorbital and the 1406 postfrontal would be expected. (The separation in Lethiscus identified by Wellstead, 1982, is 1407 a break: Pardo et al., 2017; J. Pardo, pers. comm.) This bone has been variously identified as one or the other in the literature; there seems to be no evidence on which to base a decision, 1408 1409 and the ontogeny of *Phlegethontia* suggests that the bone is a fusion product of postorbital 1410 and postfrontal (Anderson, Carroll & Rowe, 2003: fig. 9b). We have arbitrarily followed the latest publication (Pardo et al., 2017) and, by analogy, the tradition for **dinosaurs in scoring 1411 1412 the postfrontal as absent and the postorbital (POSORB 1, ch. 61 below) as present; however, we have also scored several POSORB characters as unknown for all aïstopods under the 1413 1414 assumption that the dorsal ossification center of Phlegethontia may be the postfrontal. Reexamination of ** Ophiderpeton could help to test this approach. - We have scored *Pseudo-1415 phlegethontia as unknown for all POSFRO and POSORB characters; see ch. 31 (PAR 1) 1416 1417 above. 1418 State 0 is present in Ventastega (Ahlberg et al., 2008) and Bruktererpeton (Boy & 1419 Bandel, 1973). 1420 1421 46. POSFRO 4: Postfrontal posterior margin lying flush with jugal posterior margin: no 1422 (0); ves (1). Most or all cases of state 1 are only approximate, making it difficult to decide 1423 where exactly state 0 should begin. We have changed as few scores as possible, except for scoring all aïstopods as unknown (see immediately above). 1424 1425 Ventastega (Ahlberg et al., 2008) and Westlothiana (Smithson et al., 1994) have state 1426 0. 1427 Orobates shows state 1 (Berman et al., 2004), as does *Microphon* (Bulanov, 2003). 1428 **Cheliderpeton* passes from state 0 to state 1 in ontogeny (Werneburg & Steyer, 2002: 1429 fig. 1), so we have scored the latter. 1430 Nonetheless, *Glanochthon is polymorphic (Schoch & Witzmann, 2009b: fig. 2), and 1431 so is *Australerpeton (Eltink et al., 2016: fig. 2). 1432 1433 47. INTEMP 2: Intertemporal not interdigitating (0) or interdigitating (1) with cheek. 1434 "There appears to be no signal associated with the derived state of this character" according to 1435 RC07. Yet, even for the full taxon sample (Analysis R4), this character has only six steps. 1436 State 1 is an autapomorphy of Whatcheeriidae, Temnospondyli and/or *Caerorhachis*, possibly 1437 homologous among these groups (unambiguously so in MPTs where Ossinodus is not a whatcheeriid); of (Pholiderpeton attheyi + Anthracosaurus + *NSM 994 GF 1.1 + *Palaeoherpe-1438 ton + *Neopteroplax); and of (Seymouria (Kotlassia, *Karpinskiosaurus)) - the only unam-1439 1440 biguous reversal in all MPTs occurs in *Capetus*. Thus, even though the present character is 1441 unknown or inapplicable in most OTUs, it clearly displays phylogenetic signal. 1442 State 0 is present in *Ventastega* (Ahlberg et al., 2008).

We have scored *Ossinodus* as having state 1 because the suture between skull table and cheek is not smooth and because a separate intertemporal is fairly likely present (Warren, 2007). Of ch. 32 of this matrix (PAR 2/POSFRO 3/INTEMP 1/SUTEMP 1), we have assigned state 0 (intertemporal present) or 2 (parietal-postorbital contact, supratemporal present) to it.

1450 Although the expression is very weak, we have kept state 1 for *Cochleosaurus* 1451 (Sequeira, 2004) and assigned it to **Karpinskiosaurus* (Klembara, 2011).

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48. INTEMP 3: Intertemporal/squamosal contact: absent (0); present (1). RC07 called it a
suture, but explained it as a contact in the next sentence; we have therefore scored any contact
between these two bones as state 1, without considering whether it counts as a suture.

1456 State 1 is thus present in *Ventastega* (Ahlberg et al., 2008), *Crassigyrinus* (Clack, 1457 1998: fig. 4), apparently *Eoherpeton* (Smithson, 1985: fig. 7; tentatively accepted in the 1458 reconstruction, fig. 8) and *Gephyrostegus* (Klembara et al., 2014).

1459 State 0 is found in *Panderichthys* (Vorobyeva & Schultze, 1991).

As for the preceding character, we have scored *Ossinodus* as showing state 1 in case there is a suture separating the possible intertemporal from the postorbital (Warren, 2007).

1463 49. INTEMP 4: Intertemporal not (0) much smaller than supratemporal in area and about as wide as long (1). The original name was: "Intertemporal shaped like a small, 1464 subquadrangular bone, less than half as broad as the supratemporal: absent (0); present (1)"; 1465 but under this definition, state 1 is limited to the right side of the largest Eucritta specimen 1466 1467 (Clack, 2001: fig. 6), making the character parsimony-uninformative. RC07 had scored state 1 1468 also for Baphetes, Isodectes, Trimerorhachis and Balanerpeton, but both B. kirkbvi (Beaumont, 1977: fig. 21) and B. orientalis (Milner, Milner & Walsh, 2009: fig. 5) have state 0 by 1469 1470 the width criterion, as do Isodectes (by width - the shape is somewhat arguable: Sequeira, 1471 1998), Trimerorhachis (both by shape and by width: Milner & Schoch, 2013) and Balanerpeton (by width: Milner & Sequeira, 1994). State 0 is further present in Ventastega (by shape 1472 1473 and almost certainly width: Ahlberg et al., 2008); as for the preceding two characters, we have 1474 scored Ossinodus as showing state 0 in case there is a suture separating the possible intertem-1475 poral from the postorbital (Warren, 2007).

1476 Rather than deleting this character, however, we turned to the explanation of this 1477 character by RC07 (p. 96), which speaks of "a diminutive intertemporal" and ends in: "The ornamented surface of the intertemporal is approximately square and can be 'contained' 1478 1479 within the supratemporal in the derived condition [= state 1] of this character." Indeed, intertemporals seem to occur in two size classes. If we replaced "broad" by "long" in the original 1480 1481 name, state 1 would occur in some individuals of *Isodectes* and nowhere else; specifying a 1482 square shape would restrict state 1 to Baphetes orientalis (not B. kirkbyi, where the intertem-1483 poral is pentagonal) and again the right side of the largest Eucritta specimen; the present 1484 formulation, however, justifies the original scores (Trimerorhachis may be a borderline case, 1485 but we have kept it), except for making Dendrerpetidae polymorphic (A. R. Milner, 1980; 1486 Godfrey, Fiorillo & Carroll, 1987; Holmes, Carroll & Reisz, 1998).

1487 Utegenia seems to change from state 1 to state 0 in ontogeny (Klembara & Ruta,
1488 2004a); we have kept state 0.
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50. SUTEMP 2: Rostral border of temporal embayment formed only by squamosal (0) or
at least in part by supratemporal (1). Except for the clarifying addition of "at least in part",
this wording is equivalent to the description of this character by Ruta, Coates & Quicke

(2003). RC07 changed that to: "Supratemporal forming entire edge of dorsalmost part (in
lateral aspect) of temporal notch: no (0); yes (1)." When we use this wording, however, we
cannot replicate the coding of this character, because we do not know where to draw the line
between the "notch" and the rest of the "embayment" that RC07 mention in the explanation of
this character. (No explanation was given in the 2003 version.) – We here use "tympanic/otic/
temporal/spiracular notch/embayment" as synonyms regardless of inferred functions.

1499 Contrary to the coding by RC07, this character is inapplicable when there is no 1500 embayment (SQU 3(0), see below). It is furthermore not applicable to *Acanthostega*, because 1501 the entire edge of its temporal embayment is formed by the tabular, or to taxa with a 1502 squamosal/tabular suture (the ones to which TAB 5 is applicable).

1503State 1 is present in Ventastega (Ahlberg et al., 2008), Crassigyrinus (Clack, 1998),1504Whatcheeria (Lombard & Bolt, 1995) and Silvanerpeton (Ruta & Clack, 2006: fig. 3A).

1505 *Diadectes* is polymorphic (North American species: 0 [Berman, Sumida & Lombard, 1506 1992]; *D. absitus*: 1 [Berman, Sumida & Martens, 1998]).

1507 This character is difficult to apply to **Saharastega* (D. M., pers. obs. of MNN MOR 1508 73); we have scored it as unknown.

Romer (1963) quite unambiguously showed state 1 on the preserved left side in the drawing of the specimen of **Neopteroplax* (fig. 1). The reconstruction (fig. 3, 4), however, the left side has a tabular/squamosal suture, and the right side – which is not preserved – has state 1. The text does not mention this question, except for stating (p. 423): "Laterally, intertemporal and supratemporal curve smoothly downward from the plane of the skull table." Encouraged by this sentence, which implies state 1 assuming that there is no squamosal/ tabular suture, we have accepted the specimen drawing at face value and scored state 1.

1516 **Australerpeton* is polymorphic, with both states apparently occurring in the two 1517 largest specimens (Eltink et al, 2016: fig. 2).

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1519 51. SUTEMP 3: Supratemporal narrow and strap-like, at least three times as long as 1520 wide: absent (0); present (1).

1521 The text and the skull reconstruction by Smithson et al. (1994) ascribe state 0 to 1522 Westlothiana (making it similar to diadectomorphs and basal amniotes), and RC07 accepted 1523 this. However, based on the specimen drawing (Smithson et al., 1994: fig. 5B), we strongly suspect that the occipital bone plate in question belongs to the squamosal rather than to the 1524 1525 supratemporal. If this is correct, the supratemporal is within the range of state 1 (which is 1526 otherwise limited to urocordylids, aïstopods, and the diadectomorph Orobates). We have 1527 therefore changed the score of Westlothiana to 1, and hope that the ongoing redescription of Westlothiana (M. Ruta, pers. comm. 2015; Clack & Milner, 2015) will clarify the issue. It is 1528 1529 highly unfortunate that the published specimens were split through the bone, so that one slab 1530 contains the dorsal side of the skull roof in ventral view and the other side holds the ventral 1531 side of the skull roof in dorsal view.

1532 *Lethiscus* has state 0, which we have scored, unless (and then only borderline) if 1533 measured along the curve of its long axis (Pardo et al., 2017).

1534 1535 52. SUTEMP 4: Supratemporal/squamosal suture: smooth (0); interdigitating (1). According to RC07, "no clear signal is associated with the distribution of the derived state". 1536 1537 At 20 steps for 158 OTUs (Analysis R4), the state distribution of this character is indeed not very tidy; nonetheless, state 1 is synapomorphic of Whatcheeria and Pederpes, of Temno-1538 1539 spondyli (reversed in *Deltaherpeton and at least six times among traditional temnospondyls), 1540 of Seymouria, Kotlassia and *Karpinskiosaurus and also of *Coloraderpeton and *Pseudo-1541 phlegethontia (unknown in other aïstopods except Oestocephalus). Clearly, this character is 1542 not useless.

State 0 is present in Ventastega (Ahlberg et al., 2008) and Acanthostega (Porro, 1543 1544 Rayfield & Clack, 2015). We have also assigned it to Dendrerpetidae, where the suture is not 1545 straight (especially in lateral view) but still smooth (A. R. Milner, 1980, 1996; Holmes, Carroll & Reisz, 1998). 1546

1547 State 1 is known in Acheloma (Polley & Reisz, 2011) and in one middle-sized 1548 specimen of *Acanthostomatops (Witzmann & Schoch, 2006a: fig. 2C), while the others have state 0. We have also scored state 1 in *Nigerpeton; the suture is difficult to find and to 1549 1550 confirm, but it is clearly not a straight line (D. M., pers. obs. of MNN MOR 70).

1551

Unknown in Lethiscus (Pardo et al., 2017: ext. data fig. 2, 3). 1552 *Spathicephalus has state 1 (Smithson et al., 2017: fig. 3C). So does

*Pseudophlegethontia (on the left side; see ch. 31, PAR 1). 1553

1554

*Glanochthon is polymorphic (Schoch & Witzmann, 2009b: fig. 2).

We have assigned state 1 to **Platyoposaurus*, though it is a somewhat borderline case 1555 1556 (Gubin, 1991: drawing 3). Similarly, although weak, interdigitation is present in 1557 *Pholidogaster (Panchen, 1975: fig. 14) and *Australerpeton (Barberena, 1998: fig. 3).

1558

1559 53. TAB 1/SQU 4: Separately ossified tabular: present (0); absent (1). RC07 distinguished 1560 TAB 1, which had the present name, from SQU 4, which described the absence (0) or presence (1) of a single bone in the places normally occupied by the squamosal, the tabular, 1561 and the supratemporal. SQU 4(1) was limited to the adelogyrinids. Based on which bones are 1562 1563 lost in other taxa in this matrix (and elsewhere among limbed vertebrates), we interpret the "squamosotabular bone" (Andrews & Carroll, 1991) as simply the squamosal, so that the 1564 adelogyrinids lack tabulars and SQU 4 turns out to be a duplicate of TAB 1. We do, however, 1565 identify potential homologues of the "tabular horns" in Adelospondylus, which we have 1566 1567 scored TAB 2(1) and TAB 6(1), and Adelogyrinus, which we have scored TAB 6(1) (TAB 2 being unknown), both after the drawings by Andrews & Carroll (1991). 1568 Ventastega shows state 0 (Ahlberg et al., 2008).

- 1569
- 1570

State 1 is present in Albanerpetidae (McGowan, 2002).

1571 State 0, tentatively reconstructed by Jenkins, Walsh & Carroll (2007), appears likely 1572 for *Eocaecilia*: what appears to be the tabular or supratemporal is caudally broken on the left 1573 side of the crushed type specimen (MNA V8066, formerly MCZ 9010), but appears to have 1574 reached the caudal edge of the skull table on the right side (D. M., pers. obs.). 1575

1576 54. TAB 2-3-9: "Ventral tabular horn" (caudal process of tabular lying ventral to 1577 tabular ornamented surface): absent (0); pointed (1); button-like (2); rectangular (3) 1578 (unordered). No sequence for ordering is apparent: the longest rectangles are as long as the 1579 longest buttons, while the shortest rectangles are extremely short; the widest buttons are no 1580 wider than the widest horns, and the widest horns are at least as wide as the widest rectangles, 1581 while the narrowest horns are extremely narrow.

1582 RC07 distinguished three characters: TAB 2, the presence or absence of a "[b]lade-1583 like [...] horn"; TAB 3, the presence or absence of a "[r]ounded, button-like posterior 1584 process"; and TAB 9, the presence or absence of a "[d]orsoventrally flattened, posteriorly directed, subhorizontal outgrowth" from the ventral rather than the caudal surface of the 1585 1586 tabular. Tellingly, these characters had almost completely mutually exclusive distributions: 1587 TAB 2(1) was assigned to Acanthostega, Crassigyrinus, Whatcheeria, Caerorhachis, all 1588 anthracosaurs, Gephyrostegus, Silvanerpeton and Utegenia; TAB 3(1) was scored for Greererpeton, Baphetes, Megalocephalus, Edops, "Dendrerpeton" and Pederpes; TAB 9(1) 1589 1590 was ascribed to Discosauriscus, Ariekanerpeton, Microphon and Utegenia. Most of these OTUs were scored 0, rather than "unknown", for the other two characters, which means that 1591

RC07 treated these three characters as describing three different processes that were not homologous to each other.

1594 From comparison across the taxon sample, it is obvious that all three processes are 1595 primary homologues of each other; indeed, state TAB 3(1) becomes state TAB 2(1) in the 1596 ontogeny of Apateon pedestris (compare fig. 7 of Boy & Sues, 2000, to fig. 3D of Schoch & 1597 Milner, 2008). "Horns" are apparently always at or close to the lateral margin of the tabular, while "buttons" are usually near the medial margin; but buttons can be approximately in the 1598 1599 middle as in various baphetids (Beaumont, 1977), quite close to the lateral margin (immature 1600 Apateon pedestris: Boy & Sues, 2000: fig. 7; Pederpes: Clack & Finney, 2005; *Bystrowiella: Witzmann & Schoch, 2017: fig. 2A), and even at the lateral margin, projecting lateral to it 1601 (*Spathicephalus: Beaumont & Smithson, 1998). "Flattened processes" stand out from the 1602 1603 ventral side of the tabular to which they are attached (all the way to the caudal edge of the skull table); but so, in many or perhaps all cases, do "horns" (Platyrhinops: Clack & Milner, 1604 1605 2010; Anthracosaurus: Clack, 1987a: fig. 2; *Branchiosaurus: Werneburg, 2012a: fig. 7) and 1606 even "buttons" (baphetoids: Beaumont, 1977, Beaumont & Smithson, 1998; Greererpeton: 1607 Smithson, 1982: fig. 13B).

1608 All four states are mutually exclusive; this fact lets us merge all three of the original 1609 characters.

1610 To their description of TAB 2, RC07 (p. 97) added: "Under the definition of a tabular 'horn', we include processes of the subdermal part of the bone, which in anthracosaurs has 1611 also a separate dermal component." This dermal component, the "dorsal tabular horn", is not 1612 limited to anthracosaurs, however; what is unique to anthracosaurs is that the dorsal and the 1613 1614 ventral horn point in different directions (most prominently in Proterogyrinus, but also in 1615 Anthracosaurus and to a lesser degree Pholiderpeton atthevi: Clack, 1987a). More commonly, 1616 it lies directly on top of the ventral horn, and that this is the condition seen in the other 1617 anthracosaurs which have a single, dorsoventrally thick "horn" per side (e.g. **Neopteroplax*: 1618 Romer, 1963). Gephyrostegus even has a dorsal horn without a ventral horn: the horn is a 1619 dorsoventrally very thin process of the ornamented surface alone (Klembara et al., 2014). We 1620 have redefined TAB 6 to code for the presence or absence of the "dorsal tabular horn".

State 0 is present in *Solenodonsaurus* (Danto, Witzmann & Müller, 2012).

1621

1622 State 1 occurs in Ventastega (Ahlberg et al., 2008), Ichthyostega (Clack & Milner, 2015: fig. 8), Eryops (Sawin, 1941), Acheloma (Polley & Reisz, 2011), most likely Broiliellus 1623 1624 (Carroll, 1964: fig. 9), Eoscopus (Daly, 1994), Platyrhinops (Clack & Milner, 2010; Werneburg, 2012a), Apateon (Schoch & Milner, 2008) and Leptorophus (Boy, 1986, 1987; 1625 1626 Schoch, 2014a) as well as apparently Chenoprosopus (Hook, 1993), Westlothiana (Smithson et al., 1994: fig. 5A) and Adelospondylus (Andrews & Carroll, 1991; see TAB 1/SQU 4). 1627 1628 Further, *Nigerpeton has state 1 (D. M., pers. obs. of MNN MOR 69 and MNN MOR 70); the 1629 "horn" is merely curved ventrally and therefore only shown as a stippled line in Stever et al. (2006: fig. 2A). 1630

1631 State 2 is found in *Trimerorhachis* ("only a very rudimentary horn well set off from 1632 the sculptured part of the bone": Milner & Schoch, 2013: 99), likely *Phonerpeton* (Dilkes, 1633 1990), and *Limnoscelis* ("a distinct, low, dome-like swelling of unknown function": Berman, 1634 Reisz & Scott, 2010: 196, fig. 3, 4).

Kotlassia (Bulanov, 2003: fig. 30) and *Seymouria* (Laurin, 1996a, 2000; Klembara et
al., 2007) have state 3, even though the rectangle becomes extremely short in (adult) *S. baylorensis* and *Kotlassia*.

1638 Unknown in *Balanerpeton* (Milner & Sequeira, 1994), Dendrerpetidae (A. R. Milner,
1639 1980, 1996; Holmes, Carroll & Reisz, 1998) and *Capetus* (Sequeira & Milner, 1993).

1640 The tabulars of *Brachydectes* are so modified that this character is hard to apply 1641 (Pardo & Anderson, 2016); we have scored it as unknown.
- 1643 (D. M., pers. obs. of MNN MOR 73).
- 1644 The condition of **Karpinskiosaurus* is intermediate between state 1 and 2 (Klembara, 1645 2011: fig. 3C); we have scored partial uncertainty.
- In **Sclerocephalus*, the ornamented surface possibly grows over the ventral horn in large specimens, but this is not the case in the specimen illustrated by Schoch & Witzmann (2009a: fig. 5A) which clearly shows state 1. Schoch (2009a), however, stated that state 0 occurs in the "terrestrial" morph and state 1 is restricted to the aquatic morph; we have accepted this and have scored **Sclerocephalus* as polymorphic, but caution that preservation may cause false appearances of state 0 when skulls are only exposed in dorsal view.
- 1652

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1642

1653 deleted TAB 4: Tabular/squamosal suture extending onto skull table dorsal surface: 1654 present (0); absent (1). This character was scored (usually 1) for almost all taxa in RC07, yet 1655 almost none possess a tabular/squamosal suture. Because it is further influenced by presence 1656 and position of the supratemporal and the temporal embayment, it would be inapplicable to most of the taxon sample if taken literally. It could be reinterpreted as the presence or absence 1657 1658 of participation of the squamosal in the dorsal surface of the skull roof, but that is already 1659 PAR 7 (ch. 36). We have therefore deleted this character. As it was scored by RC07, it required the same number of steps under the TH and the LH. 1660

- 1662 55. TAB 5: **Tabular/squamosal suture: smooth (0); interdigitating (1).** This character is 1663 inapplicable in the absence of contact between the tabular and the squamosal, notably in 1664 *Eusthenopteron* and *Panderichthys*, which were originally scored 0.
- 1665 Broiliellus has state 0 (Carroll, 1964: fig. 9).
- 1666 *Batropetes* is polymorphic (Glienke, 2013, 2015).
- 1667 State 1 occurs in *Brachydectes* (Pardo & Anderson, 2016: fig. 3A, C).
- **Micropholis* shows state 1 when the suture is present and long enough to tell (Schoch & Rubidge, 2005: fig. 1C, 3; not the oversimplified fig. 2C, which shows the same specimen as fig. 1C).
- 1671 In *Ecolsonia* (Berman, Reisz & Eberth, 1985), **Acanthostomatops* (Witzmann & Schoch, 2006a) and **Erpetosaurus* (Milner & Sequeira, 2011), the suture is probably too short to tell.
- 1674

1675 56. TAB 6: **"Dorsal tabular horn": absent (0); present (1).**

The original wording was: "Tabular (including its ornamented surface) elongate 1676 posterolaterally or posteriorly in the form of a massive, horn-like process, conferring a 1677 1678 boomerang-like shape to skull outline in plan view: absent (0); present (1)". (Evidently "plan" 1679 means dorsal and ventral.) State 1 was exclusively limited to *Diplocaulus* and *Diploceraspis*. 1680 To make this character more useful, we have excluded the size of the tabulars in this character 1681 (very large ones are necessary to give a boomerang shape to the entire skull instead of just the skull table) and compromised on "massive", interpreting this character as the presence or 1682 1683 absence of tabular "horns" composed of the ornamented surface (different from TAB 2-3-9) 1684 that extend markedly caudal to the postparietals. Thus, Baphetes (Beaumont, 1977: fig. 18, 20), Megalocephalus (Beaumont, 1977: fig. 10(b), 11(a)), Platyrhinops (Clack & Milner, 1685 2010), Micromelerpeton (Schoch, 2009), *Micropholis (Schoch & Rubidge, 2005: fig. 3) and 1686 *Cheliderpeton (Werneburg & Steyer, 2002) are polymorphic, while state 1 alone is docu-1687 mented in Ventastega (Ahlberg et al., 2008), Acanthostega (Clack, 2003), Chenoprosopus 1688 1689 (Hook, 1993; Reisz, Berman & Henrici, 2005), Cochleosaurus (Sequeira, 2004), Trimerorha-1690 chis (Milner & Schoch, 2013), Balanerpeton (at least sometimes: Milner & Sequeira, 1994: 1691 fig. 2, 4, 5), Dendrerpetidae (A. R. Milner, 1980, 1996; Holmes, Carroll & Reisz, 1998),

Eryops (both morphotypes: Werneburg, 2007b), Acheloma (Maddin, Reisz & Anderson, 1692 1693 2010; Polley & Reisz, 2011), Broiliellus (Carroll, 1964), tentatively Amphibamus (Schoch & 1694 Milner, 2014: fig. 30A; possibly Daly, 1994: fig. 18), Eoscopus (Daly, 1994), Apateon and Leptorophus (Schoch & Milner, 2008), Eoherpeton (Panchen, 1975; Smithson, 1985), Prote-1695 1696 rogyrinus (Holmes, 1984), Archeria (Holmes, 1989), both species of Pholiderpeton (Panchen, 1697 1972; Clack, 1987b), Anthracosaurus (Clack, 1987a), Bruktererpeton (Boy & Bandel, 1973), 1698 Gephyrostegus (Klembara et al., 2014), Discosauriscus and Seymouria (Laurin, 1996a, 2000; 1699 Klembara, 1997), apparently Westlothiana (Smithson et al., 1994: fig. 5B), Adelospondylus 1700 and Adelogyrinus (Andrews & Carroll, 1991; see TAB 1/SQU 4), Sauropleura (all three 1701 species illustrated in Bossy & Milner, 1998: fig. 53), Lethiscus (Pardo et al., 2017), Capetus (Sequeira & Milner, 1993), Silvanerpeton (Ruta & Clack, 2006: especially fig. 5), *Chronio-1702 1703 saurus (Clack & Klembara, 2009), *Iberospondylus (Laurin & Soler-Gijón, 2006), *Karpinskiosaurus (Klembara, 2011), *NSM 994 GF 1.1 (Holmes & Carroll, 2010), *Spathicephalus 1704 1705 (Beaumont & Smithson, 1998), *Sclerocephalus (Schoch & Witzmann, 2009a), *Glano-1706 chthon (Schoch & Witzmann, 2009b), *Archegosaurus (Witzmann, 2006), *Platyoposaurus 1707 (Gubin, 1991), *Konzhukovia (Gubin, 1991), *Lydekkerina (Shishkin, Rubidge & Kitching, 1708 1996; Jeannot, Damiani & Rubidge, 2006; Hewison, 2007), *Acanthostomatops (Witzmann & 1709 Schoch, 2006a), *Erpetosaurus (Milner & Sequeira, 2011), *Mordex and *Branchiosaurus (Werneburg, 2012a), *Palaeoherpeton (Panchen, 1964), *Neopteroplax (Romer, 1963) and 1710 1711 *Australerpeton (Barberena, 1998; Eltink et al., 2016).

Unknown in *Urocordylus* (Bossy & Milner, 1998: fig. 53); not preserved in **Niger- peton* (D. M., pers. obs. of MNN MOR 69 and MNN MOR 70); damaged in MNN MOR 73
(D. M., pers. obs.), therefore unknown in **Saharastega*.

1715 The tabulars of *Brachydectes* are so modified that this character is hard to apply 1716 (Pardo & Anderson, 2016); we have scored it as unknown.

1718 57. TAB 7: Parietal-parietal width smaller than (0) or greater than (1) distance between
1719 skull table posterior margin and orbit posterior margin, measured along skull midline.
1720 We interpreted the width to mean the maximum width between the lateral margins of the

1721 parietals.

- 1722 State 0 is found in *Ventastega* (Ahlberg et al., 2008), *Kotlassia* (just barely; Bulanov, 1723 2003: fig. 30) and *Brachydectes* (barely: Pardo & Anderson, 2016: fig. 4B).
- 1724 State 1 occurs in *Broiliellus* (Carroll, 1964), *Gephyrostegus* (Klembara et al., 2014) 1725 and *Scincosaurus* (Milner & Ruta, 2009).
- **Saharastega* is scored 1 because it has state 1 for the left orbit and exact equality
 between the distances for the right orbit.

1728 Probably subequal in *NSM 994 GF 1.1, therefore scored as unknown.

- Unclear in *Hapsidopareion* due to disarticulation (CG78: fig. 13A); unclear and likely
 borderline in **Neopteroplax* (Romer, 1963: fig. 1, 3).
- 1731

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1732 58. TAB 8: Tabular without (0) or with (1) posteroventrally sloping occipital exposure. 1733 See POSPAR 7 for the meaning of "sloping".

1734 State 0 is present in *Ventastega* (Ahlberg et al., 2008), *Rhynchonkos* (Szostakiwskyj, 1735 Pardo & Anderson, 2015) and *Lethiscus* (Pardo et al., 2017).

State 1 occurs in *Oestocephalus* (Carroll, 1998a; Anderson, 2003a), *Orobates* (Berman
et al., 2004) and *Tseajaia* (Moss, 1972; Berman, Sumida & Lombard, 1992), and probably in *Hapsidopareion* (CG78: fig. 13A).

Diadectes is polymorphic (Berman, Sumida & Lombard, 1992; Berman, Sumida &Martens, 1998).

Unknown for Eocaecilia (where it is not clear if the tabular had any occipital 1741 1742 exposure; Jenkins, Walsh & Carroll, 2007) and Westlothiana (Smithson et al., 1994). The 1743 tabulars of Brachydectes are so modified that this character is hard to apply (Pardo & 1744 Anderson, 2016); we have scored it as unknown as well.

1746 59. TAB 10: Tabulars entirely on occipital surface: no (0); yes (1).

1747 State 0 is present in Ventastega (Ahlberg et al., 2008) and Limnoscelis (Berman et al., 1748 2010). 1749

1750 60. POSORB 1: Separately ossified postorbital: present (0); absent (1).

State 0 is present in Ventastega (Ahlberg et al., 2008).

1752 State 1 is documented in Albanerpetidae (McGowan, 2002, Venczel & Gardner, 1753 2005).

1754 Adelospondylus was scored 1 in RC07. Ruta, Coates & Quicke (2003: 311) cited 1755 Andrews & Carroll (1991) as their only source for this score. However, Andrews & Carroll (1991: 364, fig. 13A, B) stated that whether a small postorbital was present or absent is un-1756 1757 known. Carroll & Andrews (1998: 151) considered the postorbital "small or absent in Adelo-1758 spondylus", and also noted that the adelogyrinid postorbital is in the position where the intertemporal would be expected, complicating this issue further. Not having seen the specimen, 1759 1760 we have changed the score to unknown for the time being.

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1762 61. POSORB 2: Postorbital without (0) or with (1) ventrolateral digitiform process fitting into deep, vertical groove along jugal lateral surface. 1763

1764 State 0 is present in Ventastega (Ahlberg et al., 2008) and, given the assumption 1765 explained under ch. 45 (POSFRO 1), Oestocephalus (Anderson, 2003: fig. 2) and 1766 Phlegethontia (Anderson, 2002).

1767 State 1 is found in Ervops (Sawin, 1941) and more weakly in Rhynchonkos (Szosta-1768 kiwskyj, Pardo & Anderson, 2015).

1769 Cochleosaurus (Sequeira, 2004) and Platyrhinops (Clack & Milner, 2010) are 1770 polymorphic; so is *Acanthostomatops (Witzmann & Schoch, 2006a). Unknown in Westlothiana (Smithson et al., 1994).

1771

State 1 is documented in one specimen of *Glanochthon (Schoch & Witzmann, 1772 1773 2009b: fig. 2J); but because this specimen is juvenile and all other illustrated specimens show 1774 state 0, we have decided to ignore it and score state 0 for **Glanochthon*.

1775 1776

62. POSORB 3: Postorbital contributing to (0) or excluded from (1) orbit margin.

State 0 is present in Ventastega (Ahlberg et al., 2008) and, given the assumption ex-1777 1778 plained under ch. 45 (POSFRO 1), Oestocephalus (Anderson, 2003: fig. 2) and Phlegethontia 1779 (Anderson, 2002).

1780 Acherontiscus was scored 1 in RC07. Ruta, Coates & Quicke (2003: 311) cited Carroll (1969a) as their only source for this score; however, Carroll (1969a) did not mention this 1781 1782 question in the text, presented a reconstruction drawing where the postorbital does contribute 1783 substantially to the orbit margin, and included a specimen drawing that can be interpreted 1784 either way, depending on which faint lines are sutures and which are breaks. Carroll (1998c) 1785 did not show drawings of the skull, but stated: "In contrast with adelogyrinids, the postorbital appears to enter the margin of the orbit." Not having seen the specimen, we have changed the 1786 1787 score to unknown for the time being.

1788

1789 63. POSORB 4: Postorbital irregularly polygonal (0) or broadly crescentic and 1790 **narrowing to a posterior point (1).** We have adopted a very broad interpretation of "broadly crescentic" and concentrated on absence and presence of the pointed caudal end; RC07
emphasized that the postorbital "terminates in an acute posterior extremity" in state 1. Very
likely, however, many more states – or characters – should be distinguished to represent the
diversity of postorbital shapes that occur in the OTUs of this matrix.

Taking the drawings by Clack & Milner (2015: fig. 8A, C) at face value, we have scored polymorphism for *Ichthyostega*.

Ventastega (Ahlberg et al., 2008) and *Platyrhinops* (Clack & Milner, 2010) display
state 0. We have kept state 0 for *Baphetes*: although the juvenile *B. orientalis* described by
Milner, Milner & Walsh has a very clear case of state 1, the adult (Beaumont, 1977: fig. 25) is
borderline, and in *B. kirkbyi* the caudal suture with the supratemporal is almost perfectly
transverse (Beaumont, 1977: fig. 18, 21).

Megalocephalus has rather polygonal postorbitals as well, but a clear caudal point is there, the suture with the supratemporal being oblique; we have therefore scored state 1 (Beaumont, 1977). *Trimerorhachis* has very long postorbitals with a very clear caudal point (Milner & Schoch, 2013). State 1 is also found in *Chenoprosopus* (Reisz, Berman & Henrici, 2005), in **Saharastega* (D. M., pers. obs. of MNN MOR 73), and, borderline, in *Rhynchonkos* (Szostakiwskyj, Pardo & Anderson, 2015: fig. 1); note that fig. 63 of CG78 is mirrored.

1808 *Kotlassia* was scored 1 in RC07, but its caudal point is far ventral (Bulanov, 2003: fig.
1809 30), instead of dorsal as usual; we prefer to treat this unique condition as state 0.

1810 *Seymouria* was scored 1 in RC07, but the caudal end of its postorbital is a straight 1811 vertical suture (Laurin, 2000: fig. 1).

1812 State 1 is present in *Paleothyris* (Carroll, 1969b), *Petrolacosaurus* (though this may be 1813 due to the temporal fenestrae; Reisz, 1981), and *Westlothiana* (at least on the right side, and at 1814 least in the specimen drawings as opposed to the reconstruction; Smithson et al., 1994).

1815 Batropetes fritschi and its sister-group B. niederkirchensis have state 0 (Glienke,
1816 2013), but B. palatinus has state 1 (Glienke, 2015), making Batropetes polymorphic. *Micro1817 pholis is polymorphic as well (Schoch & Rubidge, 2005: fig. 3).

1818 Unknown in *Hapsidopareion*, where the temporal embayment is so large that it 1819 constrains the shape of the postorbital, and *Lethiscus* (see ch. 45 – POSFRO 1 – and 1820 Anderson, Carroll & Rowe, 2003: fig. 9B).

1821 We have assigned state 0 to **Spathicephalus* because the postorbital is only crescentic 1822 insofar as it parallels the orbit margin and because it lacks a caudal point.

**Platyoposaurus* seems to be polymorphic, judging from the drawings by Efremov
(1932), Konzhukova (1955) and Gubin (1991). So is **Lydekkerina* (Jeannot, Damiani &
Rubidge, 2006).

**Erpetosaurus* has a clear caudal point, but the extremely long postorbitals are
lozenge-shaped, being much wider in the middle than at the orbit margin; we have assigned
state 0, even though this polygon is not irregular.

64. POSORB 5: Postorbital/tabular suture: absent (0); present (1). Unlike RC07, we have
scored this character as unknown (inapplicable) when the supratemporal is present. This
affects all OTUs scored 0 in RC07 except *Hyloplesion*, the diplocaulids and *Hapsidopareion*;
we have scored the latter as unknown as well, however, because its temporal embayment is
unusually large and acts like a supratemporal for the purpose of this character.

1835 *Microbrachis* has state 1 (Olori, 2015).

1836

1837 65. POSORB 6: Postorbital not wider (0) or wider (1) than orbit. Judging from the original
1838 scores, this is meant to be measured in strict dorsal view.

1839 State 0 occurs in *Ventastega* (Ahlberg et al., 2008). We have kept state 0 for 1840 *Limnoscelis*, which is borderline (Berman, Reisz & Scott, 2010: fig. 3A).

1841 State 1 occurs in Ichthyostega (Clack & Milner, 2015: fig. 8) and Cochleosaurus 1842 (Sequeira, 2004). 1843 Unknown in Lethiscus (see ch. 45 - POSFRO 1 - and Anderson, Carroll & Rowe, 1844 2003: fig. 9B); *Phlegethontia*, however, has state 0 regardless of how much of the apparently 1845 compound bone consists of the postorbital (Anderson, 2002). The condition is so borderline in the reconstruction of *Nigerpeton (Steyer et al., 1846 1847 2006) and the specimen drawings of *Lydekkerina (Jeannot, Damiani & Rubidge, 2006) that 1848 we have scored both as unknown. Pers. obs. of *Nigerpeton (by D. M.) failed to clarify its 1849 condition: the orbit margin is only preserved on two separate pieces of MNN MOR 70. 1850 1851 66. POSORB 7: Postorbital at least one-fourth of the width of the skull table at the same 1852 transverse level: absent (0); present (1). RC07 used "skull roof" instead of "skull table". Again, this character is evidently meant to be measured in strict dorsal view. 1853 1854 State 0 occurs in Ventastega (Ahlberg et al., 2008), Colosteus (Hook, 1983) and 1855 Silvanerpeton (Ruta & Clack, 2006) as well as *Nigerpeton (D. M., pers. obs. of MNN MOR 1856 70). 1857 State 1 occurs in Ichthyostega (Clack & Milner, 2015: fig. 8), Baphetes and Megaloce-1858 phalus (Beaumont, 1977), Eucritta (Clack 2001), Edops (Romer & Witter, 1942; D. M., pers. obs. of MCZ 1378), Cochleosaurus (Sequeira, 2004), Neldasaurus (Chase, 1965), Trimero-1859 rhachis (Milner & Schoch, 2013), Eryops (Sawin, 1941), Amphibamus (Schoch, 2001), Do-1860 leserpeton (Sigurdsen & Bolt, 2010), Eoscopus (Daly, 1994), Kotlassia (Bulanov, 2003: fig. 1861 30), Scincosaurus (Milner & Ruta, 2009), all diplocaulids (A. C. Milner, 1980), and *Chroni-1862 1863 osaurus (Clack & Klembara, 2009). 1864 Apateon passes from state 0 to state 1 during ontogeny (Schoch & Fröbisch, 2006). 1865 Still, Leptorophus retains state 0 as scored by RC07 (Boy, 1986), so we have kept the score of 1866 0 for Schoenfelderpeton. 1867 Unknown in Adelogyrinus (Andrews & Carroll, 1991) and Lethiscus (see ch. 45 -1868 POSFRO 1 – and Pardo et al., 2017). 1869 Microphon is polymorphic (Bulanov, 2003: fig. 16, 22), though we caution that this 1870 difference between M. exiguus (state 1) and M. gracilis (state 0) could be ontogenetic, with 1871 the known skull of *M. gracilis* being closer to maturity than that of *M. exiguus* (literally "the tiny one"). 1872 1873 *Acanthostomatops is polymorphic, often within the same specimen, and all cases are close to the boundary between the states (Witzmann & Schoch, 2006a). 1874 1875 *Glanochthon is likewise polymorphic, sometimes between the left and the right side 1876 of the same individual (Schoch & Witzmann, 2009b: fig. 2). 1877 1878 67. POSORB 8: Anteriormost part of postorbital [dorso]me[d]ial margin with sigmoid 1879 profile in dorsal or lateral aspect: absent (0); present (1). A clearer wording could be 1880 "ventrolateral digitiform process on the postfrontal: absent (0); present (1)". State 0 is seen in Ventastega (Ahlberg et al., 2008) and Batropetes (Glienke, 2013). 1881 1882 Some specimens of Trimerorhachis show state 1 on one side (Milner & Schoch, 1883 2013); we have scored this as polymorphism. 1884 Unknown in Lethiscus (see ch. 45 - POSFRO 1 - and Pardo et al., 2017); not 1885 preserved in *Nigerpeton (D. M., pers. obs. of MNN MOR 70). 1886 State 1 is documented in one specimen of *Glanochthon (Schoch & Witzmann, 2009a: 1887 fig. 2I); but because this specimen is juvenile and all other illustrated specimens show state 0, 1888 we have decided to ignore it and score state 0 for *Glanochthon.

1889 On the right side of *Palaeoherpeton, the process could be considered just another 1890 part of the interdigitation of the suture, but on the left side, state 1 is clearly present (Panchen, 1891 1964: fig. 11, 12).

1892

*Australerpeton is polymorphic (Eltink et al., 2016: fig. 2–5). 1893

1894 68. SQU 1: Rostral end of squamosal lying posterior to (0) or anterior to (1) parietal 1895 midlength (measured along the midline). RC07 phrased "rostral end" as "anterior part" 1896 without defining where the caudal end of this part might lie.

1897 Ventastega (Ahlberg et al., 2008), Westlothiana (Smithson et al., 1994) and Micraroter and Euryodus (CG78) show state 0, which is also borderline present in Rhynchonkos 1898 1899 (Szostakiwskyj, Pardo & Anderson, 2015).

1900 State 1 occurs in Eucritta (Clack, 2001), Valdotriton (Evans & Milner, 1996), Batro-1901 petes (Glienke, 2013) and Cardiocephalus (CG78) as well as Adelospondylus and Adelogyri-1902 nus (Andrews & Carroll, 1991).

1903 Trimerorhachis is usually borderline; there are a few clear cases (at least on one side 1904 of certain skulls) of state 1 and a few less clear ones of state 0 (Milner & Schoch, 2013). We 1905 have scored polymorphism.

1906 The specimen of *Archegosaurus illustrated by Witzmann (2006: fig. 5) has state 1 1907 when the right parietal is used for measurement and is borderline when the left one is chosen; 1908 we have scored state 1.

1909 In **Konzhukovia* the rostral ends of the squamosals are at parietal midlength (Gubin, 1910 1991); we have scored it as unknown.

1911 **Erpetosaurus* is polymorphic and often borderline (Milner & Sequeira, 2011), much 1912 like Trimerorhachis.

1913 *Branchiosaurus starts out with state 1, but apparently reaches state 0 in ontogeny 1914 (Werneburg, 2012a); we have scored state 0. 1915

1916 SQU 2 is merged with JAW ART 1 and DEN 8, see below.

1917

1918 69. SQU 3: Caudolateral edge of skull: straight or convex (0); dorsoventrally tall 1919 embayment (1); dorsally restricted notch (2) (unordered). The original name and description of this character contradict each other: "Squamosal without (0) or with (1) broad, 1920 1921 concave embayment. An embayment is widespread among early tetrapods, a deeply incised 1922 squamosal notch is seen only in some stem amniotes and, conspicuously, in temnospondyls 1923 and salientians." [italics in the original] Judging from its name, the "deeply incised squamosal 1924 notch" (found, incidentally, in few temnospondyls and no salientians!) was lumped with the 1925 complete absence of an embayment into the same state – and indeed this was reflected in the 1926 matrix. We have not ordered this character because the temporal embayment could disappear 1927 by rostrocaudal shortening (which might pass from state 2 over 1 to 0 or directly from 2 to 0) 1928 or by dorsoventral narrowing (from 1 over 2 to 0). As the criterion for distinguishing between 1929 states 1 and 2, we have primarily used whether the embayment encroaches on the 1930 quadratojugal (state 1) or has its ventral end within the squamosal (state 2).

1931 Within state 2, a difference between a short triangular notch (e.g. Eoherpeton: Smith-1932 son, 1985; *Llistrofus: Bolt & Rieppel, 2009: fig. 4) and a narrow, deep one which has almost parallel edges for much of its length (e.g. Seymouria: Laurin, 1996a, 2000; Phonerpeton: 1933 1934 Dilkes, 1990; D. M., pers. obs. of MCZ 2313) could be recognized, but this is already 1935 included in other characters (TAB 7, ORB 5).

1936 The temnospondyls Capetus (Sequeira & Milner, 1993) and Phonerpeton (Dilkes, 1937 1990: state 2: D. M., pers. obs. of AMNH 7150 [7 cm skull length]: borderline state 1; MCZ 1938 2313 [10 cm skull length]: extreme case of state 2) appear to pass from state 1 to state 2 in its ontogeny; so does, more clearly, the seymouriamorph **Karpinskiosaurus* (Klembara, 2011).
The difference between these states is not, however, size-dependent, as demonstrated by the
fact that *Phonerpeton* has state 2 while *Dendrysekos* (Dendrerpetidae), at the same skull size
as *Phonerpeton*, has state 1 (Holmes, Carroll & Reisz, 1998).

1943 State 1 further occurs in Gephyrostegus; although not rounded, the embayment is 1944 extremely tall (Klembara et al., 2014), quite unlike what is seen in anthracosaurs. State 1 is 1945 unambiguously present in Ecolsonia (Berman, Reisz & Eberth, 1985; that the tabular and the 1946 quadratojugal meet caudal to the embayment does not matter), Solenodonsaurus (Laurin & 1947 Reisz, 1999), Diadectes (Berman, Sumida & Lombard, 1992; Berman, Sumida & Martens, 1948 1998), arguably Batropetes (Glienke, 2015: fig. 9D, E), Adelogyrinus (Andrews & Carroll, 1949 1991), Ariekanerpeton and Utegenia (Klembara & Ruta, 2004a, 2005a), Leptoropha (Bula-1950 nov, 2003), Orobates (Berman et al., 2004), Silvanerpeton (Ruta & Clack, 2006), and Tsea-1951 jaia (Moss, 1972; Berman, Sumida & Lombard, 1992; Reisz, 2007; D. M., pers. obs. of CM 1952 38033). It is also seen in **Iberospondylus* and **Acanthostomatops*, even though the greatly 1953 enlarged quadratojugal creates the appearance of state 2 in dorsal view (Laurin & Soler-Gijón, 1954 2006; Witzmann & Schoch, 2006a).

1955 State 2, the plesiomorphy, is seen in Ventastega (Ahlberg, Lukševičs & Lebedev, 1956 1994; Ahlberg et al., 2008), Ichthyostega (Clack & Milner, 2015: fig. 8), Edops (D. M., pers. 1957 obs. of MCZ 1378), adult Chenoprosopus (Langston, 1953: fig. 8), Cochleosaurus (Sequeira, 1958 2004), Trimerorhachis (Milner & Schoch, 2013), Balanerpeton (somewhat arguably; Milner 1959 & Sequeira, 1994), Eryops (D. M., pers. obs. of casts on exhibit in various museums as well 1960 as TMM, CM, USNM and MCZ specimens; very difficult to tell from publications like Sawin, 1941), Acheloma (Polley & Reisz, 2011), the most mature specimens of Micromeler-1961 peton (Schoch, 2009b: fig. 2b), Apateon (throughout ontogeny: Boy, 1987; Schoch & Frö-1962 1963 bisch, 2006), Leptorophus (though borderline: Boy, 1986), Caerorhachis (Ruta, Milner & 1964 Coates, 2002), all anthracosaurs, Lethiscus (Pardo et al., 2017) and Microphon (Bulanov, 1965 2003).

From the available illustrations, we cannot tell if *Kotlassia* (Bulanov, 2003: fig. 30) has state 1 or 2. We have assigned the same partial uncertainty to **Pholidogaster* (Panchen, 1968 1975: fig. 15).

Dendrerpetidae is polymorphic, with *Dendrysekos* having state 1 (see above) but *Dendrerpeton acadianum* showing state 2 instead (Milner, 1996: fig. 6A; Schoch & Milner, 2014:
fig. 16B). Unfortunately the state of *Dendrerpeton confusum* is unknown (Milner, 1996: fig. 8), and *D. rugosum* probably but not certainly has state 2 (A. R. Milner, 1980: fig. 6a, c), so
we cannot reconstruct the ancestral state for Dendrerpetidae.

We have scored state 0 or 2 for *Oestocephalus*: a very small notch as seen in *Lethiscus*cannot be excluded judging from Carroll (1998a: fig. 2A, 3C).

1976 This character is not applicable to *Phlegethontia* because so much of the dermal skull 1977 roof is lost; the caudal edge of the putative squamosal (Anderson, 2002) could be called state 1978 1 or even 2, but is most likely unrelated, lacking e.g. a caudomedial lamina.

1979 Despite diagenetic squishing, an unusual version of state 0 is recognizable in 1980 **Saharastega* (D. M., pers. obs. of MNN MOR 73).

1981 We have assigned state 1 to **Liaobatrachus*, although *L. zhaoi* might be said to have 1982 state 2 instead (Dong et al., 2013: fig. 6C, 7D).

1983 In *caseasaurs the supratemporals project caudally beyond the rest of the skull table, 1984 producing the impression of state 2 (*Oedaleops, Eocasea*) or possibly 1 (*Eothyris*) in lateral 1985 view. We consider this an unrelated feature and have scored state 0 for *Caseasauria.

1986 Although the reconstruction of **Bystrowiella* (Witzmann & Schoch, 2017: fig. 15) 1987 suggests state 2, the photo and specimen drawing (fig. 3A, C) strongly suggest state 1, which 1988 we have scored.

1989 1990	State 2 is visible in *Coloraderpeton (Pardo et al., 2017: video).
1990 1991 1992 1993	70. SQU 5: Squamosal without (0) or with (1) internal shelf bracing quadrate from behind. RC07 scored state 1 for the distinctive condition found in diplocaulids and <i>Scinco-saurus</i> . Therefore, we have not considered the smaller caudal exposure of the squamosal
1994 1995	found in amniotes, diadectomorphs and possibly <i>Batropetes niederkirchensis</i> and * <i>Crinodon</i> as state 1. However, state 1 is unambiguously found in * <i>Australerpeton</i> , where a medial pro-
1996	cess of the squamosal meets the pterygoid dorsal to the occipital exposure of the quadrate
1997	<i>Lethiscus</i> has state 0 (Pardo et al., 2017).
1999	Unknown in <i>Bruktererpeton</i> (Boy & Bandel, 1973); best scored as unknown in
2000	*Sanarastega (D. M., pers. obs. of MINN MOR 73).
2002	71. JUG 1: Separately ossified jugal: present (0); absent (1). State 0 is present in <i>Vantastaga</i> (Ablberg Lukševičs & Lebedev, 1994) and <i>Lathiscus</i>
2003	(Pardo et al., 2017).
2005 2006	Given the seemingly bad preservation of this area in <i>Triadobatrachus</i> (all sources), we have scored it as unknown as RC07 had already done for the guadratoiugal (OUA IUG 1)
2007	
2008	72. JUG 2-6: Maxilla-quadratojugal contact excluding jugal from ventral edge of skull (0): jugal contributes to ventral edge of skull between maxilla and quadratojugal, but
2010	does not project laterally beyond toothrow (1); jugal laterally overlaps toothrow (2) (or-
2011	dered). We have merged two correlated characters that we interpret as parts of a continuous
2012	character. This character is not applicable to taxa with state JUG 1(1); a maxilla-quadratojugal
2013	contact can be present when there is no jugal (if the quadratojugal is present: QUAJUG 1(0)),
2014	but this is then the only possible manifestation of MAX $6(0)$ and thus already covered in this
2015	matrix.
2016	State 0 is present in <i>Ventastega</i> (Ahlberg, Luksevics & Lebedev, 1994) and <i>Eocaecilia</i>
2017	(Jenkins, Walsh & Carroll, 2007). We have kept it for <i>Oestocephalus</i> , where the lower
2018	temporal bar is interrupted but the maxilla extends much farther caudally than the jugal does
2019	(Carroll, 1998a; Anderson, 2003a); the same condition appears to be present in
2020	*Coloraderpeton (Anderson, 2003a; Pardo et al., 2017).
2021	<i>Cephyrosiegus</i> has state 1 (Kiembara et al., 2014), as does <i>Leiniscus</i> (Pardo et al., 2017)
2022	2017). State 2 is not confined to pontulide: it is shared by <i>Proiliellus</i> (Correll 1064: figs 0
2023	10)
2024	Schoenfelderneton is scored as unknown due to its paedomorphosis
2025	Unknown in <i>Leptoropha</i> (Bulanov 2003: fig. 12) Inapplicable to <i>Batropetes</i> due to
2020	OUAIUG 1(1) to Hansidonareion Pelodosotis and *Llistrofus due to CHE EMA 1(1) and to
2028	<i>Rhynchonkos</i> due to OUAJUG 1(?) (which was already scored by RC07): see below for those
2029	characters.
2030	Unknown in * <i>Nigerpeton</i> (D. M., pers. obs. of MNN MOR 69 and MNN MOR 70).
2031	* <i>Lvdekkerina</i> is polymorphic, having state 0 on the left and state 1 on the right side of
2032	the holotype (Hewison, 2007).
2033	We have scored state 0 for *Diploradus and *Aytonerpeton after Clack et al. (2016:
2034	matrix).
2035	
2036	73. JUG 3: Jugal/pterygoid contact: absent (0); present (1).
2037	Eocaecilia (Jenkins, Walsh & Carroll, 2007), Limnoscelis (Reisz, 2007; Berman,
2038	Reisz & Scott, 2010) and Lethiscus (Pardo et al., 2017) have state 0. So does Ossinodus, in

spite of the palatal exposure of the jugal (Warren, 2007) that gives state 1 to *Cochleosaurus*(as already scored; Sequeira, 2004), **Saharastega* (Damiani et al., 2006) and **Konzhukovia*(Gubin, 1991) but not **Palatinerpeton* (Boy, 1996), **Platyoposaurus* (Gubin, 1991: drawing
or **Australerpeton* (Eltink et al., 2016).

2043 Unknown in *Edops* (Romer & Witter, 1942: fig. 3B; D. M., pers. obs. of MCZ 1378) 2044 and *Rhynchonkos* (Szostakiwskyj, Pardo & Anderson, 2015).

**Nigerpeton* has state 0 as illustrated by Steyer et al. (2006: fig. 2B), although that
drawing is downright idealized (D. M., pers. obs. of MNN MOR 70, where these bones are
very hard to identify; they are not preserved in the other two skulls).

Milner & Sequeira (2011) considered state 1 probably present in **Erpetosaurus*. Although this is not clear from their figures 2 and 5, we have accepted it. (Milner & Sequeira, 2050 2011: 65, referred to a specimen number and fig. 2, but the specimen with that number is shown in fig. 5 instead, at least judging from the captions.)

2052 Clack et al. (2012b: 22) implied state 0 for the *St. Louis tetrapod by stating: "The 2053 ectopterygoid appears to contribute to the margin of the adductor fossa." The caudal (distal) end of the preserved right ectopterygoid, however, is broken off; fig. 2B of Clack et al. 2054 2055 (2012b) is misleading in representing the break at the caudal end of the specimen as a line, 2056 implying a vertical surface - it is an inclined surface (D. M., pers. obs. of MB.Am.1441.1 and MB.Am.1441.2). The lingual margin does not appear to be broken, but is too irregular to 2057 represent the edge of the subtemporal fenestra; most likely, then, it is part of the sutural 2058 2059 surface for the pterygoid. By comparison to other animals, the caudal end of the ectopterygoid 2060 would be expected far distal to the ectopterygoid fang rather than such a short distance distal to it. On the left side, most of the large Meckelian fenestra is preserved; if the mesiodistal 2061 overlap between the adductor fossa and the Meckelian fenestra was not substantially larger 2062 2063 than in Greererpeton (Bolt & Lombard, 2001: fig. 5), the entire adductor fossa of the lower 2064 jaw and thus the entire subtemporal fenestra must have lain well distal (caudal) of the entire 2065 preserved fragment of the ectopterygoid. We have therefore scored the *St. Louis tetrapod as 2066 unknown. 2067

74. JUG 4: Maximum depth of jugal ventral to orbit greater (0) or smaller (1) than half
of anteroposterior eye diameter. One might think that this character is size-related, with
larger animals having relatively smaller eyes at comparable ontogenetic stages and therefore
deeper jugals ventral to them, but that is clearly not the case in our taxon samples.

2072 Ventastega has state 1 (Ahlberg, Lukševičs & Lebedev, 1994). So do Albanerpetidae
2073 (McGowan, 2002; Venczel & Gardner, 2005) and Lethiscus (Pardo et al., 2017).

For *Trimerorhachis* (not including *?T. sandovalensis*), where the jugal is excluded from the orbit margin by a strikingly long lacrimal/postorbital suture, we have combined the width of the jugal with that of the lacrimal and/or postorbital. Doing so marginally results in state 0 (Milner & Schoch, 2013).

We have scored *Eucritta* as unknown because only juvenile specimens are known and relative eye size decreases in the ontogeny of most animals.

2080 *Batropetes* is polymorphic, with *B. fritschi* having state 1 while *B. niederkirchensis* 2081 and *B. palatinus* have state 0 (in lateral view) (Glienke, 2013, 2015).

Even the largest adults of **Glanochthon angusta* show both states (Schoch & Witzmann, 2009b: fig. 2A, B).

2085 75. JUG 7: Jugal without (0) or with (1) V-shaped indentation of its orbital margin.

2084

2086 State 1 is present in *Ventastega* (Ahlberg, Lukševičs & Lebedev, 1994) and, though 2087 weakly expressed, in *Eucritta* (Clack, 2001: fig. 4, 6) and *Edops* (D. M., pers. obs. of MCZ 2088 1378; not very well visible in Romer & Witter, 1942: fig. 1).

2089 For Trimerorhachis (not including ?T. sandovalensis), where the jugal does not 2090 contact the orbit, we have applied this character to the lacrimal and the postorbital instead; this confirms the score of 0 (Milner & Schoch, 2013). 2091

2092 Unknown in Westlothiana (Smithson et al., 1994). Also unknown in Baphetes and 2093 Megalocephalus due to the antorbital fenestra and/or incomplete preservation (Beaumont, 2094 1977; Milner, Milner & Walsh, 2009), as well as in *Spathicephalus, where the jugal may not 2095 even reach the orbit proper (Beaumont & Smithson, 1998; Smithson et al., 2017).

2096 *Sclerocephalus is polymorphic, sometimes between the left and right sides of the 2097 same individual (Schoch & Witzmann, 2009a). 2098

2099 76. JUG 8: Jugal not extending (0) or extending (1) anterior to orbit anterior margin. 2100 This character is only applicable to OTUs with MAX 5/PAL 5(0) and applies to the 2101 (dorso)lateral surface of the skull, not to underlapping processes.

2102 We do not count the baphetoid antorbital fenestra as part of the orbit. Although 2103 Eucritta nonetheless seems to have state 0 as already scored (Clack, 2001: fig. 4, 6, 8), 2104 Baphetes and Megalocephalus have state 1 (Beaumont, 1977).

2105 Lethiscus has state 0 (Pardo et al., 2017).

2106 State 1 is present in Ventastega (Ahlberg, Lukševičs & Lebedev, 1994) and Limnoscelis (Berman, Reisz & Scott, 2010: fig 3B). 2107

2108 Unknown in Westlothiana (Smithson et al., 1994).

2109

2113

2110 77. QUAJUG 1: Separately ossified quadratojugal: present (0); absent (1). 2111

State 0 is present in Ventastega (Ahlberg, Lukševičs & Lebedev, 1994).

Batropetes appears to have state 1 (Glienke, 2015). 2112

Notobatrachus is polymorphic (Báez & Nicoli, 2008).

2114 The quadratojugal is unknown in *Hapsidopareion*; CG78 interpreted this as genuine absence. However, for unknown reasons, Hapsidopareion has been assigned state 0 of this 2115 2116 character ever since Ruta, Coates & Quicke (2003); neither Ruta, Coates & Quicke (2003) nor 2117 RC07 commented on this. Bolt & Rieppel (2009) pointed out that *Llistrofus has state 0 and 2118 that the absence in *Hapsidopareion* is likely taphonomic; we have scored *Hapsidopareion* as 2119 unknown.

2120 Most or all of the supposed squamosal of Phlegethontia (Anderson, 2002) is better 2121 considered the quadratojugal by comparison to other aïstopods, particularly Lethiscus (Pardo 2122 et al., 2017); we have scored state 0 of the present character.

2123 The quadratojugal of *Nigerpeton identified in Stever et al. (2006: fig. 1B) is not 2124 reproducible; the area where this bone would be expected is ossified, but the suture between 2125 the jugal and the quadratojugal is not preserved in MNN MOR 70 and wholly covered by hard 2126 sandstone in MNN MOR 69 (D. M., pers. obs.). We have consequently scored *Nigerpeton as 2127 unknown for all three QUAJUG characters.

2128 All four species of *Liaobatrachus are said to have state 0, but in three of the four 2129 species the quadratojugal is said to be fused to the quadrate, and no statement has been made 2130 about the fourth (L. beipiaoensis; Dong et al., 2013). The published figures do not resolve the 2131 situation. Given the shape of the supposedly compound bone and the lack of an explicit state-2132 ment about fusion or lack thereof in L. beipiaoensis, we have scored state 0 for the time being, 2133 but this should be investigated further.

2134 Without further comment, Schoch, Poschmann & Kupfer (2015) described their 2135 specimens of *Chelotriton as having quadratojugals separate from their quadrates. As dis-2136 cussed by Marjanović & Witzmann (2015), this would be the first documented case in all of 2137 Urodela; while separate bones are clearly shown in the line drawings (Schoch, Poschmann & 2138 Kupfer, 2015: fig. 4b-d), the photograph (fig. 4a) is unclear. However, the putative quadrato2139 jugals would immediately be considered quadratojugals if **Chelotriton* were compared only 2140 to other taxa in this matrix rather than to other salamandrids, having as they do a large orna-2141 mented surface that is sutured to those of the maxillae and the squamosals. We have here 2142 accepted them as such and scored state 0.

2143 In *Bystrowiella, the preserved margins of the jugal and the squamosal make it hard to 2144 imagine that a separate quadratojugal, or perhaps a separate-looking one as in *Chelotriton, 2145 was absent; we have scored state 0 for this character (but not the next four, which remain 2146 unknown).

2147 We interpret the unlabeled purple slivers in Pardo et al. (2017: ext. data fig. 4) as the 2148 articulated, though probably incomplete, quadratojugal of **Coloraderpeton*.

2149

2155

2156

2150 78. QUAJUG 2: Quadratojugal depth less than one-fourth of squamosal depth: absent 2151 (0); present (1).

- State 0 is present in Ventastega (Ahlberg, Lukševičs & Lebedev, 1994), apparently 2152 2153 Asaphestera (CG78) and Lethiscus (Pardo et al., 2017). 2154
 - Unknown in Scincosaurus (Milner & Ruta, 2009).
 - Notobatrachus reigi has state 1 (Báez & Nicoli, 2008).

2157 79. QUAJUG 3: Quadratojugal anteroposteriorly elongate and bar-like: no (0); yes (1).

2158 State 0 is present in Ventastega (Ahlberg, Lukševičs & Lebedev, 1994) and Lethiscus 2159 (rather elongate, but a plate, not a bar, barely reaching the temporal fenestra: Pardo et al., 2160 2017).

2161 State 1 is reconstructed for *Eocaecilia* (Jenkins, Walsh & Carroll, 2007) and, though 2162 borderline so, for *Spathicephalus (Beaumont & Smithson, 1998). 2163

2164 80. QUA 1: Quadrate without (0) or with (1) dorsal process caudal to temporal 2165 embayment. RC07 did not specify which dorsal process they meant; the one they scored as 2166 present in Seymouria, Diadectes and Limnoscelis is simply the ossification of the dorsal part 2167 of the shaft, rostromedial to where the embayment is or would be and clearly not homologous 2168 to the process found in dissorophoid temnospondyls.

2169 That process is not limited to dissorophoids, however (among which it is also found in 2170 Ecolsonia [Berman, Reisz & Eberth, 1985: 16] and *Micropholis [Schoch & Rubidge, 2005]): 2171 as Hook (1993) pointed out, Chenoprosopus has state 1, even though the process of USNM 2172 437646 seems to have been accentuated by damage and it is at best very difficult to trace the 2173 sutures around the quadrate in that specimen (D. M., pers. obs.). State 1 further occurs in 2174 *Iberospondylus (Laurin & Soler-Gijón, 2006) and in the stereospondyls *Lydekkerina (Jean-2175 not, Damiani & Rubidge, 2006: "hyoid tubercle"; Hewison, 2007: "guadrate tubercle", "guad-2176 rate boss") and *Australerpeton (Barberena, 1998; Eltink et al., 2016: fig. 8: caudolateral to 2177 the "tympanic crest").

2178 Clearly, this character is inapplicable in the absence of a temporal embayment (SQU 2179 3(0)) or if the quadrate is inclined caudodorsally to rostroventrally (JAW ART 1/SQU 2/DEN 2180 8(3/4)).

- 2181 State 0 is found in Solenodonsaurus (Danto, Witzmann & Müller, 2012), Discosauris-2182 cus (Klembara, 2009), Microphon (Bulanov, 2014: fig. 2) and Orobates (Nyakatura et al., 2183 2015: digital reconstruction).
- 2184 Unknown in *Nigerpeton (D. M., pers. obs. of MNN MOR 69 and MNN MOR 70). 2185

2186 81. PREOPE 1: Preopercular: present (0); absent (1). RC07 had exchanged the states in the 2187 text but not in the matrix.

2188 Ventastega (Ahlberg, Lukševičs & Lebedev, 1994) and Ossinodus (Warren, 2007) 2189 have state 0.

2190 So does Whatcheeria (Lombard & Bolt, 1995; Bolt & Lombard, 2000). Ruta, Coates 2191 & Quicke (2003), the preceding version of RC07, cited Clack (1998, 2001) for the absence of 2192 the preopercular (state 1) in all post-Devonian tetrapods, but Clack (1998) confirmed the pres-2193 ence of the preopercular in Whatcheeria (as part of the argument for the absence of this bone 2194 in Crassigyrinus), and Clack (2001) mentioned neither the preopercular nor Whatcheeria.

2195 Unknown in Batropetes (Glienke, 2013, 2015), Lethiscus (area not preserved: Pardo et 2196 al., 2017) and *Nigerpeton (D. M., pers. obs. of MNN MOR 69 and MNN MOR 70).

2197 The position of the putative preopercular in *Coloraderpeton (Pardo et al., 2017: ext. 2198 data fig. 4, video; scored as present in their matrix) excludes all alternatives rather clearly; we 2199 have scored state 0.

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2201 deleted NOS 1: Nostrils posterolaterally expanded: absent (0); present (1). RC07 stated: 2202 "This is a feature of branchiosaurid dissorophoids, in which the external nostril outline widens in its posterolateral portion (Boy & Sues, 2000)." They proceeded to score state 1 for their 2203 2204 three branchiosaurids (and no other OTUs). Yet, while state 1 is clearly present in Apateon 2205 dracvi (Schoch & Milner, 2008: fig. 1H) and arguably in A. pedestris (fig. 1G), it is clearly not in Schoenfelderpeton, where the nostril has a narrow caudal extension instead (fig. 4A). 2206 Leptorophus has a wider caudal extension, but it does not seem wider than the rostral half of 2207 2208 the nostril, at least not in dorsal view (fig. 4B). State 0 is clearly found in Apateon gracilis 2209 (Schoch & Fröbisch, 2006), the sister-group to most or all of the rest of Apateon (Schoch & 2210 Milner, 2008). Scoring Schoenfelderpeton as having state 0 and Apateon as polymorphic makes this character parsimony-uninformative regardless of the condition in Leptorophus, so 2211 2212 we have deleted it. This incidentally obviates the question of correlation with NOS 3, which 2213 describes a lengthening and widening of the nostril in its caudolateral part. 2214

- State 0 is present in Ventastega (Ahlberg, Lukševičs & Lebedev, 1994).
- 2215 Unknown in Westlothiana (Smithson et al., 1994).
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2217 82. NOS 3: Nostrils: margins concave throughout (0); intermediate (1); keyhole-shaped

2218 (2) (ordered). The intermediate state is new; it accounts for Broiliellus (Schoch, 2012: fig. 2219 1F) and some, though not all, **other dissorophids (Schoch, 2012) as well as the amphibamid 2220 **Georgenthalia (Anderson et al., 2008b), where the dorsal and ventral margins are convex, 2221 approaching each other somewhat, but the extreme elongation of the nostril seen in state 2 is 2222 not reached. We have also assigned it to the very long nostrils of *Archaeovenator (Reisz & 2223 Dilkes, 2003).

2224 State 0 is present in Ventastega (Ahlberg, Lukševičs & Lebedev, 1994) and 2225 Solenodonsaurus (Danto, Witzmann & Müller, 2012).

- Brachydectes appears to have state 0 or 1 (Pardo & Anderson, 2016: fig. 3A, B).
- Phlegethontia seems to have state 2 (Anderson, 2007a: fig. 2).
- 2228 *Saharastega has state 0 or 1 regardless of which candidate holes actually are the 2229 nostrils (D. M., pers. obs. of MNN MOR 73).

2231 83. NOS 4: Nostrils elliptical, with greater axis orientated obliquely in anteromedial to 2232 posterolateral direction: absent (0); present (1). RC07 added a further restriction on the 2233 length of the external nares in relation to the suture between the nasals, but this would make 2234 the character correlated to the length of the snout (for instance, it would require *Saharastega 2235 to have 10-cm-long nares to qualify for state 1, which it otherwise does whether or not 2236 Damiani et al. [2006] correctly identified the nares) and inapplicable in taxa without a suture 2237 between the nasals or without nasals.

2238 Inapplicable to greatly expanded nostrils (NOS 3(2) - Acheloma, Phonerpeton, 2239 *Ecolsonia*, **Mordex*).

2240

State 0 is present in Ventastega (Ahlberg, Lukševičs & Lebedev, 1994).

State 1 is present in Isodectes (Sequeira, 1998), Trimerorhachis (Milner & Schoch, 2241 2242 2013), Balanerpeton (Milner & Sequeira, 1994), Eryops (though the nostrils are not very 2243 elliptical: Sawin, 1941), Broiliellus (Carroll, 1964; Schoch, 2012), Eoscopus (borderline: 2244 Daly, 1994), apparently Platyrhinops (Werneburg, 2012a), Micromelerpeton (Schoch, 2009b), albanerpetids where known (McGowan, 2002; Venczel & Gardner, 2005), Eocaecilia 2245 2246 (Jenkins, Walsh & Carroll, 2007), Caerorhachis (other shapes would be difficult to accommodate: Ruta, Milner & Coates, 2002), Gephyrostegus (Klembara et al., 2014: fig. 5-7), Dia-2247 2248 dectes (Kissel, 2010: fig. 34-36), Limnoscelis (Berman, Reisz & Scott, 2010), Petrolaco-2249 saurus (Reisz, 1981), apparently Asaphestera, Hapsidopareion, Micraroter, Pelodosotis, 2250 Rhynchonkos, Cardiocephalus (at least C. peabodyi), Euryodus and Hyloplesion (CG78; 2251 Szostakiwskyj, Pardo & Anderson, 2015), Microbrachis (Vallin & Laurin, 2004), Brachydec-2252 tes (an extreme case: Wellstead, 1991; Pardo & Anderson, 2016), Lethiscus (Pardo et al., 2253 2017), Capetus (even though its nostrils are quite small: Sequeira & Milner, 1993), Orobates 2254 (Berman et al., 2004) and Tseajaia (Moss, 1972). It is also present in Batropetes, though the 2255 reconstructions in dorsal and lateral view by Glienke (2013: fig. 2E, F) contradict each other 2256 on the exact angle.

2257 Unknown in Paleothyris (Carroll, 1969b) and Westlothiana (Smithson et al., 1994); 2258 unclear and likely unknown in Saxonerpeton and Odonterpeton (CG78).

2259 Dendrerpetidae is polymorphic, with state 0 appearing in Dendrysekos (Holmes, Carroll & Reisz, 1998) and state 1 in at least some Dendrerpeton specimens (A. R. Milner, 2260 1980, 1996); *Acanthostomatops is likewise polymorphic, sometimes within the same indi-2261 2262 vidual (Witzmann & Schoch, 2006a).

We assign state 1 to *Sclerocephalus even though its nostrils have an additional 2263 2264 triangular extension that points dorsomedially and even though the caudal margin is pointed 2265 in some cases (Schoch & Witzmann, 2009a). 2266

2267 84. INT FEN 1: Internarial fenestra or fontanelle: absent, mosaic of "postrostral" bones 2268 (0); present (1); absent, no "postrostral bones" (2) (ordered). State 2 is new (and corresponds to all instances of the original state 0 except *Eusthenopteron* and *Panderichthys*); 2269 2270 the order follows the scenario suggested by Ahlberg et al. (2008).

2271 RC07 counted the presence of "median rostrals/internasals" as state 1, regardless of 2272 whether there is a fenestra (fontanelles are not mentioned) present additional to them or not. 2273 We cannot replicate this decision and find the characters independent: Ventastega (Ahlberg et 2274 al., 2008) and Acanthostega (Clack, 2003b, 2007; Porro, Rayfield & Clack, 2015) possess 2275 both a fontanelle (state 1 of the present character) and a pair of "median rostrals"; baphetids have a pair of "median rostrals" and a fully closed snout roof (state 2); Ichthyostega shows a 2276 2277 single "median rostral" and a fully closed snout (state 2); *Deltaherpeton preserves a single 2278 "median rostral/internasal" and probably had a round fontanelle or at least a deep pit (state 1; 2279 Bolt & Lombard, 2010: figs. 1, 2, 3). We have therefore split this character and coded the number of "median rostrals/internasals" as a new one, MED ROS 1 (see below). 2280 2281

- Lethiscus has state 1 (Pardo et al., 2017; J. Pardo, pers. comm.).
- 2282 Silvanerpeton has state 2 (Ruta & Clack, 2006).
- 2283 Unknown in Eucritta (Clack, 2001) and Edops (Romer & Witter, 1942; D. M., pers. 2284 obs. of MCZ 1378). Also unknown in Platyrhinops lyelli (Clack & Milner, 2010), but P. 2285 fritschi almost certainly shows state 2 (Werneburg, 2012a).
- 2286 States 1 and 2 occur in Trimerorhachis, even in T. insignis alone (Milner & Schoch, 2287 2013). The same appears to hold for Dendrerpetidae, with state 1 appearing in *Dendrysekos*

(Holmes, Carroll & Reisz, 1998) while state 2 is probably present in *Dendrerpeton confusum*

- (Holmes, Carroll & Reisz, 1998) while state 2 is probably present in *Dendrerpeton confusum*(Milner, 1996: fig. 7B); whether *D. acadianum* and *D. rugosum* have state 1 or 2 appears to
 be unknown (A. R. Milner, 1980, 1996).
 - Balanerpeton has state 1 or 2 (specimen drawings in Milner & Sequeira, 1994).

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- 2292 *Apateon* has states 1 and 2, with *A. gracilis* having state 2 throughout its ontogeny 2293 (Schoch & Fröbisch, 2006).
- 2294State 2 seems pretty clear in *Aytonerpeton (Clack et al., 2016: supplementary video22952).

85. MED ROS 1: "Median rostrals"/"medial rostrals"/"internasals": paired (0); single
(1); absent (2) (unordered). This character is split off from INT FEN 1 (see above). Pawley
(2006: appendix 14) introduced a character with the same abbreviation, but only distinguished
presence from absence – our state 1 would have been parsimony-uninformative in her matrix.

2301 All three names for these bones are unsatisfying. Strictly speaking, two bones in a 2302 transversely arranged pair cannot both be median, only a single bone can be; more 2303 importantly, the homology of these bones to any part of the "postrostral" mosaic of finned 2304 sarcopterygians is an underresearched and difficult problem – several pairs of "rostrals" can 2305 be "medial". The "internasals" never lie only between the nasals, and in Ventastega they do 2306 not lie between them at all - they do not even contact the nasals, instead the premaxillae 2307 border the internarial fenestra, and the "internasals" lie far rostral of the "nasals" in their entirety (Ahlberg et al., 2008: fig. 3c, 4a). - The name "medial rostral" occurs only, to the 2308 best of our knowledge, in fig. 6 of Clack (2002), while the text of Clack (2002, 2003b) used 2309 2310 "median".

We have scored *Eusthenopteron* and *Panderichthys* as unknown because homology is unclear, and *Crassigyrinus* likewise because its snout roof is very difficult to interpret. In *Eucritta*, this area of the skull is not preserved in any specimen (Clack, 2001), and the same holds for *Edops* (Romer & Witter, 1942; D. M., pers. obs. of MCZ 1378).

2315 One specimen of *Megalocephalus* has state 1, unlike the others, which have state 0 2316 (Beaumont, 1977: 51, 79); we have scored polymorphism.

- Otherwise, state 0 occurs in *Ventastega* (Ahlberg et al., 2008), *Acanthostega* (Clack, 2002, 2003b, 2007; Porro, Rayfield & Clack, 2015) and *Baphetes* (Beaumont, 1977); 1 is restricted to *Ichthyostega*, **Deltaherpeton* and **Elginerpeton*; state 2 accounts for all other OTUs with a known snout roof.
- Part of the supposed premaxilla of **Aytonerpeton* could be a "medial rostral" (Clack et
 al., 2016: supplementary video 2); we have scored state 0 or 2.

86. ORB 1: Interorbital distance greater than (0), subequal to (1), or smaller than half of
skull [...] width at the same level (2) (ordered). We have exchanged states 1 and 2 to make
ordering of this continuous character possible and added the specification on where to
measure skull width.

- *Ventastega* has state 2 (Ahlberg et al., 2008), as do *Cochleosaurus* (Sequeira, 2004), *Bruktererpeton* (Boy & Bandel, 1973), *Notobatrachus* (Báez & Nicoli, 2004), *Vieraella* (Báez
 & Basso, 1996) and *Tseajaia* (Moss, 1972; Berman, Sumida & Lombard, 1992 CM 38033,
 seen by D. M., is too distorted for comparison).
- Dendrerpetidae is polymorphic, with *Dendrysekos* reaching state 1 as already scored
 (Holmes, Carroll & Reisz, 1998) but *Dendrerpeton* having state 2 (A. R. Milner, 1980, 1996).
 The situation is unclear in *Hapsidopareion* due to disarticulation (CG78: fig. 13A).
- Diadectes is polymorphic, having states 0 and 1 (Berman, Sumida & Lombard, 1992;
 Berman, Sumida & Martens, 1998). So is *Batropetes*, with state 0 documented in *B. nieder- kirchensis* and *B. palatinus* and state 1 likely present in *B. fritschi* (Glienke, 2013, 2015).

2338 *Brachydectes* has state 0 (Wellstead, 1991; Pardo & Anderson, 2016).

Danto, Witzmann & Müller (2012) claimed state 0 for *Solenodonsaurus*. This is incorrect according to their fig. 3, which shows the already scored state 2.

87. ORB 2: Interorbital distance greater than (0), subequal to (1), or smaller than
maximum orbit diameter (2) (ordered). We have exchanged states 1 and 2 to allow
ordering of this continuous character.

State 0 is found in *Acanthostega* (Porro, Rayfield & Clack, 2015) and *Brachydectes* (Pardo & Anderson, 2016). We further keep state 0 for Dendrerpetidae because it is found in *Dendrysekos* (Holmes, Carroll & Reisz, 1998), *Dendrerpeton rugosum* (A. R. Milner, 1980) and *D. confusum* (A. R. Milner, 1980, 1996); only *D. acadianum*, which is only known from considerably smaller specimens than the other two species, reaches state 1 (A. R. Milner, 1980, 1996; Schoch & Milner, 2014).

2351State 1 is found in *Ichthyostega* (Clack & Milner, 2015: fig. 8) and *Trimerorhachis*2352(Milner & Schoch, 2013).

2353State 2 is present in *Ventastega* (Ahlberg, Lukševičs & Lebedev, 1994; Ahlberg et al.,23542008).

Tseajaia shows state 1 or arguably 2 (Moss, 1972, Berman, Sumida & Lombard, 1992); we have decided on state 1. (CM 38033, seen by D. M., is too distorted for comparison.)

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Eucritta is scored as unknown for having juvenile eye size.

2359 We have scored Albanerpetidae, Karaurus, Valdotriton, Notobatrachus, Vieraella, *Beiyanerpeton and *Pangerpeton as unknown, because it is unknown how much of the 2360 2361 orbitotemporal fenestra is homologous to the orbit. (RC07 had scored Brachydectes as 2362 unknown, presumably for the same reason; though see above.) Only the interorbital width of 2363 Triadobatrachus is so small that even the smallest realistic estimates for eveball size result in 2364 state 2, which was already scored. In several specimens of *Liaobatrachus, the eyes are 2365 preserved as circular stains, which are about as wide as the interorbital distance; allowing for 2366 some space around the eye in the orbit proper, we have therefore scored state 2 for 2367 *Liaobatrachus.

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As for most lissamphibians, we have assigned state 1 or 2 to **Spathicephalus*.

2369 **Cheliderpeton* passes from state 2 to state 0 in ontogeny (Werneburg & Steyer, 2002:
2370 fig. 1).

2371 States 1 and 2 are found in the largest illustrated adults of **Glanochthon* (Schoch &
2372 Witzmann, 2009b: fig. 2).

88. ORB 3/LAC 5: Rostroventral margin of orbit: round (0); angled (1); "antorbital
vacuity" present (2) (ordered). State 2, which corresponds to the original LAC 5(1), occurs
in *Baphetes*, *Megalocephalus* and **Spathicephalus*; we count it as a state of this character
because it makes state 1 inapplicable and because it may be an exaggerated version of it.
Because its ontogenetic development is unknown, we have scored *Eucritta* as having state 1
(as observed) or 2.

State 1 is also observed in *Acanthostega* (Clack, 2007; Porro, Rayfield & Clack,
2015), *Eocaecilia* (Jenkins, Walsh & Carroll, 2007), *Seymouria* (both species: Laurin, 1996a,
2000; Klembara et al., 2005, 2006, 2007) and *Batropetes* (Glienke, 2013, 2015) as well as
*Caseasauria (especially *Eothyris*) and **Neopteroplax* (Romer, 1963).

Dendrerpetidae is polymorphic: the previously scored state 0 is found in *Dendrerpeton rugosum* and *D. acadianum* (A. R. Milner, 1980, 1996: fig. 4A), while *Dendrysekos* reaches state 1 (Holmes, Carroll & Reisz, 1998: fig. 4C).

2387 The condition in *Westlothiana* is unknown (Smithson et al., 1994).

2388 *Palaeoherpeton (like Ventastega and Ichthyostega) appears to have a rostral and a 2389 ventral angle, but a negative rostroventral one, thus state 0 (Panchen, 1964).

- 2390
- 2391 89. ORB 4: Orbit deeper than long: no (0); yes (1).

2392 State 0 is present in Ventastega (Ahlberg, Lukševičs & Lebedev, 1994) and 2393 Brachydectes (Pardo & Anderson, 2016) and seems highly likely in *Aytonerpeton (Clack et 2394 al., 2016: especially supplementary video 2).

2395 Eocaecilia has state 0 as already scored (Jenkins, Walsh & Carroll, 2007). However, 2396 we have scored all other modern amphibians as unknown because it is unknown how much of 2397 the orbitotemporal fenestra is homologous to the orbit. 2398

2399 90. ORB 5: Orbit anteroposterior diameter shorter than (0), subequal to (1), or longer than (2) distance between orbit posterior margin and suspensorium anterodorsal margin 2400 2401 (ordered). We have exchanged states 1 and 2 to make ordering of this continuous character 2402 possible, and interpret the rostral end of the temporal embayment (if present) as "suspenso-2403 rium anterodorsal margin". Note that the wording implies a rostrodorsally-to-caudoventrally-2404 inclined suspensorium; when the suspensorium is inclined the other way around (ch. 146: 2405 state JAW ART1/SQU 2/DEN 8(3,4), see below), we have used its caudodorsal end as the 2406 "anterodorsal margin".

2407 "The distribution of the different states of this character is extremely irregular and 2408 shows several instances of parallel developments and reversals", wrote RC07. On the shortest 2409 of our trees from Analysis R4, it waxes and wanes gently for a total of 39 steps; there are only five direct transitions between states 0 and 2. State 2 holds Dissorophoidea and *Iberospon-2410 dylus together (ambiguously also Balanerpeton, depending on the position of *Palatinerpe-2411 2412 ton); there is only a single reversal in this clade (within *Micropholis, an OTU which shows 2413 all three states). State 2 is further synapomorphic between Ventastega and Acanthostega, and 2414 between Whatcheeria and Pederpes; state 1 ties at least the latter together with everything as 2415 far crownward as Amniota, with a total of 11 reversals to state 0 (four of them in Anthraco-2416 sauria). Clearly, this character carries phylogenetic signal.

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Euryodus has state 0 (CG78); so does Brachydectes (Pardo & Anderson, 2016).

2418 Not counting the antorbital fenestra (see ch. 88: ORB 3/LAC 5) rostral to the lateral 2419 outgrowth of the prefrontal (ch. 15: PREFRO 7), Baphetes and Megalocephalus have state 0 2420 as well (Beaumont, 1977).

2421 Ventastega (Ahlberg et al., 2008) has state 2, as do Acanthostega (Clack, 2003b, 2007; Porro, Rayfield & Clack, 2015), Balanerpeton (Milner & Sequeira, 1994, with the exception 2422 of the rather small specimen in fig. 4 that may have state 1), Phonerpeton (an extreme case of 2423 2424 state 2: Dilkes, 1990; D. M., pers. obs. of AMNH 7150 and MCZ 2313), Doleserpeton 2425 (Sigurdsen & Bolt, 2010) and Gephyrostegus (Klembara et al., 2014).

2426 We have scored all modern amphibians other than Eocaecilia and *Chelotriton as 2427 unknown because it is unknown how much of the orbitotemporal fenestra is homologous to 2428 the orbit. 2429

All three states occur in *Micropholis (Schoch & Rubidge, 2005).

2430 While *Oedaleops* has state 2, the larger *Eothyris* has state 1; we have scored only the 2431 latter state for *Caseasauria.

2432 *Cheliderpeton passes from at least state 1 to state 0 in ontogeny (Werneburg & 2433 Steyer, 2002: fig. 1). 2434

2435 91. PIN FOR 1: Pineal foramen present in adults (0); absent in adults (1). Ruta, Coates & 2436 Ouicke (2003) had coded the presence and the position of the pineal foramen as PIN FOR 1 2437 and PIN FOR 2, respectively. Ruta & Coates (2007) merged them into a character they called

(Milner & Sequeira, 2003; Sequeira, 2004, and references therein), showing that absence does 2441 2442 not in fact make position inapplicable. Further, PIN FOR 2 can now simply be ordered instead 2443 of requiring a stepmatrix. 2444 The situation in Hapsidopareion is unclear because of disarticulated parietals and 2445 frontals (CG78: figs. 13, 14). 2446 State 1 is now known in *Rhynchonkos* (Szostakiwskyj, Pardo & Anderson, 2015). 2447 Both species of Cardiocephalus are polymorphic, and so is Micraroter (CG78). 2448 Euryodus is polymorphic, with E. primus having state 1 and E. dalyae having state 0 2449 (CG78). 2450 92. PIN FOR 2: Pineal foramen caudal to (0), at the level of (1), or rostral to (2) 2451 2452 interparietal suture midlength (ordered). 2453 Unknown in Ventastega (Ahlberg et al., 2008). 2454 Acanthostega has state 2 (Porro, Rayfield & Clack, 2015). 2455 Ichthyostega appears to have states 0 and 1 (Clack & Milner, 2015: 21, fig. 8). 2456 Chenoprosopus has state 0 (Reisz, Berman & Henrici, 2005). 2457 State 1 is found in Cochleosaurus (Milner & Sequeira, 2003). 2458 Limnoscelis shows state 1 (Berman, Reisz & Scott, 2010: fig. 3A). 2459 The situation in Hapsidopareion is unclear because of disarticulated parietals and 2460 frontals (CG78: figs. 13, 14). Micraroter has state 2 (Carroll & Gaskill, 1978). 2461 2462 Although *Phlegethontia* lacks parietals, we have kept state 2 because the frontals reach 2463 the pineal foramen (Anderson, 2002). 2464 *Caseasauria has states 0 and 1 (state 1 in *Eothyris*, state 0 in *Oedaleops*: Reisz, 2465 Godfrey & Scott, 2009). 2466 States 0, 1 and 2 are documented in *Glanochthon, apparently independent of onto-2467 genetic age (Schoch & Witzmann, 2009b: fig. 2). 2468 Milner & Sequeira (2011: 63) stated that state 1 is "almost" reached in **Erpetosaurus*, and reconstructed state 1 (fig. 11); their photos and drawings of specimens, however, show 2469 2470 varying extents of state 2. Because Milner & Sequeira (2011) documented the existence of 2471 many more specimens than they figured, we have scored polymorphism. 2472 In *Neopteroplax, only state 2 can be excluded; the presence of the foramen (PIN 2473 FOR 1) remains unknown (Romer, 1963: fig. 1). 2474

2475 93. L SC SKU 1: Lightly sculptured area (subdued ornament) adjacent to skull roof 2476 midline: absent (0); present (1).

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- State 0 is present in Ventastega (Ahlberg et al., 2008).
 - State 1 makes a surprise appearance in Ossinodus (Warren & Turner, 2004).

2479 Steyer et al. (2006: appendix 2: ch. 39) scored state 1 of this character for 2480 **Nigerpeton*, but did not mention it anywhere in the text and illustrated it only ambiguously 2481 (fig. 2A). Consequently, we scored state 0 in the first two preprints of this paper (Marjanović 2482 & Laurin, 2015, 2016). State 1 is in fact correct, so we have now scored it: although some-2483 what difficult to find or to photograph, it is found on the frontals and a third of the parietals of 2484 MNN MOR 70 (D. M., pers. obs.).

2485 Although conditions that may count as state 1 are widespread in **Chelotriton* (Schoch, 2486 Poschmann & Kupfer, 2015), MB.Am.45 has state 0, which we have scored.

2487

PIN FOR 2. We kept this in the first two preprints of this paper (Marjanović & Laurin, 2015,

2016) except for Analysis EB. Here we separate them again because the pineal foramen has a

known position – PIN FOR 2(1) – in immature *Cochleosaurus* even though it is lost in adults

2488 94. PTF 1: Posttemporal fossa occurring at occiput dorsolateral corner, delimited 2489 dorsally by skull table, not bordered laterally and floored by dorsolateral extension of 2490 opisthotic (0); fossa present near occiput dorsolateral corner, delimited dorsally by oc-2491 cipital flanges of tabular and postparietal and bordered laterally as well as ventrally by 2492 dorsolateral extension of opisthotic meeting tabular ventromedial flange (1); small fossa 2493 present near occiput ventrolateral corner, bordered laterally by tabular ventromedial 2494 flange, delimited dorsally by dorsal portion of the lateral margin of the suproccipitalopisthotic complex and floored by lateral extension of opisthotic (2); absence of fossa (3) 2495 2496 (unordered). It is possible that this character should be ordered or be treated according to a 2497 more complex stepmatrix, but we are not sure about this and cannot find a suggestive pattern 2498 in the data.

2499 State 0 is present in *Panderichthys* (Brazeau & Ahlberg, 2006) and *Ventastega* 2500 (Ahlberg et al., 2008) and makes a surprise appearance in *Edops* (D. M., pers. obs. of MCZ 2501 1378 – the short paroccipital process has an unfinished end in this huge skull).

The potentially informative specimen of *Chenoprosopus*, USNM 437646, is crushed, but state 1 is the best fit (D. M., pers. obs.).

2504 *Doleserpeton* shows state 1, even though the lateral border is formed by the tabular 2505 rather than the opisthotic (Sigurdsen, 2008). This is common in stereospondyls as well, 2506 including **Australerpeton* (Barberena, 1998; Eltink et al., 2016).

2507 State 2 fits the condition reconstructed for *Batropetes* best, though there may not have 2508 been any floor (Glienke, 2013).

2509 *Rhynchonkos* shows state 2 or 3 (Szostakiwskyj, Pardo & Anderson, 2015); *Lethiscus* 2510 has state 1 or 3 (Pardo et al., 2017).

Eocaecilia (Jenkins, Walsh & Carroll, 2007), *Brachydectes* (Pardo & Anderson, 2016)
 and *Orobates* (Berman et al., 2004) have state 3.

Triadobatrachus has state 1 (ignoring the fact that the frontoparietal plays the roles of the absent postparietals and tabulars) or 3; despite the crushing and the preservation as a natural mold, the other states can most likely be excluded (Ascarrunz et al., 2016: 3D model 1).

*Saharastega has state 1 or 3 (D. M., pers. obs. of MNN MOR 73).

2518 State 1 makes a somewhat unexpected appearance in *Caseasauria (*Eothyris*; Reisz, 2519 Godfrey & Scott, 2009). While the fenestra is too small to reach the postparietal, state 1 is 2520 otherwise a perfect match; state 2, expected for very early amniotes, is not.

*Quasicaecilia has state 0 or 3 (Pardo, Szostakiwskyj & Anderson, 2015: fig. 2).

2523 95. SKU TAB 1: Ratio of width to postorbital midline length of skull table: ≤ 1 (0); 2524]1;1.5] (1);]1.5;2] (2);]2;2.5] (3); > 2.5 (4) (ordered). We have recoded this character much 2525 like we did with PREMAX 7. Ruta, Coates & Quicke (2003) worded it as follows, under the 2526 section headline "Proportions of skull table" (italics in the original):

2527 "SKU TAB 1. Absence (0) or presence (1) of condition: postorbital region of skull roof abbreviated. Although shortening of the postorbital skull roof region occurs in various 2528 2529 degrees, several crown-group taxa are distinctly different from the outgroup and from stem-2530 tetrapods in that their skull roof is usually wider than long, regardless of the morphology and 2531 proportions of its various constituent bones. Several temnospondyls more crownward than 2532 trimerorhachoids [...] and crown-lissamphibians [...] have acquired the derived state of this character independent of several basal and crown-amniotes, Westlothiana, microsaurs, 2533 2534 Scincosaurus and derived diplocaulids [...]."

2535 Compare RC07 (italics in the original):

2517

2521

2536 "SKU TAB 1. *Postorbital region of skull table abbreviated and at least one-third* 2537 *wider than long: absent (0); present (1).* The derived state is acquired in parallel by total 2538 group amniotes and amphibians (except the most basal taxa of both groups)."

2539 The 2003 version was irreproducible. The 2007 version is close to unambiguous (fully 2540 so for many OTUs) if taken at face value, but the question remains whether the skull table or 2541 the skull roof was meant (see main text). As with PREMAX 7, the original scores fail to 2542 provide evidence: the width/length ratio of the skull table, the width/length ratio of the skull 2543 roof, the ratio of the width of the skull table to the length of the skull roof and the ratio of the 2544 width of the skull roof to the length of the skull table are all about equally bad matches for the 2545 scores by RC07 (Appendix-Table 3, Data S5). We have decided in favor of the skull table for 2546 both measurements (the postorbital length of the skull table is, as in TAB 7, the distance 2547 between the caudal extremities of the orbits/orbitotemporal fenestrae - averaged where 2548 necessary – and the transverse level of the caudal end of the skull table in the sagittal plane); 2549 one reason is the fact that the postorbital length of the skull roof depends on the position of 2550 the caudal extremities of the suspensoria, which is already a character in this matrix (JAW 2551 ART 1/SOU 3/DEN 8).

Like PREMAX 7, this is a continuous character which we have arbitrarily divided into states by creating a state for each interval of 0.5 (lumping the few extreme outliers above 3 into the same state as the other OTUs above 2.5).

The ratios, sources, and state changes are presented in Appendix-Table 3; they and our measurements are contained in Data S5. In salientians, the caudal margin of the orbitotemporal fenestra was taken to be the rostral margin of the otic capsule, not of the lateral process of the parietal that covers only the caudal or caudomedial part of the otic capsule.

**Llistrofus* has state 0 (Appendix-Table 3). *Hapsidopareion* appears to differ starkly in
having state 2, but this could be ontogenetic: the skull the reconstruction (CG78: fig. 13B) is
based on is much smaller than the **Llistrofus* skull, and indeed only about half as long as
another skull which CG78 referred to *Hapsidopareion* but only illustrated in ventral view (fig.
the latter skull appears to have a proportionally longer postorbital region. We therefore
scored *Hapsidopareion* as having state 0, 1 or 2.

Unknown in Acherontiscus (Carroll, 1969a) and Dolichopareias (Andrews & Carroll,
1991).

Appendix-Table 3: Ratios of skull table width to postorbital (postorbitotemporal) skull
table length, and changes to the scores of character 95 (SKU TAB 1). Taxa underlain in
blue were scored 0 by RC07, taxa underlain in yellow were scored 1, and the remainder were
scored as unknown or have been added by us; the latter are marked with an asterisk.
Abbreviation: *Ph., Pholiderpeton.* See Data S5 and its legend for more information.

OTU	Ratio	New	Measured in:
	(rounded)	score	
*Coloraderpeton	0.231	0	Anderson, 2003a: fig. 3A; not measurable in
			Pardo et al., 2017, but looks the same and
			clearly does not leave state 0
*Llistrofus	0.515	0	Bolt & Rieppel, 2009
*Pseudophlegethontia	0.600	0	Anderson, 2003b: fig. 3
Phlegethontia	0.652	0	Anderson, 2007a
Odonterpeton	0.698	0	CG78: fig. 99B
Sauropleura	0.706	0	Bossy & Milner, 1998
Eocaecilia	0.716	0	Jenkins, Walsh & Carroll, 2007

*Erpetosaurus	0.724	0	Milner & Sequeira, 2011
Oestocephalus	0.732	0	Anderson, 2003b
Adelogyrinus	0.745	0	Andrews & Carroll, 1991
Notobatrachus	0.813	0	Báez & Nicoli, 2004
*Sparodus	0.826	0	Carroll, 1988
Lethiscus	0.836	0	J. Pardo, pers. comm. 2017
Adelospondylus	0.852	0	Andrews & Carroll, 1991
Captorhinus	0.906	0	Fox & Bowman, 1966: fig. 3
Neldasaurus	0.912	0	Schoch & Milner, 2014: fig. 20C
Colosteus	0.983	0	Hook, 1983
Ventastega	1.000	0	Ahlberg et al., 2008
Urocordylus	1.000	0	Bossy & Milner, 1998
Greererpeton	1.074	1	Smithson, 1982
Crassigyrinus	1.078	1	Clack, 1998
*Pholidogaster	1.087	1	Panchen, 1975
Isodectes	1.090	1	Schoch & Milner, 2014: fig. 20E
Paleothyris	1.091	1	Carroll, 1969b: fig. 4B
Panderichthys	1.103	1	Vorobyeva & Schultze, 1991
*Deltaherpeton	1.106	1	Bolt & Lombard, 2010: fig. 2; right side ap-
-			proximately doubled
*Utaherpeton	1.111	1	Carroll, Bybee & Tidwell, 1991
Euryodus	1.119	1	CG78: fig. 37
Eusthenopteron	1.130	1	Clack, 2007
*Chroniosaurus	1.132	1	Clack & Klembara, 2009
*Cheliderpeton	1.155	1	Werneburg & Steyer, 2002
*Archegosaurus	1.159	1	Witzmann, 2006: fig. 5
Baphetes	1.159	1	Beaumont, 1977: fig. 21
Chenoprosopus	1.170	1	Schoch & Milner, 2014: fig. 13E
Trimerorhachis	1.191	1	Schoch & Milner, 2014: fig. 20A
Eucritta	1.200	1	Clack, 2001: fig. 8
Ptyonius	1.200	1	Bossy & Milner, 1998
*Australerpeton	1.206	1	Eltink et al., 2016: fig. 5
*Glanochthon	1.214	1	Schoch & Witzmann, 2009b: fig. 2A approx-
			imately doubled
Ph. attheyi	1.228	1	Panchen, 1972
Cardiocephalus	1.228	1	CG78: fig. 69
Pantylus	1.281	1	Romer, 1969: fig. 1
Proterogyrinus	1.304	1	Holmes, 1984
Caerorhachis	1.306	1	Ruta, Milner & Coates, 2002
Silvanerpeton	1.344	1	Ruta & Clack, 2006
Ph. scutigerum	1.346	1	Clack, 1987b
*Konzhukovia	1.348	1	Gubin, 1991: drawing 6a
*Sclerocephalus	1.358	1	Schoch & Witzmann, 2009a
*Neopteroplax	1.366	1	Romer, 1963: fig. 3
Cochleosaurus	1.388	1	Schoch & Milner, 2014: fig. 13D
*Palatinerpeton	1.404	1	Boy, 1996: fig. 3
Albanerpetidae	1.414	1	Celtedens: McGowan, 2002
*Platyoposaurus	1.419	1	Gubin, 1991: drawing 3a

Balanerpeton	1.458	1	Schoch & Milner, 2014: fig. 17A
Bruktererpeton	1.458	1	estimated from Boy & Bandel, 1973: fig. 7
Edops	1.459	1	Schoch & Milner, 2014: fig. 13A
Acanthostega	1.465	1	Porro, Rayfield & Clack, 2015
Dendrerpetidae	1.466	1	Dendrysekos: Schoch & Milner, 2014: fig. 17C
Megalocephalus	1.468	1	Beaumont, 1977: fig. 8
Capetus	1.500	1	Sequeira & Milner, 1993
Micromelerpeton	1.500	1	Beaumont, 1977: fig. 8
Westlothiana	1.500	1	Smithson et al., 1994
*Palaeoherpeton	1.500	1	Panchen, 1964
Kotlassia	1.542	2	Bulanov, 2003: fig. 30
Keraterpeton	1.545	2	Bossy & Milner, 1998
Whatcheeria	1.586	2	Lombard & Bolt, 1995: fig. 1A
Vieraella	1.594	2	Báez & Basso, 1996: fig. 6, 7
*Mordex	1.605	2	Schoch & Milner, 2014: fig. 32A
Gephyrostegus	1.614	2	Klembara et al., 2014
*Lydekkerina	1.634	2	Hewison, 2007: fig. 30
Stegotretus	1.667	2	Berman, Eberth & Brinkman, 1988: fig. 10B
Hyloplesion	1.667	2	CG78: fig. 89B
Ichthyostega	1.667	2	Clack & Milner, 2015: fig. 8
Pederpes	1.674	2	Clack & Finney, 2005
*Iberospondylus	1.685	2	Laurin & Soler-Gijón, 2006: fig. 1A left side
			approximately doubled
Microbrachis	1.689	2	Vallin & Laurin, 2004
Ossinodus	1.705	2	Warren, 2007
Valdotriton	1.711	2	Evans & Milner, 1996
*Micropholis	1.750	2	Schoch & Rubidge, 2005: fig. 3B
Phonerpeton	1.778	2	Dilkes, 1990: fig. 1
Discosauriscus	1.780	2	Klembara et al., 2006
Rhynchonkos	1.825	2	CG78: fig. 63
Pelodosotis	1.829	2	CG78: fig. 48
Ariekanerpeton	1.854	2	Klembara & Ruta, 2005a
Seymouria	1.877	2	Laurin, 1996a
Archeria	1.900	2	Holmes, 1989
*NSM 994 GF 1.1	1.920	2	Holmes & Carroll, 2010
Amphibamus	1.938	2	Schoch & Milner, 2014: fig. 30
Eoherpeton	1.943	2	Panchen, 1975
Brachydectes	1.965	2	Pardo & Anderson, 2016: fig. 4b
Solenodonsaurus	1.972	2	Danto, Witzmann & Müller, 2012
*Karpinskiosaurus	2.020	3	Klembara, 2011
Scincosaurus	2.027	3	Milner & Ruta, 2009
Doleserpeton	2.044	3	Sigurdsen & Bolt, 2010
Schoenfelderpeton	2.048	3	Boy, 1986: fig. 13
Broiliellus	2.050	3	Carroll, 1964
*Bystrowiella	2.051	3	Witzmann & Schoch, 2017: fig. 15C
Diceratosaurus	2.061	3	Bossy & Milner, 1998
Orobates	2.092	3	Kissel, 2010: fig. 32B
*Saharastega	2.105	3	D. M., pers. obs. of MNN MOR 73

*Nigerpeton	2.113	3	Steyer et al., 2006
Eoscopus	2.130	3	Daly, 1994: fig. 3
Leptorophus	2.156	3	Boy, 1986: fig. 4
Eryops	2.167	3	Schoch & Milner, 2014: fig. 3C
Petrolacosaurus	2.186	3	Berman, Sumida & Lombard, 1992: fig. 11
Micraroter	2.189	3	CG78: fig. 56
Microphon	2.195	3	Bulanov, 2003: fig. 22
Asaphestera	2.326	3	CG78: fig. 7
Karaurus	2.333	3	Ivachnenko, 1978
*Acanthostomatops	2.333	3	Witzmann & Schoch, 2006a
Limnoscelis	2.364	3	Kissel, 2010: fig. 13A ¹
Ecolsonia	2.371	3	Berman, Reisz & Eberth, 1985: fig. 5A
Anthracosaurus	2.388	3	Clack, 1987a
Acheloma	2.395	3	Polley & Reisz, 2011
Batrachiderpeton	2.397	3	Bossy & Milner, 1998
*Caseasauria	2.398	3	Eothyris: Reisz, Godfrey & Scott, 2009
Batropetes	2.445	3	Glienke, 2013: fig. 2
Platyrhinops	2.471	3	Clack & Milner, 2010: fig. 9
Saxonerpeton	2.471	3	CG78: fig. 22
*Carrolla	2.563	4	Maddin, Olori & Anderson, 2011
Utegenia	2.627	4	Klembara & Ruta, 2004a
*Gerobatrachus	2.657	4	estimated from Anderson et al., 2008a: fig. 2b
*Tungussogyrinus	2.795	4	Werneburg, 2009
Apateon	2.860	4	Schoch & Fröbisch, 2006: fig. 1D
*Spathicephalus	2.867	4	Beaumont & Smithson, 1998: fig. 5
Tuditanus	2.889	4	Carroll & Baird, 1968: fig. 9
*Archaeovenator	2.963	4	Reisz & Dilkes, 2003
Tseajaia	2.976	4	Berman, Sumida & Lombard, 1992: fig. 11
*Liaobatrachus	3.100	4	Dong et al., 2013
*Crinodon	3.500	4	CG78: fig. 11
*Chelotriton	3.571	4	Marjanović & Witzmann, 2015: fig. 7
Triadobatrachus	3.724	4	Roček & Rage, 2000; roof estimated
*Quasicaecilia	3.809	4	Pardo, Szostakiwskyj & Anderson, 2015: fig. 3
Diplocaulus	5.238	4	Olson, 1951: pl. 5B left side doubled
Diploceraspis	5.849	4	Beerbower, 1963: fig. 2
Diadectes	6.280	4	Kissel, 2010: fig. 36B

¹ A line drawing identical to Berman, Reisz & Scott (2010: fig. 3A), but slightly more convenient to measure.

2578

2579

2580 96. FONT 1: Dorsal exposure of frontoparietal fontanelle: absent (0); present (1).

2581 State 0 is present in *Ventastega* (Ahlberg et al., 2008). This was already correctly 2582 scored by RC07, who had not known of that material. Probably they intended to score 2583 *Ventastega* for TEM FEN 1, but slipped one column to the left; *Ventastega* indeed has state 0 2584 of that character (Ahlberg, Lukševičs & Lebedev, 1994).

2586 97. TEM FEN 1: Broad opening in skull postorbital region: absent (0); present (1). RC07 2587 had added "(aïstopod pattern)", but potential primary homologues of the aïstopod temporal 2588 fenestra can be found elsewhere.

Most obviously, the diapsid Petrolacosaurus has two temporal fenestrae. In principle, 2589 2590 they could have arisen from a single fenestra that was subdivided by a contact between 2591 processes of the postorbital and the squamosal. There is no evidence that this actually 2592 happened, but, firstly, to take this into account would mean to insert assumptions about 2593 secondary homology into the determination of primary homology; secondly, the lateral 2594 temporal fenestra has subdivided itself in just such a fashion (by a contact between 2595 neomorphic processes of the jugal and the squamosal) in several **dinosaurs, e.g. 2596 **Cryolophosaurus (Hammer & Hickerson, 1994), giving these animals a total of three 2597 temporal fenestrae per side. We have therefore scored Petrolacosaurus as possessing state 1.

2598 On the other hand, fenestrae can become confluent with other openings. Both temporal 2599 fenestrae (per side) and the orbit of Cenozoic and many Mesozoic **birds have indeed 2600 merged in such a way; at least in principle, the orbitotemporal fenestra found in Brachydectes and all modern amphibians in this matrix other than *Eocaecilia* might be the result of a similar 2601 2602 merger. We have therefore scored all these OTUs as sharing state 1. This does not, however, 2603 apply to the very elongate orbit of *Batropetes*, which retains the postfrontal and postorbital bones at its caudal margin (Glienke, 2013, 2015). 2604

2605 Finally, states 1 of this character and the next are not mutually exclusive. In particular, 2606 the temporal fenestra of most diapsids is open ventrally, as the contact between jugal and quadratojugal has been lost. Because of the orientation of the quadratojugal in *Llistrofus 2607 (Bolt & Rieppel, 1999: fig. 4), we have scored state 1 of the present character for that OTU. 2608

2609 2610 State 0 is in any case present in *Ventastega* (see FONT 1 above).

2611 98. CHE EMA 1: Ventral emargination of cheek (pattern of certain tuditanomorph 2612 microsaurs): absent (0); present (1). This pattern is not limited to Hapsidopareion, 2613 Micraroter and Pelodosotis (and *Llistrofus): a very mild version occurs in Batropetes 2614 (Glienke, 2015), a less mild one in *Lethiscus* (Pardo et al., 2017; also scored in their matrix) 2615 and Phlegethontia (Anderson, 2002). We have scored Oestocephalus and *Coloraderpeton as 2616 unknown because there is no non-phylogenetic way to tell if their ventrally open temporal fenestra is continuous with an emargination (Carroll, 1998a; Anderson, 2003a; Pardo et al., 2617 2618 2017, excluding their matrix, where state 1 was scored for **Coloraderpeton*).

- 2619 State 0 is present in Ventastega (Ahlberg et al., 2008). 2620
 - Unknown in *Nigerpeton (D. M., pers. obs. of MNN MOR 69 and MNN MOR 70).

The cheek (jugal, quadratojugal) is absent in *Brachydectes*, possibly *Triadobatrachus*, 2621 2622 and all salamanders except (see QUAJUG 1 above) *Chelotriton; we have accordingly scored 2623 them as unknown.

2624

2625 deleted IFN 1: Interfrontonasal: absent (0); present (1). As RC07 explicitly mentioned, this character is parsimony-uninformative because state 1 is limited to Eryops. We have 2626 2627 therefore deleted it. Our addition of *Crinodon has made it parsimony-informative again, but 2628 there would be little point in reintroducing this character, given the fact that *Crinodon and 2629 *Eryops* are among the least similar taxa in the entire matrix except where symplesiomorphies 2630 are concerned.

2631 Recently an interfrontal has been discovered in most specimens of *Batropetes*, though 2632 it is absent in some of both B. fritschi and B. palatinus (Glienke, 2013, 2015; tentatively confirmed for B. palatinus by D. M., pers. obs. of MB.Am.1232.1). Because PAUP* cannot re-2633 2634 construct ancestors as polymorphic, state 1 could not hold Batropetes and *Crinodon to-2635 gether.

The evidence for paired interfrontonasals in any colosteids (Bolt & Lombard, 2010) is not convincing. If *Greererpeton* has a single bone between the frontals, nasals and premaxillae, it should probably be considered a "median rostral" (see MED ROS 1 above) rather than an interfrontonasal.

2640 One specimen of *Sclerocephalus has an interfrontonasal (Boy, 1988: 116), as does 2641 one of *Lydekkerina (Jeannot, Damiani & Rubidge, 2006). Given the fact that so many more specimens of both (Jeannot, Damiani & Rubidge, 2006; Schoch & Witzmann, 2009a) lack it, 2642 2643 and the fact that the *Lydekkerina individual with an interfrontal also has an interparietal 2644 (Jeannot, Damiani & Rubidge, 2006), we have decided to ignore these cases as aberrations of 2645 development. In Eryops, every one of the many known skulls shows the interfrontonasal, 2646 while even its **closest relatives always lack it (Werneburg, 2007b, 2012b; Werneburg & 2647 Berman, 2012).

2648

2649 99. SUS 1: Anteroposteriorly narrow, bar-like squamosal: absent (0); present (1).

2650State 0 is present in Ventastega (Ahlberg, Lukševičs & Lebedev, 1994) and most2651likely Batropetes (Glienke, 2013: fig. 6H; contra Carroll, 1991). It is also known in Lethiscus2652(Pardo et al., 2017) and *Saharastega (D. M., pers. obs. of MNN MOR 73).

State 1 is found in all modern amphibians in this matrix except *Eocaecilia* (0 as already scored) and *Vieraella* (unknown). We note, however, that ***Gobiates*, possibly closely related to **Liaobatrachus*, has state 0 (Roček, 2008).

2656 *Cardiocephalus* was scored as sharing state 1 in RC07. The squamosal shown on both 2657 sides of the skull in CG78: fig. 30A is dorsoventrally narrow, not rostrocaudally. We have 2658 scored state 0.

2659Most of the squamosal of **Carrolla* is unknown, but state 1 is likely enough (Maddin,2660Olori & Anderson, 2011) that we have scored it as present.

2661

100. SC 1: Lateral-line system on skull roof totally enclosed (0), mostly enclosed with short sections in grooves (1), mostly in grooves with short sections enclosed (2), entirely in grooves (3), absent (4) (ordered). RC07 had "skull table" instead of "skull roof". We have ordered this and the following character because the present sequence of states represents a gradual movement of the lateral-line organ from inside the bones to their surface and beyond (the organ is present in extant aquatic lissamphibians, but never leaves traces on bones).

2668 States 0 and 4 can be difficult to distinguish from the outside. Indeed, Warren (2007) 2669 reported that *Edops*, *Chenoprosopus* and *Ervops*, previously thought to have state 4 (but see below for Chenoprosopus), have state 0. We have scored both as possibilities in Edops and 2670 *Eryops*, because it is not clear if this canal in the quadratojugal which had no connection to 2671 2672 the outside – at least in that bone – is homologous to a lateral-line canal or rather carried 2673 nerves and/or blood vessels; Čerňanský et al. (2016) did not commit to any interpretation and 2674 called for more research. Because the quadratojugal of Cochleosaurus is only known in 2675 external (dorsolateral and edge-on ventral) view, we have scored it the same way.

Pawley (2006: 188) claimed that Dendrerpeton (Dendrerpetidae) has "pits and 2676 2677 perforations" for the postcranial lateral line in the ventralmost row of dorsal scales, and Schoch (2013: 21; not citing Pawley, 2006) even spoke of "possible lateral line sulci", both 2678 2679 implying that the absence of traces of cranial lateral lines in this taxon (e.g. A. R. Milner, 1980, 1996) is unexpected and may turn out to be erroneous. However, Pawley (2006) and 2680 2681 Schoch (2013) both cited only Dawson (1882) for these observations. Although Dawson (1882: 647) mentioned "minute round pores, probably mucous or perspiratory pores" in 2682 dorsal scales ("horny scales", as opposed to the more strongly mineralized "bony" ventral 2683 2684 ones) and mentioned that the ventralmost row of dorsal scales is "in some specimens" com-2685 posed of unusually large scales "forming a sort of Vandyke edging", he gave no indication

that the pores are restricted to that row. The closest Dawson (1882: 647) came to such a 2686 2687 statement is the following somewhat enigmatic sentence: "In front the skin projects into long 2688 pendant lappets, terminated by similar angular points, and covered with oval scales, not imbricated, and each having a pore in its centre." No pores or pits or sulci are illustrated in 2689 2690 plate 40; fig. 5 (p. 648) shows a pore on one scale without indicating where on the body it lay. 2691 Earlier, Dawson (1863: pl. IV: fig. 25 - not cited by Pawley, 2006, or Schoch, 2013) had drawn pores on each one of six or seven rows of scales of "Dendrerpeton oweni" (junior syn-2692 2693 onym of D. acadianum: Milner, 1996; Schoch & Milner, 2014), and the accompanying 2694 description gives no indication that the supposed pores were – one might guess – only visible on one row and extrapolated to the others; rather, "[a] limited portion of the upper, and I sup-2695 2696 pose, anterior part [of an isolated patch of scales preserved in contact with "many fragments 2697 of the skull" of *D. acadianum*] is covered with imbricated scales, which [...] generally have a 2698 small spot or pore near the outer margin" (Dawson, 1863: 34). - There is another patch of 2699 scales (Dawson, 1863: pl. V: fig. 22–24) where very large scales, each with a supposed pore, 2700 form a row between much smaller dorsal scales (drawn too small to determine if pores were 2701 present) and ventral scales (drawn too small in fig. 22, not shown in fig. 23-24). It was described as follows (Dawson, 1863: 36-37): "The best preserved specimen (Fig. 22 [of pl. 2702 2703 V]), which is about one inch in length and half an inch in breadth, is covered with very small imbricated scales. It is crossed by six or seven obscure ridges, which both at the bottom and 2704 along a mesial line, projected into points covered with larger scales. A row of large scales 2705 2706 with round pores, connects these along the lower side (Figs. 23 and 24.) [sic] If, as seems probable, this fragment belonged to the side of the trunk or tail, it would perhaps indicate a 2707 2708 division of the sub-cutaneous muscles into an upper and lower band, as in the newts." This 2709 patch, which Dawson (1863) tentatively referred (not in the text, only in the legend to plate V 2710 on page 48) to the nomen dubium (Steen, 1934) **"Hylonomus" wymani, is similar to the 2711 patch drawn in p. VI, fig. 62, where a row of very large scales separates two areas of much smaller ones, but no pores are shown (only parallel striations); that patch was referred to 2712 2713 "Hylonomus aciedentatus", which is a junior synonym of D. acadianum (Milner, 1996; 2714 Schoch & Milner, 2014). – Given that the supposed pores are not restricted to a single row in at least one specimen, we suspect that the "pores" may be growth centers - denser than the 2715 2716 rest of the scale, not a hole in it. In any case, Dawson (1882) cannot be cited as evidence that any dendrerpetid had a postcranial lateral line, and while one specimen described and 2717 2718 illustrated by Dawson (1863) may in principle provide such evidence, such a conclusion 2719 requires numerous assumptions about correct anatomical identification and the referral of that 2720 specimen. At present, thus, no dendrepetid should be thought to have had a postcranial lateral line; if Pawley (2006) and Schoch (2013) did not merely miscite Dawson (1863 or 1882), they 2721 2722 must have relied on unpublished personal observations which they did not mention. In any 2723 case, however, it is painfully obvious that dendrerpetid scales have never been adequately described or illustrated. Dawson's descriptions of his light-microscopic observations are 2724 2725 superficial and confused by modern standards, and his line drawings - in stark contrast to contemporary illustrations of dinosaur or crocodyliform bones, which have been called 2726 2727 "almost better than the bone" – are of extremely limited usefulness.

Ventastega shows state 1 (Ahlberg, Lukševičs & Lebedev, 1994). RC07 scored it as 0,
but probably they intended to score *Ventastega* for SC 2, the only mandible character they did
not score, and slipped one column to the left; *Ventastega* indeed has state 0 of SC 2 (Ahlberg,
Lukševičs & Lebedev, 1994).

"Lateral line sulci intermittently present, but state of preservation and coarse sculpture
tend to obscure their courses except anterolateral to nares and partly across quadratojugal" in *Chenoprosopus* (Langston, 1953: 365). The smaller specimen USNM 437646 lacks lateralline sulci (Hook, 1993; D. M., pers. obs.), but this may be ontogenetic: perhaps sulci only

2736 appeared with progressing metaplastic ossification of the dermis. We have scored state 3, 2737 which may be visible in CM 34909 (D. M., pers. obs.) as a sulcus (wide, shallow sculpture) 2738 rostral to the right naris (this area is not preserved on the left side) and possibly along the left 2739 jaw margin (this area is not preserved on the right side); the most convincing candidate for a 2740 lateral-line sulcus lies on the left jugal ventral to the orbit (this area is not preserved on the 2741 right side). Mehl's (1913) "mucus canal" must be the nasolacrimal canal and has not been 2742 mentioned in more recent literature as far as we know.

Isodectes was scored in RC07 as possessing state 1. There is, however, no clear 2743 2744 evidence for enclosed canals anywhere on the animal; we have been cautious and scored the 2745 interrupted grooves (Sequeira, 1998) as state 2 or 3.

2746 Trimerorhachis was scored as having state 2 or 3, yet there is no evidence for state 2 2747 (Milner & Schoch, 2013); we have scored 3 alone.

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2755

Acheloma shows state 4 (Polley & Reisz, 2011).

2749 Traces of the lateral lines have never been mentioned or reconstructed for Broiliellus 2750 (Carroll, 1964; Schoch, 2012; Schoch & Milner, 2014). Because they would be preserved and 2751 visible, we have scored state 4.

2752 Traces of the lateral lines have never been mentioned for Amphibamus and are absent 2753 from all reconstructions (most recently Schoch & Milner, 2014: fig. 30A). Because the 2754 implied state 4 may be visible in Daly (1994: fig. 18), we have scored it.

Micromelerpeton has state 4 when adult (Schoch, 2009b).

2756 Apateon was scored as unknown; the only species known from metamorphosed 2757 individuals shows state 4 – apparently throughout ontogeny (Werneburg, 1991: 85). 2758

Albanerpetidae has state 4 according to all literature about this taxon.

2759 Proterogyrinus was scored as possessing state 1 or 2. It has state 3; the grooves, where 2760 present at all, are shallow and not bridged, but evidently interrupted (Holmes, 1984) like in *Archegosaurus (Witzmann, 2006) - the lateral-line organ was not deeper in the bone, but 2761 2762 deeper in the thicker skin than in more obvious cases of state 3.

2763 Similarly, Archeria was given state 2 or 3, while it has state 3 (Holmes, 1989); Pholi-2764 derpeton attheyi was scored 2, but shares 3 (Panchen, 1972: 288-291, fig. 4); and Anthraco-2765 saurus, usually claimed to have state 4 but scored 1 by RC07, shows state 3 as well (Clack, 2766 1987a).

Discosauriscus reached state 4 when adult (Klembara, 2009). This is interpreted as 2767 2768 part of a transition to terrestrial life. Accordingly, we have added state 4 as an option (partial 2769 uncertainty) to all seymouriamorphs for this and the following character, except of course 2770 Seymouria (which already had state 4 for both) and Kotlassia (which is unknown for both).

Batropetes was scored 1; it has state 4 – the large pits on the frontals are unrelated to 2771 2772 lateral-line canals (Glienke, 2015).

2773 Saxonerpeton was scored as completely unknown, but CG78: 33 probably allow only 2774 states 3 and 4; we have scored it as possessing state 3 or 4. 2775

Microbrachis has state 3 (Olori, 2015).

Of the traces identified in Hyloplesion by Olori (2015), not all are convincing -2776 2777 notably those on the maxilla (Olori, 2015: fig. 28C) are very narrow, sharp and irregular -, 2778 but the remainder (in particular Olori, 2015: fig. 28A, B dorsal of the arrow, D) are good 2779 enough to score state 3, which is not unexpected in this apparently fully aquatic animal.

2780 Acherontiscus was scored as having state 1 or 2. It rather clearly has state 3, with 2781 wide, long, likely interrupted rather than bridged grooves (Carroll, 1969a).

2782 Adelospondylus, too, was scored as having state 1 or 2. Judging from Andrews & 2783 Carroll (1991: 254, fig. 13A, B, 14A, B), it is better scored as having state 3 or 4, because the 2784 possible grooves are wide and may well be interrupted rather than bridged.

2785Dolichopareias was scored as having state 1. In the absence of evidence that the wide2786grooves (Andrews & Carroll, 1991) continued inside the bone, we have changed the score to27873.

2788 *Scincosaurus* is polymorphic, with most specimens having state 4 but some showing a 2789 very weak version of state 3 instead (Milner & Ruta, 2009).

Bossy & Milner (1998: 83–84, 122) stated that diplocaulids, without further qualifications, have lateral-line canals; to our surprise, all diplocaulids were originally assigned state 4. *Keraterpeton* (Bossy & Milner, 1998: 83–84, 122) and *Batrachiderpeton* (Bossy & Milner, 1998: fig. 58B) have state 3, and so do *Diceratosaurus* (D. M., pers. obs. of MB.Am.778 – very deep sculpture lies mostly, but not only around the orbits) and *Diploceraspis* (Beerbower, 1963); in the absence of evidence that *Diplocaulus* had state 4, we have scored it as unknown.

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Notobatrachus has state 4 according to all figures.

Ossinodus has state 1 or 2 (Warren, 2007).

We have scored **Chroniosaurus* as possessing state 0 or 4; state 4 occurs in the specimens described by Clack & Klembara (2009), state 0 possibly in quadratojugals attributed to "*Jugosuchus*", some of which could be referable to **Chroniosaurus* (Clack & Klembara, 2009: 17).

**Nigerpeton* has state 2. The fact (best visible in MNN MOR 108; D. M., pers. obs.)
that the grooves lie on top of the sculpture instead of under it excludes states 0 and 1; the fact
that the infranarial canal is visible in MNN MOR 69 but not the less eroded MNN MOR 70
(D. M., pers. obs.) excludes state 3.

2807 State 3 cannot be excluded in **Saharastega* (D. M., pers. obs. of MNN MOR 73); this 2808 means partial uncertainty between states 3 and 4.

Beaumont & Smithson (1998: 191) stated about **Spathicephalus mirus*: "In none of the skulls is there evidence of [the] lateral line canal system". In his description of **S*. *pereger*, Baird (1962: unnumbered table) did not mention the lateral lines at all, but showed a groove that seems to loop around the orbit and might have carried a lateral-line canal, if indeed it was continuous, which is hard to tell from the photograph. We have kept the score of the **Spathicephalus* OTU as unknown.

2815 **Sclerocephalus* is apparently polymorphic, with some of the largest individuals 2816 showing state 3 (at least on part of the skull) and others state 4 (Schoch & Witzmann, 2009a).

Gubin (1991: drawing 6) illustrated **Konzhukovia* as having state 4, or rather did not shade the sculptured surface sufficiently to make the sulci stand out (some patterns in the sculpture vaguely suggest a few); following personal observation, Pereira Pacheco et al. (2016: appendix 2) reported state 3, which we have scored.

The lateral-line canals of **Elginerpeton* are wholly enclosed in the postorbital (Ahlberg, 1998) and almost wholly enclosed in the premaxilla (Ahlberg, 1995); the probable maxilla (Ahlberg, 1995: table 1) has not been described or illustrated, and other skull-roof bones are unknown. We have tentatively scored state 1.

2825

101. SC 2: Mandibular canal totally enclosed (0), mostly enclosed with short sections in grooves (1), mostly in grooves with short sections enclosed (2), entirely in grooves (3), absent (4) (ordered).

- 2829 State 0 is present in *Ventastega* (see SC 1 above).
- 2830 *Ichthyostega* is best scored as possessing state 0 or 1 (Clack et al., 2012a).
- 2831 *Whatcheeria* should rather be scored as 1 than as 2 (Lombard & Bolt, 2006).
- 2832 Surprisingly, Milner & Lindsay (1998) did not comment on the presence or condition
- of lateral-line canals in the *Baphetes* specimen they described. Their fig. 4 seems to show the mandibular canal extending over most, perhaps all the length of the preserved part of the

2835 lower jaw; we have tentatively scored state 2 or 3. The specimen described by Milner, Milner 2836 & Walsh (2009) does not contradict this, but does not narrow it down either, showing state 1, 2837 2 or 3.

2838

Trimerorhachis has state 1, 2, or 3 (Milner & Schoch, 2013: fig. 7A).

2839 Langston (1953: 369) wrote about the lower jaw of Chenoprosopus: "Lateral line 2840 canals ill-defined: marginal sulcus [= mandibular canal] appears on ventrolateral surface of angular, continuous forward across splenials following dentary-splenial sutures, terminates 2841 2842 anteriorly at symphysis, perhaps continuous posteriorly with a shallow groove on ventral and 2843 posterior faces of surangular; dental sulcus [= oral canal], if present, poorly developed." 2844 Because we have not been able to find a statement in the literature that explicitly contradicts 2845 this, we have scored state 3.

2846 Isodectes was scored in RC07 as possessing state 1. There is, however, no clear 2847 evidence for enclosed canals anywhere on the animal; we have been cautious and scored the 2848 interrupted grooves (Sequeira, 1998) as state 2 or 3. 2849

Neldasaurus has state 2 or 3 as for the skull roof (Chase, 1965).

2850 Acheloma (Polley & Reisz, 2011) and Ecolsonia (D. M., pers. obs. of CM 38017 and 2851 CM 38024) have state 4.

2852 Traces of the lateral lines have never been mentioned or reconstructed for Broiliellus 2853 (Carroll, 1964; Schoch, 2012; Schoch & Milner, 2014). Because they would be preserved and 2854 visible, we have scored state 4.

2855 Schoch (2009b) did not mention the lower jaw of Micromelerpeton, but given the lack 2856 of lateral-line grooves on the skull in the adult stage, we have added state 4 to the observed 2857 uncertainty of state 2 or 3 of larvae (which was scored in RC07). 2858

Albanerpetidae has state 4 according to all literature about this taxon.

2859 Klembara et al. (2014) drew attention to a groove on the dentary of Gephyrostegus, 2860 wondering whether it was a lateral-line canal (state 3) or housed a blood vessel (state 4). We 2861 have kept the latter score, because the groove is discontinuous on both sides of the individual 2862 shown in their fig. 3, the rostralmost grooves ending in foramina as do several shorter 2863 grooves.

2864 Except for Microbrachis, which was correctly scored as having state 3, and 2865 Rhynchonkos, which was correctly given state 4, all "microsaurs" were scored either as having state 0 or 1 (partial uncertainty) or as entirely unknown in RC07. This was not com-2866 2867 mented on by RC07 or Ruta, Coates & Quicke (2003), so we can only speculate that state-2868 ments by CG78 about pits and grooves on lower jaws were misinterpreted as referring to 2869 lateral-line canals and led to the common score of 0 or 1. It is clear from context that these 2870 statements all refer to ornament and traces of nerves or blood vessels. CG78: 166 stated 2871 unambiguously that "Microbrachis is unique in having a lateral line canal groove, running 2872 along the ventral margin of the angular, the posterior splenial and the dentary." This groove is illustrated in fig. 107A, and no such groove is shown on any other "microsaur" (fig. 103, 105, 2873 2874 107). The correction to state 4 concerns Batropetes (Glienke, 2013: 81; 2015), Tuditanus 2875 (Carroll & Baird, 1968; CG78: fig. 4), Pantylus (Romer, 1969: 23), Asaphestera (CG78: fig. 2876 7; D. M., pers. obs. of NMC 10041), Saxonerpeton, Hapsidopareion, Micraroter, Pelodosotis, 2877 Cardiocephalus, Euryodus, Hyloplesion and Odonterpeton (specimen drawings in CG78). 2878 Olori (2015: 39, table S3) reported "distinct pores" on the dentary of Hyloplesion "which may 2879 also connect to the lateral line system" and scored state 3; we are unconvinced - pores could 2880 correspond to nerves or blood vessels, or to electroreceptory organs.

2881 Unknown in Scincosaurus (Milner & Ruta, 2009).

2882 Batrachiderpeton has state 3 (Bossy & Milner, 1998: 88, fig. 60C); so do Diplocaulus 2883 (Douthitt, 1917) and Diploceraspis (Beerbower, 1963). In the absence of evidence that any 2884 other diplocaulids had the (to our surprise) originally scored state 4, and given the facts that Bossy & Milner (1998) did not single out *Batrachiderpeton* as unusual and did not mention *Diplocaulus* or *Diploceraspis* in this context, we have scored them (i.e. *Keraterpeton* and *Diceratosaurus*) as unknown; see also SC 1 above.

2888 *Notobatrachus* has state 4 (Báez & Nicoli, 2004); apparently, so does *Lethiscus* (Pardo et al., 2017).

2890 *Ossinodus* has state 1 or 2; the material described by Warren (2007) is insufficient to 2891 distinguish between the two, so we have scored accordingly, but it should be mentioned that 2892 the distribution of pores and open grooves on the postsplenial hints at an ontogenetic 2893 transition from 2 to 1 (if not even 0).

- **Nigerpeton* shows state 3; because not the entire lower jaw is preserved, state 2
 cannot be excluded (D. M., pers. obs. of MNN MOR 69, MNN MOR 70 and MNN MOR
 so we have scored partial uncertainty.
- The mandibular canal of the *St. Louis tetrapod appears to be (D. M., pers. obs. of MB.Am.1441.2) visible for a greater length than indicated by Clack et al. (2012b); we have scored state 2 rather than 1 or 2.
- 2900 Godfrey & Holmes (1989) tentatively implied state 3 for the *Parrsboro jaw; we have 2901 accepted this.
- The area that would have borne the mandibular canal is not preserved in **Australerpeton*, but part of the oral canal is preserved as an open groove (Eltink & Langer, 2004 2014), so we have scored state 2 or 3.
- 2906 102. VOM 1-13: Vomer approximately as wide as long or wider (0), intermediate (1), at
 2907 least 2½ times longer than wide (2) (ordered). This is a merger of two correlated characters
 2908 that described parts of a continuous character.

- 2909 Some snouts are so long and narrow that only state 2 is possible, making this character 2910 inapplicable. (The shape of the snout is not directly a character in this matrix, but correlates to 2911 varying extents with several characters.) This concerns Acheloma (Polley & Reisz, 2011), 2912 Archeria (already scored as unknown), *Archegosaurus, *Platyoposaurus and *Australerpe-2913 ton. Furthermore, the combination of a long snout, round interpterygoid vacuities and a vomer/pterygoid contact (states VOM 5-10/PTE 10-12-18/INT VAC 1(2 or lower) and INT 2914 2915 VAC 3(1), which together imply short pterygoids and long vomers) likewise makes state 2 of 2916 the present character inevitable; this concerns Chenoprosopus (Langston, 1953), Cochleosau-2917 rus (Sequeira, 2004), Neldasaurus (where "the vomers [...] are approximately four times as long as they are wide" - Chase, 1965: 172), *Nigerpeton (Steyer et al., 2006) and, borderline, 2918 *Glanochthon (Schoch & Witzmann, 2009b). Note that in all of these the vomers are as wide 2919 2920 as possible, occupying the entire space between the midline, the (pre)maxillae and the 2921 choanae.
- 2922State 0 is found in Ventastega (Ahlberg, Lukševičs & Lebedev, 1994), Colosteus2923(Hook, 1983: fig. 1), Eoscopus (Daly, 1994), and Ariekanerpeton (Klembara & Ruta, 2005a:2924fig. 13).
- 2925 State 1 occurs in Baphetes (Beaumont, 1977: fig. 19), Trimerorhachis (Milner & 2926 Schoch, 2013), Caerorhachis (Ruta, Milner & Coates, 2002: fig. 5c), Bruktererpeton (though 2927 almost state 2; Boy & Bandel, 1973: fig. 7), Batropetes (Glienke, 2013, 2015), Asaphestera 2928 (most likely; CG78: fig. 7), apparently Micraroter (CG78: fig. 53, 56), Rhynchonkos (CG78: 2929 fig. 63; Szostakiwskyj, Pardo & Anderson, 2015: fig. 3A), Diceratosaurus (Jaekel, 1903; D. 2930 M., pers. obs. of MB.Am.778), Capetus (Sequeira & Milner, 1993: fig. 9), Pederpes (as reconstructed by Clack & Finney, 2005: fig. 17), Silvanerpeton (Ruta & Clack, 2006: fig. 8), 2931 2932 and Utegenia (Klembara & Ruta, 2004a: fig. 14) unless this is ontogenetic. CG78 (fig. 13, 14) 2933 depicted Hapsidopareion as having state 2, which was scored in RC07; however, the condition in *Llistrofus (Bolt & Rieppel, 2009), which falls near the upper end of state 1, strongly 2934

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- 2935 2936 specimens and that the correct score is 1. 2937 State 2 is present in *Lethiscus* (Pardo et al., 2017) and *Orobates* (Berman et al., 2004:
- 2938 fig. 3B).

2939 In Echerpeton (Smithson, 1985: fig. 8) and Proterogyrinus (Holmes, 1984: fig. 3), the 2940 vomer is entirely unknown, but the skull is too narrow for state 0 given the shape of the 2941 palatine, so we have ascribed state 1 or 2 to both.

- 2942 As reconstructed (Panchen, 1972: fig. 7), Pholiderpeton atthevi has state 1 on the left 2943 and 2 on the right side. We have scored it as polymorphic.
- 2944 Gephyrostegus has state 2 (Klembara et al., 2014). 2945
 - The condition in *Kotlassia* is unknown (Bulanov, 2003).
- 2946 State 1 or 2 is present in Cardiocephalus (CG78: fig. 30) and Euryodus (CG78: fig. 2947 37, 38).
- 2948 The vomers of Microbrachis are so inclined (rostromedially to caudolaterally) that we 2949 cannot decide between states 0 and 1 (Vallin & Laurin, 2004: fig. 5).
- 2950 Ossinodus, too, has state 0 or 1 (Warren, 2007: fig. 6).
- 2951 The vomers of **Karpinskiosaurus* are so inclined (rostromedially to caudolaterally) 2952 that we cannot decide between states 1 and 2 (Klembara, 2011: fig. 3C).

2953 *Chelotriton has state 1 when the toothed caudal processes that frame the cultriform 2954 process, characteristic of salamandrids, are taken into account, or 0 when they are ignored 2955 (Schoch, Poschmann & Kupfer, 2015); we have gone with the latter option in order to prevent a salamandrid autapomorphy from making *Chelotriton look less amphibamid-like. 2956 2957

2958 103. VOM 3: Vomer with (0) or without (1) fangs comparable in size to, or larger than, 2959 marginal teeth (premaxillary or maxillary).

2960 State 0 is present in Ventastega (Ahlberg, Lukševičs & Lebedev, 1994) and Acheloma (Polley & Reisz, 2011). 2961

2962 Jarvik (1996) reconstructed Ichthyostega with state 1. Ahlberg, Lukševičs & Lebedev 2963 (1994) demonstrated that it has state 0 instead (which is also figured in the line drawing of 2964 Blom, 2005: fig. 3). This is further confirmed by Jarvik's (1996) own pl. 26:1 and by D. M.'s 2965 observations of TMM 41224-2, AMNH 23100 and MCZ 3361 - a total of five casts of the 2966 specimen figured in that plate (MGUH VP 6055). Clack & Milner (2015) mentioned this 2967 issue and provided further evidence for state 0, but did not make clear if specimens showing 2968 state 1 are known; for the time being, we have scored state 0.

- 2969 The most mature known individual of Amphibamus – the neotype, YPM 794 – has 2970 state 0 (if only on one side: Daly, 1994: 27). We regard this as the adult condition (see also 2971 Marjanović & Laurin, 2008: 193). Schoch & Milner (2014: 56) stated that Amphibamus lacks 2972 fangs on the vomer, palatine and ectopterygoid, but puzzlingly did not mention Daly (1994) in 2973 the context of Amphibamus at all, even though they of course mentioned YPM 794 and cited 2974 Daly (1994) as a source for *Eoscopus*.
- 2975 State 1 is found in Doleserpeton (Bolt, 1969; Sigurdsen & Bolt, 2010), Batropetes 2976 (Glienke, 2013, 2015), Hyloplesion (Olori, 2015), Diceratosaurus (Jaekel, 1903; D. M., pers. obs. of MB.Am.778 and CM 34656), Lethiscus (Pardo et al., 2017), Orobates (Nyakatura et 2977 2978 al., 2015: digital reconstruction) and Ossinodus (Warren, 2007). Following the matrix of 2979 Pardo et al. (2017), we have also scored it for **Coloraderpeton*.
 - Apparently unknown in Broiliellus (Schoch, 2012: fig. 2F).
- 2981 The vomer is wholly unknown in *Pelodosotis* (CG78: 80-81).
- 2982

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2983 104. VOM 4: Vomer without (0) or with (1) small teeth (denticles), the basal diameter 2984 and/or height of which is less than 30% of that of adjacent marginal teeth (premaxillary or maxillary) and remaining vomer teeth (if present). RC07 further specified for VOM 4 that the denticles "form[...] [a] continuous shagreen or discrete, [sic] patches", but denticles occur in other arrangements as well. The purely size-based distinction of "teeth" and "denticles" (here and in other characters below) may not be satisfactory, but in any case there is no histological difference (Gee, Haridy & Reisz, 2017).

2990 State 0 is present in *Ventastega* (Ahlberg, Lukševičs & Lebedev, 1994), *Whatcheeria* 2991 (Lombard & Bolt, 1995) and all preserved vomer fragments of *Edops* (D. M., pers. obs. of 2992 MCZ 1378 – the pterygoid fragments bear denticles throughout) as well as in *Batropetes* 2993 (Glienke, 2013, 2015), *Scincosaurus* (Milner & Ruta, 2009) and *Tseajaia* (Moss, 1972).

The entire vomer (except the rostral edge and the intervomerine fossa) of *Acheloma* (Polley & Reisz, 2011), *Broiliellus* (Carroll, 1964) and *Platyrhinops* (Clack & Milner, 2010) is covered by denticles, giving them state 1. *Limnoscelis* (Berman, Reisz & Scott, 2010) and *Ossinodus* have state 1 as well (Warren, 2007).

Although the vomerine denticles are restricted to a single ridge, they are present (state 1) in *Chenoprosopus* (Hook 1993; D. M., pers. obs. of USNM 437646).

3000The vomer of *Bruktererpeton* has two rows of denticles in its caudal corner (Boy &3001Bandel, 1973). We count this as state 1.

3002 *Hapsidopareion* (CG78: fig. 14E) has state 1; note that, on the morphologically left 3003 side of the latter, the vomer has a longitudinal break, and the medial fragment with its two 3004 remaining denticles was referred to the pterygoid by CG78.

3005 *Diceratosaurus* shows both states: the narrow-snouted morph, such as CM 34656, has 3006 a curled row of full-sized teeth on each vomer, while the broad-snouted morph, exemplified 3007 by CM 34670, CM 67157 and CM 81507 as well as MB.Am.778, instead has a field of 3008 denticles largely arranged in several parallel rows (D. M., pers. obs.). Ontogeny is an unlikely 3009 explanation: CM 67157 is larger than CM 34656 and CM 34670 but has the same skull length 3010 as the narrow-snouted CM 34696. In the absence of further evidence we have scored 3011 *Diceratosaurus* as polymorphic.

3012 **Micropholis* has a few scattered non-fang teeth on the vomer, but all appear to have a
3013 width well over 30% of that of the marginal teeth (Schoch & Rubidge, 2005: fig. 2B, ?D). It
3014 thus has state 0.

3015Although this is not obvious from Maddin, Olori & Anderson (2011), *Carrolla has3016state 0 (D. M., pers. obs. of TMM 40031-54). We have followed the matrix of Pardo et al.3017(2017) in scoring state 0 for *Coloraderpeton as well.

The vomer of **Glanochthon* "is covered by numerous tubercles that could represent vestigial denticles" (Schoch & Witzmann, 2009b: 126). We have scored it as unknown, not counting the very small teeth (which may well qualify as denticles) of the parachoanal toothrow (see VOM 8).

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3023 105. VOM 5-10/PTE 10-12-18/INT VAC 1: Pterygoids sutured to each other plus 3024 contacting parasphenoid along entire length, interpterygoid vacuities therefore absent 3025 (0); pterygoids sutured only toward their rostral ends (1); contact between pterygoids 3026 absent, pterygoid/vomer suture still present (2); pterygoids do not contact vomers, but still overlap palatines medially for part of the palatines' length (3); pterygoids entirely 3027 3028 caudal to palatines, but still reach well mesial to subtemporal fenestrae (4); pterygoids 3029 do not extend mesially beyond their contribution (if any) to the rostral rims of the 3030 subtemporal fenestrae (5) (ordered). This is a fusion of six redundant characters that represent parts of a single continuous character, the gradual "retreat" of the palatal ramus of 3031 3032 the pterygoid (from mesial to distal) coupled to size increase of the interpterygoid vacuities. 3033 The palatine, if present (see PAL 8 below), is excluded from contacting the interpterygoid vacuities or the parasphenoid in states 0 to 2 (VOM 10(0)) as opposed to states 3 and 4 (VOM 3034

3035 10(1)). States 4 and 5 include the condition where the ectopterygoid participates in the margin 3036 of the interpterygoid vacuity, found in some temnospondyls that are not included in this 3037 matrix. State 5 is a rewording of PTE 18(1): "Pterygoid palatal ramus a robust, abbreviated, 3038 flange-like to digitiform structure, as long as or barely longer than combined length of quad-3039 rate ramus plus basicranial articulation"; note that it is not limited to caudates as originally 3040 scored, but also occurs in Broiliellus (borderline: Schoch, 2012: fig. 2F), Eocaecilia (Jenkins, 3041 Walsh & Carroll, 2007), Triadobatrachus (Roček & Rage, 2000; Ascarrunz et al., 2016) and 3042 even Diploceraspis (Beerbower, 1963: fig. 4A). (Furthermore, it does not occur in the 3043 caudates *Beiyanerpeton and *Chelotriton [Roček & Wuttke, 2010; Gao & Shubin, 2012; Schoch, Poschmann & Kupfer, 2015]. We have, however, assigned state 5 to *Gerobatra-3044 3045 chus, where the mesial end of the pterygoid is barely mesial to the mesial tip of the subtempo-3046 ral fenestra, even though [much like in *Broiliellus*] the rostral rim of the fenestra is mostly 3047 formed by the ectopterygoid [Anderson et al., 2008a] - a bone caudates lack.)

3048 We have not directly represented VOM 5, "Vomer excluded from (0) or contributing 3049 to (1) interpterygoid vacuities", although this distinction could be added to the present character as a split of state 2: it clearly depends at least in part on the width of the skull or that 3050 3051 of the interpterygoid vacuities; if Scincosaurus or Bruktererpeton had wider skulls or 3052 interpterygoid vacuities, their vomers would end up forming the rostral margins of the 3053 interpterygoid vacuities, unless a neomorphic medial process appeared on the pterygoids. The width of the interpterygoid vacuities is coded here as INT VAC 2 and INT VAC 4. 3054

3055

Ventastega has state 0 (Ahlberg, Lukševičs & Lebedev, 1994).

3056 Ichthyostega almost, but not quite, reaches state 0; it has state 1 (Jarvik, 1996: pl. 26-3057 28; D. M., pers. obs. of TMM 41224-2 = AMNH 23100 = MCZ 3361, a total of five casts of 3058 MGUH VP 6055, which is the specimen figured in Jarvik, 1996: pl. 26:1). 3059

Whatcheeria has state 1 (Lombard & Bolt, 1995).

3060 Clack (2001: fig. 8) tentatively reconstructed state 1 for *Eucritta* under the assumption 3061 that the medial margin of the pterygoid (fig. 5) is complete as preserved. In seymouriamorphs, 3062 the palate closes in ontogeny (see below), so it is possible that state 0 – which was scored in 3063 RC07 – would have arisen later in *Eucritta*; state 0 is indeed seen in *Megalocephalus*, though 3064 Baphetes retains state 1. We have assigned state 0 or 1 to Eucritta.

3065

States 2 and 3 are both found in Trimerorhachis (Milner & Schoch, 2013).

McGowan (2002: 9) limited the possibilities for Albanerpetidae to state 1, 2, or 3. 3066 3067 Although McGowan's figures are coarse, his assessment is consistent with Maddin et al. 3068 (2013a: fig. 5H, I).

3069 Gephyrostegus has state 1 (Klembara et al., 2014).

3070 In seymouriamorphs the palate closes during ontogeny. Therefore we have assigned 3071 state 0 to Discosauriscus (Klembara, 1997: fig. 28, not fig. 24 or fig. 34; Klembara et al., 3072 2006: fig. 5B), and state 0 or 1 to Kotlassia (instead of just the observed state 1: Bulanov, 3073 2003: fig. 30) and also to Leptoropha (the pterygoid of which, not coded by RC07, is known: 3074 Bulanov, 2003: S33). Ariekanerpeton, Microphon and Utegenia were all given state 0, 1 or 2 3075 in RC07; given that only state 1 is observed in Ariekanerpeton (Klembara & Ruta, 2005a: 64, 3076 fig. 3B, 13A), Microphon (Bulanov, 2003: S40, S49) and apparently Utegenia (Klembara & 3077 Ruta, 2004a: fig. 11A, 14A), we have restricted all three to state 0 or 1 as well.

3078 Diadectes shows state 0 in some American species (Olson, 1947), state 1 or 2 in others 3079 (Case & Williston, 1912), and state 1 in D. absitus (Berman, Sumida & Martens, 1998). We 3080 have scored it as possessing states 0 and 1 because making partial uncertainty part of a 3081 polymorphism is not possible.

3082 Limnoscelis has state 1 (Berman, Reisz & Scott, 2010).

3083 It seems a safe assumption that Westlothiana possessed palatines (Smithson et al., 3084 1994). We have kept state 1 or 2, though whether 0 and 3 can really be excluded might be 3085 arguable. 3086 State 2 seems most likely in *Batropetes* (Glienke, 2013, 2015). 3087 State 1 is found in Microbrachis (Vallin & Laurin, 2004; Olori, 2015) and Hyloplesion 3088 (Olori, 2015). 3089 As reconstructed by Wellstead (1991) and Pardo & Anderson (2016), Brachydectes has a unique condition with an extremely broad parasphenoid that makes interpterygoid 3090 3091 vacuities impossible. Regardless, it has state 2: there is a pterygoid/vomer contact rather than 3092 a palatine/parasphenoid contact, excluding states 3 and higher, and the pterygoids do not 3093 come anywhere near each other (being separated by the parasphenoid), excluding states 1 and 3094 0. 3095 The reconstruction and the specimen drawing of Adelospondylus (Andrews & Carroll, 3096 1991) are not very similar to each other. We have added state 0 to the uncertainty of states 1, 3097 2 or 3 scored in RC07. 3098 Diceratosaurus has state 1 (D. M., pers. obs. of CM 26231; compatible with the 3099 slightly disarticulated MB.Am.778, which was reconstructed as just reaching state 2 by 3100 Jaekel, 1903: pl. III). 3101 Lethiscus possesses state 1 or 2 (Pardo et al., 2017); Oestocephalus appears to have 3102 state 0, 1 or 2 (Carroll, 1998a: 153, fig. 2, 3). 3103 In Phlegethontia, the vomers and the palatines are absent. Technically, only states 0 3104 and 5 could therefore be excluded; however, given the length (rostral/mesial extent) of the "palatoquadrates" (Anderson, 2002, 2007a), we have scored state 1 or 2, because a palatine 3105 would have to be in a highly unusual position rostral to the "palatoquadrates". 3106 3107 Palatines (at least as separate bones) are likely also absent in Vieraella (Báez & Basso, 1996); given again the length of the pterygoids, states 0, 1, 2 and 5 can be excluded, so we 3108 3109 have scored state 3 or 4. The same applies to *Chelotriton, except that its pterygoid is so short 3110 (close to state 5, without reaching it: Roček & Wuttke 2010; Schoch, Poschmann & Kupfer, 3111 2015) that we have also excluded state 3, leaving state 4 for this OTU. 3112 Ossinodus has state 0 or 1 (Warren 2007). 3113 States 3 and 4 both occur in *Micropholis (Schoch & Rubidge, 2005: fig. 2). We have included the condition of *Karpinskiosaurus (Klembara, 2011: fig. 3C) in 3114 3115 state 0. 3116 The CT scans of *Carrolla (only known specimen: TMM 40031-54) by Maddin, Olori 3117 & Anderson (2011) seem to only distinguish finished bone surfaces from everything else, and 3118 not to distinguish spongy bone from the matrix. Thus, fig. 4F of Maddin, Olori & Anderson 3119 (2011) fails to show some bone that is clearly present – and also misses what must be the 3120 suture between vomer and pterygoid (D. M., pers. obs. of TMM 40031-54). The lateral 3121 elements of the palate have been pushed dorsally against the skull roof, breaking the 3122 pterygoid and rotating the palatine, but D. M. confirms the reconstruction of the palate by 3123 Maddin, Olori & Anderson (2011: fig. 7B) in this respect (see below for ch. 119, PTE 3-9, 3124 however). *Carrolla thus has state 2. It is, however, noteworthy how thin (labiolingually) the 3125 mesial process of the pterygoid is (probably shared with Batropetes: Glienke, 2013, 2015). 3126 Fig. 14b of Werneburg (2012a) suggests state 3 for *Mordex, although fig. 14a (which does not show any sutures in the articulated palate of the smallest specimen) looks like state 2 3127 3128 unless we assume that the palatine is split lengthwise and the lateral part alone is 3129 disarticulated. We have made this assumption and scored state 3.

Following the matrix by Pardo et al. (2017), we have scored state 1 or 2 for **Coloraderpeton*.

Whatcheeria (the premaxilla participates in the margin of the choana: Lombard & Bolt, 1995), *Cochleosaurus* (Sequeira, 2004), *Trimerorhachis* (Milner & Schoch, 2013), *Acheloma* (Polley & Reisz, 2011) and *Batropetes* (Glienke, 2013, 2015) have state 0. We have also scored state 0 for *Silvanerpeton* because the reconstruction by Ruta & Clack (2006: fig. 8) seems to make state 1 impossible.

State 1 is present in *Ventastega* (Ahlberg, Lukševičs & Lebedev, 1994), *Acanthostega*(Porro, Rayfield & Clack, 2015: fig. 4C), *Balanerpeton* (Milner & Sequeira, 1994: 338),
Dendrerpetidae (*Dendrerpeton acadianum*: Milner, 1996: fig. 6; in *Dendrysekos* the condition
is unknown, but state 1 may well have been just barely present as in *Balanerpeton*: Holmes,
Carroll & Reisz, 1998: fig. 4), apparently *Diceratosaurus* (D. M., pers. obs. of MB.Am.778),
most likely *Lethiscus* (Pardo et al., 2017) and *Ossinodus* (Warren, 2007).

Phonerpeton is apparently polymorphic: the previously scored state 0 was
reconstructed by Dilkes (1990: fig. 1), but is almost certainly excluded by Dilkes (1993: fig.
and by AMNH 7150 (D. M., pers. obs.). Dilkes (1993: fig. 4) also figured a clear case of
state 0 in a specimen that cannot be referred to *Phonerpeton* with sufficient certainty (Dilkes,
1993).

The condition in *Platyrhinops* is unknown; it is possible that the palatine contacts the vomer lateral to the choana (Clack & Milner, 2010), and if so, the position of the suture between palatine and vomer lateral to the choana is unknown with respect to the maxilla (Clack & Milner, 2010).

Unknown also in **Saharastega* due to the problem of identifying the nasal passage (D.
M., pers. obs. of MNN MOR 73).

3156 Schoch & Witzmann (2009b) scored both species of **Glanochthon* as having a 3157 premaxillary contribution to the margin of the choana (state 0 of their ch. 32), which would 3158 mean state 0 of the present character. However, this contradicts their fig. 3D, which 3159 unambiguously shows state 1 in **G. angusta*. Figure 3E, for **G. latirostris*, does not show the 3160 maxilla/premaxilla suture, but if it was in about the same place as in **G. angusta*, state 1 3161 would again result. We have scored state 1.

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3163 107. VOM 8: Vomer with (0) or without (1) lateral (parachoanal) toothrow. RC07 specified a "toothed lateral crest" instead of a toothrow, but, firstly, the presence of the 3164 3165 parachoanal toothrow - not otherwise represented in this matrix - is much easier to ascertain 3166 in published line drawings than the presence of a crest, and secondly, the alveoli of toothrows 3167 are usually (among taxa in this matrix) attached to a low but sharp labial crest, so that a toothrow without a crest is unlikely to occur. Incidentally, a crest without a toothrow is 3168 3169 documented in Cochleosaurus (Sequeira, 2004), Phonerpeton (Dilkes, 1990: fig. 1; D. M., 3170 pers. obs. of MCZ 1485) and Ervops (D. M., pers. obs. of MCZ 1129 and MCZ 2766), all of which were scored 1 – we conclude that RC07 did not consider a crest covered with denticles 3171 3172 "toothed", and have kept these scores.

We count oblique toothrows (oblique relative to the choanae) as VOM 9(0), not VOM 8(0); see VOM 9. The OTUs concerned were already scored 1 or unknown for VOM 8.

State 0 is present in *Ventastega* (Ahlberg, Lukševičs & Lebedev, 1994), *Whatcheeria*(Lombard & Bolt, 1995), *Micromelerpeton* (Boy, 1995), *Rhynchonkos* (CG78: fig. 63;
Szostakiwskyj, Pardo & Anderson, 2015), *Cardiocephalus* (CG78), *Lethiscus* (Pardo et al.,
2017), *Microphon* (Bulanov, 2003, 2014), *Ossinodus* (Warren, 2007) and **Karpinskiosaurus*(Klembara, 2011). We have further followed the matrix of Pardo et al. (2017) in scoring state
0 for **Coloraderpeton*.

3181 *Acheloma* (Polley & Reisz, 2011), *Eoscopus* (Daly, 1994), *Bruktererpeton* (Boy & 3182 Bandel, 1973), *Gephyrostegus* (Klembara et al., 2014), *Batropetes* (Glienke, 2013, 2015) and

Diceratosaurus (at least the broad-snouted morph – in which, however, a suggestive extension of the denticle field is present: D. M., pers. obs. of MB.Am.778; idealized by

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Jaekel, 1903: pl. III) have state 1. Likewise, the pterygoid toothrows of *Orobates* do not continue onto the vomers (Nyakatura et al., 2015: digital reconstruction)

3187 *Trimerorhachis* is polymorphic, sometimes between the left and right sides of the 3188 same individual (Milner & Schoch, 2013: fig. 3C).

3189 In *Eocaecilia*, a single continuous toothrow extends along the labial margins of both 3190 vomers and palatines. Because the choanae lie lingual to it, we have kept the score of 1.

This character and the next are hard to apply to *Brachydectes*: a toothrow spans the length of each vomer, but the teeth are so large and the vomers so narrow that the orientation of the toothrows is wholly dictated by that of the vomers (Pardo & Anderson, 2016). We have no non-phylogenetic arguments for either taking the parachoanal orientation of the toothrows at face value (state 0 of this character) or interpreting it as a salamandrid-like homolog of the interchoanal toothrow (state 0 of the next character), so we have had to score both as unknown.

3198 The vomer is wholly unknown in *Pelodosotis* (CG78: 80–81); the present character is also apparently unknown in *Euryodus* (CG78).

3201 108. VOM 9: Vomer with (0) or without (1) transverse (interchoanal) toothrow. RC07 specified "transversely orientated, anterior crest" and did not mention any teeth. Indeed, a 3202 3203 toothless and (especially medially) largely rounded crest is present in Ichthyostega (Jarvik, 3204 1996: pl. 26:1; Clack & Milner, 2015: fig. 8C; D. M., pers. obs. of TMM 41224-2 = MCZ 3361). A similar condition is found in *Ervops*, where this ridge additionally bears relatively 3205 large denticles that continue rostromedially but not caudally (D. M., pers. obs. of AMNH 3206 3207 4673). A sharp ridge is found in *Phonerpeton*, where the entire vomer except for the floor of the rostral palatal vacuity bears scattered denticles (Dilkes, 1990: fig. 1; D. M., pers. obs. of 3208 MCZ 1485). Finally, Cochleosaurus has several denticle-bearing crests on the vomer, one of 3209 3210 which is transverse (Sequeira, 2004). However, all four of these OTUs were scored 1 (which 3211 we have kept); we consider this evidence that RC07 actually had a crest bearing a toothrow in 3212 mind, as they stated more clearly for VOM 8. For the same reasons as in VOM 8, we have 3213 scored the toothrow alone.

3214 Metamorphosed salamanders often have a transverse toothrow at the caudal end of the 3215 vomer; some clades instead have an S-shaped or straight toothrow that extends rostromedially 3216 to caudolaterally or caudally. These toothrows are homologous to each other and to the 3217 toothrows at the labial margin of the vomer seen in larvae and in neotenic adults that have not 3218 undergone complete metamorphosis: during metamorphosis, the part of the vomer lingual to 3219 the toothrow is destroyed, and the vomer grows on the labial side. For this reason we have 3220 scored the toothrows of Karaurus, Valdotriton (double to triple; see VOM 11), *Beivanerpeton, *Pangerpeton and *Chelotriton (Schoch, Poschmann & Kupfer, 2015 -3221 3222 Roček & Wuttke, 2010: 323, appear to have assigned them to the inexistent palatine) all as 3223 representing state 0. We have done the same with *Eocaecilia*, where a single continuous 3224 toothed crest extends along the labial margins of both vomers and palatines.

Because of this movement of the crest during salamander metamorphosis, and because the crest often lies about in the middle of the vomer in temnospondyls, we have scored the toothed crest of the frogs *Notobatrachus* (Báez & Nicoli, 2004), *Vieraella* (teeth unknown, but more ventral than the rest of the vomer: Báez & Basso, 1996) and **Liaobatrachus* (Dong et al., 2013) as constituting state 0 as well; in the latter, notably, the crest lies in the middle of the vomers rather than at their caudal edge (despite a general absence of paedomorphic features). The same applies to *Batrachiderpeton*, *Diplocaulus* and *Diploceraspis* (Williston, 3234 State 0 is further present in *Ventastega* (Ahlberg, Lukševičs & Lebedev, 1994), 3235 *Trimerorhachis* (Milner & Schoch, 2013), *Ptyonius* (Bossy & Milner, 1998) and *Ossinodus* 3236 (Warren, 2007). We have also counted the rostralmost two teeth on the vomer of *Lethiscus* 3237 (Pardo et al., 2017) as forming a row; the vomer is too narrow for a longer transverse 3238 toothrow. Finally, we have assigned state 0 to *Doleserpeton*, see VOM 11.

3239 Acheloma (apparently: Polley & Reisz, 2011), Eoscopus (Daly, 1994), Bruktererpeton
3240 (Boy & Bandel, 1973), Batropetes (Glienke, 2013, 2015), Microphon (Bulanov, 2003) and
3241 Orobates (Nyakatura et al., 2015: digital reconstruction) have state 1.

Unknown in *Edops* (D. M., pers. obs. of MCZ 1378); the vomer is wholly unknown in *Pelodosotis* (CG78: 80–81).

3244 State 0 is clearly present in juvenile **Glanochthon angusta* (Schoch & Witzmann, 3245 2009b: fig. 3A), but its further fate in ontogeny is unclear from the description and the 3246 illustrations; because fig. 4D might show its persistence in adult **G. latirostris*, we have 3247 provisionally scored state 0.

deleted VOM 11

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RC07 called this character "**Vomer without (0) or with (1) nearly transverse patch of small teeth (denticles) lying posterome[d]ial to choana.**" They stated that state 1 "is found in *Doleserpeton* and some basal salientians", and scored it for *Doleserpeton*, the salientian *Notobatrachus* and the caudates *Karaurus* and *Valdotriton*. However, this is not defensible:

Except for the pit that bears the fang-replacing toothrow, the entire vomer of *Doleserpeton* is covered by denticles (Sigurdsen & Bolt, 2010; already correctly scored as VOM 4(1)). There is thus no transverse patch, causing us to score state 0.

Conversely, *Notobatrachus* and *Karaurus* lack denticles altogether. In *Karaurus*, the teeth that lie caudomedial to the choana have full size and are part of the transverse vomerine toothrow, far from being a patch of denticles (Ivachnenko, 1978: fig. 1b); those of *Notobatrachus* are smaller than the marginal teeth, but still rather too large for being denticles, and form a straight row borne on a crest on each vomer (Báez & Nicoli, 2004). These teeth constitute VOM 9(0).

3264 Two to three rows of (small) teeth larger than the (tiny) marginal teeth are found on 3265 each otherwise toothless vomer of Valdotriton, and they lie rostromedial to the choana, which is not separate from the interpterygoid vacuity (Evans & Milner, 1996). This, too, constitutes 3266 state 0, even if the position of this double or triple toothrow would have changed in further 3267 3268 ontogeny, corresponding as it does to what is seen halfway through metamorphosis in extant 3269 salamanders. While the toothrow shares the fact of not being single with a patch of denticles, 3270 denticles are defined in other characters of the present matrix as being much smaller than 3271 marginal teeth.

Among the OTUs scored as unknown by RC07, state 0 is now known in *Ventastega*, *Whatcheeria*, *Acheloma*, *Bruktererpeton* and *Ossinodus* (see VOM 4) as well as *Gephyrostegus* (Klembara et al., 2014) and *Capetus* (Sequeira & Milner, 1993).

3275 State 0 was scored in RC07, but is in fact unknown, in *Neldasaurus*, for which Chase 3276 (1965: 176) specified: "The obstinate character of the matrix left no indication of palatal teeth 3277 in areas other than those described [...], but the fragments of the pterygoid bones [...] show 3278 that [...] [parts of the pterygoid] are covered by a densely-packed shagreen of small teeth 3279 except at the medial edge of the bone." Denticles are not mentioned anywhere else in the 3280 paper. We conclude that their presence, let alone arrangement, is unknown on the vomer – as
already scored for the palatine (PAL 2) and the ectopterygoid (ECT 3). The state is also unknown in *Hapsidopareion* (CG78).

The vomers of *Archeria* and *Pelodosotis*, also originally scored 0, are entirely unknown (CG78: 80–81; Holmes, 1989).

In other words, once denticles are specified, state 1 **does not occur in this matrix at** all – except in **Gerobatrachus* (Anderson et al., 2008a). In the wording of 2007, then, this character is parsimony-uninformative – quite apart from the issue of correlation with VOM 4.

Ruta, Coates & Quicke (2003), however, did not specify denticles, and cited Bolt 3288 3289 (1969, 1977, 1979, 1991) as support for their statement that state 1 is shared between 3290 Doleserpeton and various unspecified lissamphibians. This must refer to Bolt's hypothesis 3291 that the short rows of full-sized (not "small"!) teeth found on the vomer, palatine and dentary 3292 of *Doleserpeton* in the positions (indeed in recognizable pits) where other temnospondyls bear 3293 fangs are homologous to lissamphibian toothrows. While we are skeptical about this idea, we 3294 have deleted the present character but scored *Doleserpeton* as having state VOM 9(0) to avoid 3295 bias against the TH.

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3297 109. VOM 12: Distinct posterolateral process of vomer bordering more than half of 3298 choana posterior margin: absent (0); present (1).

State 0 is documented in *Ventastega* (Ahlberg, Lukševičs & Lebedev, 1994), *Acheloma* (Polley & Reisz, 2011), *Bruktererpeton* (Boy & Bandel, 1973), *Diceratosaurus* (D.
M., pers. obs. of MB.Am.778), *Lethiscus* (Pardo et al., 2017) and *Ossinodus* (Warren, 2007).
Breaks in MNN MOR 73 (D. M., pers. obs.) support the reconstruction of state 0 in **Saharastega* by Damiani et al. (2006).

3304 State 1 must be scored for *Limnoscelis* (Reisz, 2007; Berman, Reisz & Scott, 2010). 3305 Rather than a caudal margin distinct from the medial one, the choana has a caudolateral point 3306 where the lateral edge of the vomer continues into a caudolateral process that extends all the 3307 way to the medial edge of the maxilla, excluding the palatine from the margin of the choana.

3308 State 1 is further present in *Acanthostega* (Porro, Rayfield & Clack, 2015) and in 3309 *Batropetes* as reconstructed by Glienke (2013).

3310 Unknown in *Scincosaurus* (Milner & Ruta, 2009); the vomer is wholly unknown in 3311 *Pelodosotis* (CG78: 80–81).

3313 110. PAL 1: Palatine with (0) or without (1) fangs comparable in size to or larger than 3314 marginal teeth (premaxillary or maxillary).

Jarvik (1996) reconstructed *Ichthyostega* with state 1. Ahlberg, Lukševičs & Lebedev (1994) demonstrated that it, as well as *Ventastega*, had state 0 instead. For *Ichthyostega*, this is confirmed by Jarvik (1996: pl. 26:1) and TMM 41224-2 = AMNH 23100 = MCZ 3361 (D. M., pers. obs.; five casts of the figured specimen MGUH VP 6055). Clack & Milner (2015) mentioned this issue and provided further evidence for state 0 in *Ichthyostega*, but did not make clear if specimens showing state 1 are known; for the time being, we have scored state 0.

The most mature known individual of *Amphibamus* – the neotype, YPM 794 – has state 0 (Daly, 1994: 27). We regard this as the adult condition (see also Marjanović & Laurin 2008: 180). Schoch & Milner (2014: 56) stated that *Amphibamus* lacks fangs on the vomer, palatine and ectopterygoid, but puzzlingly did not mention Daly (1994) in the context of *Amphibamus* at all, even though they of course mentioned YPM 794 and cited Daly (1994) as a source for *Eoscopus*.

3328 State 0 is also found in *Lethiscus* (Pardo et al., 2017), *Ossinodus* (Warren, 2007) and 3329 *Silvanerpeton* (Ruta & Clack, 2006). Batropetes (Glienke, 2013), Diceratosaurus (Jaekel, 1903; D. M., pers. obs. of
MB.Am.778), Orobates (Nyakatura et al., 2015: digital reconstruction) and Tseajaia (Moss,
1972: 12) have state 1.

- This character is inapplicable to *Notobatrachus*, which lacks (separate) palatines (PAL 8(1)). It also has to be scored as unknown for *Vieraella*, where the presence of palatines is unknown.
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111. PAL 2: Palatine without (0) or with (1) small teeth (denticles), the basal diameter
and/or height of which is less than 30% of that of adjacent marginal teeth (maxillary)
and remaining palatine teeth (if present). See VOM 4; RC07 even wrote "remaining vomer
teeth" instead of "remaining palatine teeth".

Ventastega (Ahlberg, Lukševičs & Lebedev, 1994), *Whatcheeria* (Lombard & Bolt, 1995), *Batropetes* (Glienke, 2013), apparently *Oestocephalus* (Carroll, 1998a), *Orobates* (Berman et al., 2004) and *Tseajaia* (Moss, 1972: 12) have state 0. Although this is not obvious from Maddin, Olori & Anderson (2011), so does **Carrolla* (D. M., pers. obs. of TMM 40031-54). We further follow the matrix of Pardo et al. (2017) in scoring state 0 for **Coloraderpeton*.

Acheloma (Polley & Reisz, 2011), *Broiliellus* (Carroll, 1964), *Platyrhinops* (Clack &
Milner, 2010), *Limnoscelis* (Fracasso, 1983: 121) and *Diceratosaurus* (at least the broadsnouted morph: Jaekel, 1903; D. M., pers. obs. of MB.Am.778) possess state 1, as does **Ni- gerpeton* (D. M., pers. obs. of MNN MOR 69). The smallest teeth on the palatines of *Pantylus*(Romer, 1969; CG78) and *Stegotretus* (Berman, Eberth & Brinkman, 1988) qualify for state 1
as well.

While CG78 did not mention or illustrate denticles for *Hapsidopareion*, this may be due to preservation or preparation issues; we have scored it as unknown.

Unknown in *Edops* (D. M., pers. obs. of MCZ 1378). Probably also unknown in *Kotlassia*, judging from the comments on the preservation of the toothrow and on the pterygoid and parasphenoid (Bulanov, 2003: S55).

The dots in the reconstruction of **Neopteroplax* (Romer, 1963: fig. 5) appear to represent denticles, but there is no evidence for them in the specimen drawing (fig. 2) or the text; instead, in the specimen drawing, the denticle field has a very sharp edge that appears to coincide with the suture between pterygoid and palatine. We have therefore scored state 0.

112. PAL 4: Palatine with (0) or without (1) row of teeth (3+) comparable in size to, or
greater than, marginal teeth (maxillary) and parallel to these.

3365 *Ventastega* (Ahlberg, Lukševičs & Lebedev, 1994), *Microphon* (Bulanov, 2014) and 3366 *Ossinodus* (Warren, 2007) have state 0.

Phonerpeton (D. M., pers. obs. of AMNH 7150), *Ecolsonia* (D. M., pers. obs. of CM
38017), *Bruktererpeton* (Boy & Bandel, 1973: 51), *Batropetes* (Glienke, 2013), *Dicerato- saurus* (at least the broad-snouted morph: D. M., pers. obs. of MB.Am.778) and *Tseajaia*(Reisz, 2007) show state 1.

Unknown in *Asaphestera* (CG78: 19). We follow the matrix of Pardo et al. (2017) in
keeping the same score for *Lethiscus*, where both vomers are damaged labially (Pardo et al.,
2017: fig. 1, ext. data fig. 1).

**Micropholis* is polymorphic (Schoch & Rubidge, 2005), as (apparently) is **Sclero- cephalus* (Schoch & Witzmann, 2009a).

3376 *Orobates* has state 1 as originally scored (Nyakatura et al., 2015: digital 3377 reconstruction); however, this is impossible to see in Berman et al. (2004).

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3379 deleted PAL 6: Palatine articulates with maxilla only at anterior extremity of the 3380 former: absent (0); present (1). State 1 was scored in RC07 only for branchiosaurids and 3381 Petrolacosaurus. However, Werneburg (2012a: 43-44) reports that it is only known from larvae in the branchiosaurid Apateon – the skeletally most mature individuals of A. dracyi 3382 3383 (neotenic), A. caducus (neotenic) and A. gracilis (metamorphosed) have state 0. Conversely, 3384 state 1 is present in larval but not metamorphosed Amphibamus (Milner, 1982; Werneburg, 3385 2012a: 44) and *Platyrhinops* (Werneburg, 2012a). It stands to reason that the observed state 1 in Leptorophus and Schoenfelderpeton (and *Tungussogyrinus) is likewise larval or paedo-3386 3387 morphic. This leaves state 1 to *Petrolacosaurus* alone (because of its suborbital fenestra), 3388 making this character parsimony-uninformative, so we have deleted it. We could instead have 3389 specified that state 1 only occurs in larvae – but the ontogeny of way too many taxa in this 3390 matrix is insufficiently known.

Ventastega shows state 0 (Ahlberg, Lukševičs & Lebedev, 1994), as do *Brukterer- peton* (Boy & Bandel, 1973: 51), *Lethiscus* (Anderson, Carroll & Rowe, 2003; Pardo et al.,
2017) and *Ossinodus* (Warren, 2007).

Unknown in *Adelogyrinus* (Andrews & Carroll, 1991) and *Orobates* (Berman et al., 2004); inapplicable to *Phlegethontia*, which lacks palatines (Anderson, 2002).

3397 113. PAL 7: Palatines very wide, almost meeting in the midline (0); unremarkable (1); 3398 very narrow in any dimension (2) (ordered). State 0 of this potentially continuous character 3399 is new and accounts for the highly unusual condition of Eoherpeton (Smithson, 1985), 3400 Bruktererpeton (Boy & Bandel, 1973), Gephyrostegus (Klembara et al., 2014; Carroll, 1970, 3401 even reconstructed the palatines as meeting in one specimen), Pantylus (Romer, 1969; CG78), Stegotretus (Berman, Eberth & Brinkman, 1988) and *Sparodus (Carroll, 1988; D. M., pers. 3402 3403 obs. of NHMW 1899/0003/0006). It does not seem to occur anywhere else in or close to our 3404 taxon sample, and there are no borderline cases we are aware of; the closest is *Crassigvrinus*, 3405 in which the palatines are roughly L-shaped and not much longer than wide, but nonetheless 3406 stay well away from the midline (Clack, 1998: fig. 4B). The distinction between states 1 and 2 3407 (originally 0 and 1), however, is harder to define; most likely, the coding remains rather subjective - the original wording (RC07: 100) is "Palatine shaped like a slender, strut-like 3408 3409 bone: absent (0); present (1)."

State 1 is in any case present in *Ventastega* (Ahlberg et al., 2008), *Micromelerpeton*(Boy, 1995; Schoch, 2009b: fig. 2c), *Apateon (A. pedestris*: Schoch & Milner, 2008; *A. caducus*: Fröbisch & Schoch, 2009b), arguably *Leptorophus* and *Schoenfelderpeton* (Boy, 1986), probably *Batropetes* (Glienke, 2013), *Lethiscus* (Anderson, Carroll & Rowe, 2003; 3414
Pardo et al., 2017) and *Ossinodus* (Warren, 2007).

3415 State 2 makes a surprise appearance in Acanthostega (Porro, Rayfield & Clack, 2015). 3416 In RC07, our state 1 was scored for *Amphibamus*. This is supported by Schoch (2001) 3417 and Schoch & Milner (2014: fig. 30B); but the individual drawn by Schoch (2002b) is not adult, because it lacks the palatal fangs noted by Daly (1994: 27) in the most mature known 3418 3419 specimen (see VOM 7, PAL 1, ECT 2), and so does the composite reconstruction by Schoch 3420 & Milner (2014). Considering Schoch's (2002b) reconstruction of the palate of *Platvrhinops* 3421 (though see Clack & Milner, 2010: fig. 9b) and the condition seen in *Iberospondylus (Laurin 3422 & Soler-Gijón, 2006), the shape of the palatine may depend on the presence of fangs; Daly 3423 (1994) did not illustrate it, so we have scored Amphibamus as unknown.

Also unknown in *Archeria* (Holmes, 1989).

3396

We have scored state 1 or 2 for *Diceratosaurus* (D. M., pers. obs. of the crushed MB.Am.778) and for *Brachydectes*, whose palatines are arguably too short for these states to be distinguishable (Pardo & Anderson, 2016: fig. 10).

- 3428 *Saharastega is best scored as having state 0 or 1 (D. M., pers. obs. of MNN MOR
 3429 73).
- 3430
- 3431 114. PAL 8: Separately ossified palatine: present (0); absent (1).

Ventastega (Ahlberg, Lukševičs & Lebedev, 1994), *Batropetes* (Glienke, 2013), *Lethiscus* (Anderson, Carroll & Rowe, 2003; Pardo et al., 2017) and *Ossinodus* (Warren,
2007) have state 0.

Unknown in *Archeria* (Holmes, 1989) and *Vieraella* (Báez & Basso, 1996), apparently
also in *Keraterpeton* (Huxley & Wright, 1867; Jaekel, 1903).

3437 We accept the interpretation of Gao & Shubin (2012) and Wang, Dong & Evans (2015: 52) that a palatine is present (state 0) in the crown-group salamander *Beiyanerpeton. 3438 3439 A palatine is also present in another Jurassic crown-group salamander, **Chunerpeton (unmarked and unmentioned in Gao & Shubin, 2003: fig. 1; mentioned by Wang, Dong & 3440 3441 Evans, 2015: 52), and has recently been reported for a third one (** Qinglongtriton: Jia & 3442 Gao, 2016). It follows that we agree with Schoch (2014b) in rejecting Schoch's earlier (1998) 3443 interpretation that the palatine is absent even in larval salamanders in which the 3444 "palatopterygoid", homologous only to the pterygoid in that view, contacts the vomer. 3445

3446 115. ECT 1-4: Ectopterygoid at least as long as palatine (0); at least about a third as long 3447 as but shorter than palatine (1); at most about a third as long as palatine (2); absent (3) 3448 (ordered). ECT 1 concerned the presence (state 0) of an ectopterygoid, ECT 4 its size 3449 ("longer than/as long as (0) or shorter than (1) palatine"). We have merged both of them with ch. 8 of McGowan (2002) as revised by Marjanović & Laurin (2008): "Ectopterygoid at least 3450 about half as long as palatine (0), about a third as long as the palatine or shorter (1), or absent 3451 3452 (2) (ordered)" to extract the maximum of phylogenetic signal while avoiding character 3453 correlation. The gap between states 0 and 1 of Marjanović & Laurin (2008) was an artefact of 3454 the small taxon sample; we now count this part of morphospace as part of our state 1.

3455 Unambiguous occurrences of state 2 are limited to Schoenfelderpeton and 3456 *Gerobatrachus; Doleserpeton (Sigurdsen & Bolt, 2010), Triadobatrachus (Ascarrunz et al., 3457 2016: fig. 4, 3D model 1), Eocaecilia (Jenkins, Walsh & Carroll, 2007; see Marjanović & 3458 Laurin, 2008: 181, for discussion of ectopterygoids in gymnophionomorphs) and 3459 Diploceraspis (Beerbower, 1963) have state 2 or 3. We have scored *Quasicaecilia the same 3460 way (Pardo, Szostakiwskyj & Anderson, 2015). *Carrolla has small, rounded ectopterygoids 3461 like taxa with state 2, but the palatine is itself so short that we have scored *Carrolla as 3462 possessing state 1.

Whatcheeria was scored as 0 for ECT 1 but unknown for ECT 4 in RC07. Lombard & Bolt (1995) did not mention the size of the ectopterygoid, technically excluding only state 3 of the present character; however, they mentioned its dentition which make states 0 and 1 probable, and would likely have mentioned if the ectopterygoid was unusually short. We have therefore scored state 0 or 1.

Isodectes was scored the same way, but there is not enough space for our state 0 in the reconstruction by Sequeira (1998: fig. 9), while the presence of the ectopterygoid is uncertain (Sequeira, 1998); we have scored state 1, 2 or 3.

We have accepted the score of 0 for Dendrerpetidae based on Godfrey, Fiorillo & Carroll (1987), judging from the text of which the reconstruction of the palate is probably justified even though the specimen drawing (fig. 1) only show the mere presence of the ectopterygoid. Other sources can only narrow the condition down to state 0 or 1 (Milner, 1996: 90; Holmes, Carroll & Reisz, 1998). Similar considerations hold for the other ECT characters.

- 3479 Ecolsonia has state 0 or 1 (Berman, Reisz & Eberth, 1985: fig. 6).
- 3480 Broiliellus has state 1 according to Schoch (2012: fig. 2F).
- 3481 We assign state 1, 2 or 3 to *Batropetes* based on Glienke (2013: fig. 4A).

3482 Bruktererpeton has state 1 or 2; while the part of the palate that contains the suture 3483 between the ectopterygoid and the palatine is missing, enough of both bones appears to be known that the other states are impossible. The reconstruction (Boy & Bandel, 1973: fig. 7) 3484 3485 further indicates that state 2 can be ruled out as well, but the text (p. 51) contradicts this by 3486 saying that only the caudal margin of the ectopterygoid is preserved.

3487 Sevmouria sanjuanensis has state 1 as originally scored (Klembara et al., 2005), but S. 3488 baylorensis has state 0 (Laurin, 2000); Seymouria is thus polymorphic.

3489 Contra Marjanović & Laurin (2008: 181), Saxonerpeton (though borderline, if the 3490 ectopterygoid is correctly identified) and Hapsidopareion most likely have state 1 (CG78: 3491 figs. 14E, 21; already scored in RC07 for Hapsidopareion).

- 3492 Olori (2015) stated that the palatine of Hyloplesion was shorter than reconstructed by 3493 CG78; we have therefore scored state 1 or 2 (rather than only 2).
- 3494 Diplocaulus shows state 3 (Bossy & Milner, 1998), as do Sauropleura (Bossy & 3495 Milner, 1998), Oestocephalus (Carroll, 1998a) and Phlegethontia (Anderson, 2002).
- 3496 Bossy (1976) and Bossy & Milner (1998) reconstructed a suture on the palate of 3497 Ptyonius that would separate the vomer from the palatine in an odd place (quite some distance 3498 caudal to the choana). Therefore, they considered the next suture (even farther caudal to the 3499 choana) to be the one between palatine and ectopterygoid. That bone, however, looks exactly like the palatine of the closely related Sauropleura (and several other "nectrideans") in their 3500 3501 own reconstructions. Given the state of preservation of Ptyonius (Bossy, 1976), we prefer not to take the reconstruction at face value and have scored Ptvonius as unknown. It should be 3502 3503 mentioned that ectopterygoids are otherwise absent in nectrideans (Bossy, 1976; Bossy & 3504 Milner, 1998) - Jaekel (1903: pl. III) reconstructed a suture between the palatine and the 3505 "transversum" (ectopterygoid) in Diceratosaurus, but we agree with RC07 in scoring 3506 Diceratosaurus as unknown because is hard to tell if MB.Am.778, the specimen on which the 3507 reconstruction is based, really possesses such a suture (D. M., pers. obs.).
- 3508 Lethiscus has state 1 (Pardo et al., 2017, excluding their matrix, where state 0 is 3509 scored). 3510
 - States 0 and 1 probably both occur in *Micropholis (Schoch & Rubidge, 2005: fig. 2).

3511 Although the suture between the palatine and the ectopterygoid cannot be found in 3512 **Ymeria*, the minimum length that includes all ectopterygoid teeth is longer than the length 3513 that remains for the palatine (Clack et al., 2012a: fig. 2), giving state 0 to *Ymeria.

3514 Werneburg (2012a: 12) stated that an ectopterygoid is not certainly preserved in 3515 *Branchiosaurus but may be present in fig. 6c, d. The bone in question is indeed most likely an ectopterygoid. Unfortunately, it may not be complete, and the length of the palatine is 3516 unknown, so we have scored state 0, 1 or 2. 3517

3518 We have followed the matrix of Pardo et al. (2017) in scoring state 0 for 3519 *Coloraderpeton; the ectopterygoid is present (J. Pardo, pers. comm.), it is scored as reaching 3520 the subtemporal fenestra, and the space where it would lie is so long that state 0 seems 3521 inevitable. 3522

3523 116. ECT 2: Ectopterygoid with (0) or without (1) fangs comparable in size to or larger 3524 than marginal teeth (premaxillary or maxillary) and remaining ectopterygoid teeth (if 3525 present).

Acanthostega (Clack, 1994a; Porro, Rayfield & Clack, 2015) and *Acheloma* (Polley & Reisz, 2011) show state 0, as does *Phonerpeton* (D. M., pers. obs. of MCZ 1485). We tentatively assign the same score to *Trimerorhachis* (Milner & Schoch, 2013); perhaps polymorphism would be better (Milner & Schoch, 2013: fig. 1, 5).

The most mature known individual of *Amphibamus* – the neotype, YPM 794 – has state 0 (Daly, 1994: 27) as already scored in RC07. We regard this as the adult condition (see also Marjanović & Laurin, 2008: 180). Schoch & Milner (2014: 56) stated that *Amphibamus* lacks fangs on the vomer, palatine and ectopterygoid, but puzzlingly did not mention Daly (1994) in the context of *Amphibamus* at all, even though they of course mentioned YPM 794 and cited Daly (1994) as a source for *Eoscopus*.

Lethiscus (Pardo et al., 2017) and *Tseajaia* (Moss, 1972: 12) have state 1. We have followed the matrix of Pardo et al. (2017) in scoring it for **Coloraderpeton* as well.

3538 Unknown in *Bruktererpeton* (Boy & Bandel, 1973: 51).

 3539
 Ichthyostega (Jarvik, 1996: pl. 26:1, 27:1; Blom, 2005; Clack et al., 2012a; Clack &

 3540
 Milner, 2015: fig. 8C) and *Lydekkerina (Shishkin, Rubidge & Kitching, 1996: fig. 7) are

 3541
 polymorphic.

3542 *Orobates* has state 1 as originally scored (Nyakatura et al., 2015: digital 3543 reconstruction); however, this is impossible to see in Berman et al. (2004).

We interpret the name of this character as saying that ectopterygoid fangs have to be larger than the remaining ectopterygoid teeth; therefore **Glanochthon* is polymorphic (Schoch & Witzmann, 2009b: figs. 3, 4) and **Australerpeton* has state 1 (Eltink et al., 2016: 848, fig. 6). **Platyoposaurus*, while borderline, has state 0, however (Gubin, 1991: drawing 36); and we concur with Pereira Pacheco et al. (2016: appendix 2) in counting the borderline condition of **Konzhukovia* (Gubin, 1991: drawing 15a) as state 0 as well.

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117. ECT 3: Ectopterygoid without (0) or with (1) small teeth (denticles), the basal diameter and/or height of which is less than 30% of that of adjacent marginal teeth (maxillary) and remaining ectopterygoid teeth (if present). See VOM 4.

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Tseajaia shows state 0 (Moss, 1972: 12).

3555State 1 occurs in Acheloma (Polley & Reisz, 2011) and Platyrhinops (Clack & Milner,35562010).

Probably unknown in *Kotlassia*, judging from the comments on the preservation of the toothrow and on the pterygoid and parasphenoid (Bulanov, 2003: S55).

The ectopterygoid is too eroded to tell in the two **Nigerpeton* specimens, MNN MOR and MNN MOR 70, that preserve it (D. M., pers. obs.).

Although this is not obvious from Maddin, Olori & Anderson (2011), **Carrolla* has state 0 (D. M., pers. obs. of TMM 40031-54). We have followed the matrix of Pardo et al. (2017) in scoring it for **Coloraderpeton* as well.

The dots in the reconstruction of **Neopteroplax* (Romer, 1963: fig. 5) appear to represent denticles, but there is no evidence for them in the specimen drawing (fig. 2) or the text; instead, in the specimen drawing, the denticle field has a very sharp edge that appears to coincide with the suture between pterygoid and ectopterygoid. We have therefore scored state 0.

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3569 118. ECT 5: Ectopterygoid with (0) or without (1) row of teeth (3+) comparable in size to, 3570 or greater than marginal teeth (maxillary) and parallel to these.

3571 State 0 is found in *Greererpeton* (Smithson, 1982), *Crassigyrinus* (Clack, 1998), 3572 *Trimerorhachis* (Milner & Schoch, 2013), *Kotlassia* (Bulanov, 2003: S55, fig. 30), and 3573 *Cardiocephalus* (CG78) as well as **Coloraderpeton* (Pardo et al., 2017: matrix; J. Pardo, 3574 pers. comm.). *Acheloma* (Polley & Reisz, 2011), *Phonerpeton* (D. M., pers. obs. of MCZ 1485), *Ecolsonia* (Berman, Reisz & Eberth, 1985; D. M., pers. obs. of CM 38017), *Gephyrostegus* (Carroll, 1970; Klembara et al., 2014), *Limnoscelis* (Fracasso, 1983; Reisz, 2007), *Microbrachis* (CG87; Vallin & Laurin, 2004; Olori, 2015), *Lethiscus* (Pardo et al., 2017) and *Tseajaia* (Moss, 1972: 12) show state 1.

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Unknown in Saxonerpeton (CG78).

3581 *Orobates* has state 1 as originally scored (Nyakatura et al., 2015: digital 3582 reconstruction); however, this is impossible to see in Berman et al. (2004).

From comparisons to *Colosteus* and *Greererpeton* (Smithson, 1982; Hook, 1983) and after pers. obs. of MB.Am.1441.2 by D. M., we disagree with Clack et al. (2012b: 22) that "the right ectopterygoid is preserved in such a way that additional teeth would very likely have been evident if present" and have scored the *St. Louis tetrapod as unknown.

3588 deleted ECT 6: Ectopterygoid/maxilla contact: present (0); absent (1). State 1, originally 3589 scored for the branchiosaurids, Petrolacosaurus, Hyloplesion and Odonterpeton, can mean 3590 different things: it can mean that the subtemporal fenestra extends all the way to the middle of 3591 the palatine (as it does in larval amphibamids, see above under PAL 6) or at least reaches the 3592 caudal end of the palatine (as CG78 reconstructed for *Odonterpeton*); or it can be due to the 3593 suborbital fenestra found in diapsids (represented in this matrix by Petrolacosaurus), which is 3594 separated from the subtemporal fenestra by an ectopterygoid-jugal (as in Petrolacosaurus) or ectopterygoid-maxilla contact (as in **crocodyliforms and some **dinosaurs, where the 3595 3596 maxilla reaches the caudal margin of the suborbital fenestra); or, at least in theory, a long 3597 caudal extension of the palatine could intervene between the ectopterygoid and the maxilla. This last possibility was reconstructed by CG78 (fig. 89) for Hyloplesion. It looks, however, 3598 3599 seriously weird. We have to wonder if the supposed ectopterygoid is actually the flange of the 3600 pterygoid (see PTE 3-9) that has broken off, and the real ectopterygoid is the fragment that 3601 lies rostrolateral to it in fig. 89E. (Compare the condition in Microbrachis: Vallin & Laurin 3602 2004: fig. 2C, 4B, 5B.) Olori (2015: 44) appeared to agree, stating that "the palatine 3603 terminates further anteriorly than was depicted by [...] [CG78] in their figure 89H, and thus is shorter than the maxilla in anteroposterior length." (The ectopterygoid is not otherwise 3604 3605 mentioned or indicated in a figure.) Most likely, then, state 1 is limited to Petrolacosaurus and Odonterpeton, and the primary homology of their conditions is wide open to question. 3606 3607 Should they be assigned separate states, the character would be parsimony-uninformative.

3608 In Odonterpeton, too, the situation is far from clear. First of all, if the reconstruction 3609 (CG78: fig. 99B) is correct, it may be due to skeletal immaturity, a condition that would be 3610 unsurprising in this tiny specimen, in which case it should be scored as unknown (see PAL 6 3611 above). The specimen drawings (CG78: fig. 98A, 99A), however, do not clearly support the reconstruction. In ventral view (right part of fig. 98A and 99A) all but the medial edge of the 3612 3613 ectopterygoid – or perhaps the caudomedial edge of the palatine – is covered by the lower jaw 3614 on one side, and nothing is exposed on the other. The description (CG78: 145) reads in full: "The ectopterygoids are small bones. The lateral margin of the left ectopterygoid, seen in 3615 3616 dorsal view through the orbit, does not appear to reach the maxilla." It is not clear to us how 3617 this conclusion was reached; according to the specimen drawing in dorsal view (CG78: left 3618 part of fig. 98A and 99A), the lateral tip of the ectopterygoid lines up with the lateral margin 3619 of the palatine, or nearly so, and the disarticulated maxilla is only preserved in lateral view. 3620 Finally, not all of the sutures in these specimen drawings are accurate (see POSPAR 1-2 3621 above).

3622 Scoring *Hyloplesion* or *Odonterpeton* as anything other than unknown, thus, will have 3623 to await further inspection of specimens. (Unfortunately, D. M. had not yet considered this 3626 Acheloma (Polley & Reisz, 2011) and Tseajaia (Moss, 1972: 12), previously scored as
3627 unknown, show state 0.
3628

deleted ECT 7: Ectopterygoid narrowly wedged between palatine and pterygoid: no (0); yes (1). RC07 explicitly ascribed state 1 to *Odonterpeton* and *Hyloplesion*, but *Odonterpeton* is reconstructed as having state 0 (CG78: fig. 99). This makes this character parsimonyuninformative (state 1 was not scored for any other OTUs, and we have not seen it in any of them), so we have deleted it. Additionally, we doubt whether state 1 occurs even in *Hyloplesion*, see ECT 6.

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3636 119. PTE 3-9: Flange on pterygoid: absent, pterygoid margin of subtemporal fenestra 3637 concave or straight throughout (0); rostrolateral-caudomedial orientation (1); 3638 mediolateral or rostromedial-caudolateral orientation ("transverse flange"), without 3639 row of large teeth (2); same with row of large teeth (3) (ordered). RC07 treated the 3640 "posterolateral flange" (PTE 9(1); our state 1) separately from the "transverse flange" (PTE 3641 3(1, 2); our states 2 and 3), but we think the "transverse flange" is only an extreme of a continuum the rest of which is called "posterolateral flange". Indeed, the two flanges never 3642 3643 occur together - except that our states 1 and 2 occur in different individuals of *Micropholis 3644 (Schoch & Rubidge, 2005: fig. 2) and apparently *Sclerocephalus (Schoch & Witzmann, 3645 2009a: fig. 4, 6), which we have both scored as having states 1 and 2.

- Interestingly, PTE 3 was called "Transverse flange of pterygoid absent (0), present without transverse tooth row (1), or present and carrying transverse tooth row." – the number "(2)" was omitted. This may of course be a simple typographic error; notably, however, state did not occur in the matrix apart from the partial uncertainty (state 1 or 2) that was scored for *Leptoropha* and *Tseajaia*.
- 3651State 0 is present in *Ventastega* (Ahlberg, Lukševičs & Lebedev, 1994). The condition3652of *Caerorhachis* is borderline (Ruta, Milner & Coates, 2002), but we have kept the score of 0.

Trimerorhachis has a weak case of state 1 (Milner & Schoch, 2013), no weaker than
that of *Neldasaurus* (already scored correctly; Chase, 1965). State 1 further appears in *Micromelerpeton* (close to state 2: Schoch, 2009b: fig. 2c), *Apateon* (Schoch & Milner, 2008), *Leptorophus* (Boy, 1986), *Rhynchonkos* (Szostakiwskyj, Pardo & Anderson, 2015: fig. 3A), *Lethiscus* (Pardo et al., 2017), *Oestocephalus* (Carroll, 1998a), apparently *Vieraella* (Estes &
Reig, 1973: fig. 1-2; Báez & Basso, 1996: fig. 6) and *Silvanerpeton* (Ruta & Clack, 2006).

Broiliellus (Schoch, 2012: fig. 2F) and Tseajaia (Moss, 1972) have state 2.

3660 If Hyloplesion was reconstructed correctly by CG78 (fig. 89H), this character is not 3661 applicable to it, because the pterygoid does not contribute to the subtemporal fenestra except 3662 by most of its quadrate ramus; if the unlikely positioned supposed ectopterygoid is part of the pterygoid instead (see ECT 6 above), Hyloplesion has state 2. We have gone with the latter 3663 option mainly because, even accepting all of the identifications by CG78, the left pterygoid 3664 3665 (though perhaps not the right one) does go just around the corner between the medial and the 3666 rostral margin of the subtemporal fossa in one specimen (CG78: fig. 89E). This issue was not 3667 addressed or figured by Olori (2015).

State 3 of the present character (= state 2 of PTE 3) is present in *Limnoscelis* (Fracasso, 1983: fig. 2; Reisz, 2007; Berman, Reisz & Scott, 2010), *Paleothyris* (Carroll, 1969b), and *Petrolacosaurus* (Reisz, 1981).

The condition is entirely unknown in *Colosteus* (Hook, 1983: fig. 1B), *Whatcheeria* (the palate of which has not yet been described: Bolt & Lombard, 2000), *Eucritta* (the reconstruction, Clack, 2001: fig. 8, appears overly ambitious judging from the accompanying text and specimen drawings), *Edops* (D. M., pers. obs. of MCZ 1378; contra Romer & Witter,
1942: fig. 3B), *Batropetes* (Carroll, 1991; Glienke, 2013, 2015), *Asaphestera* (CG78: fig. 6F),
and apparently *Pederpes* (Clack & Finney, 2005). The palate of *Keraterpeton* appears to be
entirely unknown (Huxley & Wright, 1867; Jaekel, 1903).

Neither state 0 (already scored in RC07) nor state 1 can be excluded for *Isodectes* (Sequeira, 1998). For *Scincosaurus*, figures 2B and 3B of Milner & Ruta (2009) appear to contradict each other, at least on the anatomically left side: fig. 3B shows state 0 as already scored, while fig. 2B shows state 1, unless the bulge in question was dorsal rather than lateral in life; we have scored partial uncertainty here as well.

3683 State 0 can be ruled out for *Bruktererpeton* (Boy & Bandel, 1973: fig. 7); we have 3684 accordingly scored state 1, 2 or 3.

3685 *Amphibamus* (Bolt, 1979: fig. 6B; Milner, 1982: fig. 3b; Schoch & Milner, 2014: fig. 3686 30B) and *Odonterpeton* (CG78: fig. 99A) appear to have states 1 or 2.

3687 **Acanthostomatops* has state 1, though it is close to state 2, at least in two dimensions
3688 (Witzmann & Schoch, 2006a).

3689 The reconstruction of *Carrolla by Maddin, Olori & Anderson (2011: fig. 7B) cannot 3690 be reconciled with the specimen (D. M., pers. obs. of TMM 40031-54): the drawing leaves 3691 practically no space for the subtemporal fenestra, in particular the coronoid process of the lower jaw which lies in this fenestra in the fossil, because it gives the pterygoid a large lateral 3692 3693 extension, implying that the preserved lateral margin must be a break. In the specimen, the 3694 margin is finished and rounded, as is the cranial margin of the quadrate ramus; the margin 3695 implied by Maddin, Olori & Anderson (2011: fig. 4) should be taken at face value. 3696 Furthermore, the quadrate ramus is identified in fig. 4 and described, with its suture to the quadrate, several times in the text of Maddin, Olori & Anderson (2011), yet it is entirely 3697 3698 absent from fig. 7B, where the pterygoid does not contact the quadrate at all! - One might 3699 wonder whether a transverse flange (state 2) might have merged with the equally transverse 3700 quadrate ramus immediately caudal to it; however, the pterygoid ramus of the quadrate 3701 articulates with the entire width of the quadrate ramus of the pterygoid, so that the flange 3702 would have to be extremely short and limited to the concave transition of the quadrate ramus 3703 to the rest of the pterygoid (D. M., pers. obs. of TMM 40031-54). *Carrolla thus has state 0. 3704 It remains to be seen whether this is size-related, however.

3705 "Large teeth" are not defined. Under the assumption that this simply means "not
3706 denticles", the row of teeth found in **Archaeovenator* qualifies for state 3, because the largest
3707 of those teeth are about the size of the smallest marginal teeth and distinctly larger than all
3708 denticles (Reisz & Dilkes, 2003: fig. 2).

3710 120. PTE 7: Pterygoid quadrate ramus orientated mostly caudally (0) or mostly laterally 3711 in ventral aspect (1); ramus absent, quadrate contacts central region of pterygoid (2) 3712 (ordered). State 0 was originally unspecified. State 2 is new and accounts for the condition 3713 seen in Batropetes (Glienke, 2013), Brachydectes (Wellstead, 1991; Pardo & Anderson, 3714 2016) and Scincosaurus (Milner & Ruta, 2009); the character is ordered because it is 3715 potentially continuous and reflects a widening of the parasphenoid and a rostral repositioning of the quadrates - although the correlation with JAW ART 1/SQU 2/DEN 8 (below) is not 3716 3717 perfect.

3718 State 0 is present in *Ventastega* (Ahlberg, Lukševičs & Lebedev, 1994) and *Lethiscus* 3719 (Pardo et al., 2017).

Keraterpeton was scored in RC07 as having state 0. The palate appears to be entirely unknown (Huxley & Wright, 1867; Jaekel, 1903), and indeed state 1 would be expected from the proportions of the skull (Jaekel, 1903: fig. 1, 2); we have changed the score to unknown. 3723 State 1 is clearly found in *Diceratosaurus* (Jaekel, 1903: pl. III), *Diplocaulus* (Bossy 3724 & Milner, 1998) and *Diploceraspis* (Beerbower, 1963). In *Batrachiderpeton* (Bossy & 3725 Milner, 1998), the quadrate ramus is oriented much more laterally than caudally; we count

3725 Milner, 1998), the qu 3726 this as state 1 as well.

State 1 is also documented in **Chelotriton* (Roček & Wuttke, 2010; Schoch,
Poschmann & Kupfer, 2015); but in MB.Am.45, which is preserved in dorsal view only, state
0 would be expected because the suspensoria extend far caudal to the occiput. We have scored
partial uncertainty.

We infer state 0 for the *St. Louis tetrapod because the lower jaw, and indeed its Meckelian fenestra, continues well distal to the basipterygoid process (Clack et al., 2012b).

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121. PTE 11: **Pterygoid/maxilla contact: absent (0); present (1).** Because the ectopterygoid, if present, usually lies between the pterygoid and the maxilla, it would have been tempting to merge this character with ECT 1-4 (above), but Clack (1998: fig. 4B) suggests that the maxilla and the pterygoid could meet caudal to the ectopterygoid in *Crassigyrinus* (scored here as unknown), and indeed they meet caudal to the well developed ectopterygoid in *Caerorhachis* (see below) and *Micraroter* (CG78: 88; previously scored as unknown), so we have kept them separate.

Acanthostega (Clack, 1994a), *Acheloma* (Polley & Reisz, 2011), *Bruktererpeton* (Boy
& Bandel, 1973: fig. 7), *Batropetes* (Glienke, 2013) and *Lethiscus* (Anderson, Carroll &
Rowe, 2003; Pardo et al., 2017) have state 0.

Caerorhachis was scored 0 in RC07. Ruta, Milner & Coates (2002: fig. 4b), however, clearly showed state 1 on the right side of the specimen. On the left side of the same specimen, they reconstructed state 0 (fig. 5c); Ruta, Milner & Coates (2002) did not mention this discrepancy in the text. While it is possible that the left side had state 0, especially if the maxillary process of the pterygoid was genuinely absent and has not broken off, the left side of the palate is much too disarticulated to tell for sure; in particular, the ectopterygoid is missing on that side (fig. 3b, 5a). We have therefore scored state 1 alone.

Unknown in *Whatcheeria* (Lombard & Bolt, 1995), *Doleserpeton* and *Triadobatrachus*, together with but not entirely dependent on the existence and extent of the ectopterygoid (Sigurdsen & Bolt, 2010; Ascarrunz et al., 2016: fig. 4, 12, 3D model 1; see also character ECT 1-4 above), apparently *Keraterpeton* (Huxley & Wright, 1867; Jaekel, 1903) and *Silvanerpeton* (Ruta & Clack, 2006).

The condition in *Edops* is likewise unknown (D. M., pers. obs. of MCZ 1378); RC07 may have misplaced the question mark to the next character, the state of which is known (see below).

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For **Erpetosaurus* and the *St. Louis tetrapod, see JUG 3 above.

We follow Pardo et al. (2017: matrix) in scoring state 0 for **Coloraderpeton*.

122. PTE 13: Pterygoid without (0) or with (1) distinct, me[d]ially directed process for
basipterygoid articulation. This character is only applicable when the interpterygoid
vacuities are not too small; we have scored it as inapplicable where that condition is not
fulfilled (this concerns a large majority of the OTUs scored 0 by RC07), as well as in a few
other OTUs that lack space for such a process like *Greererpeton* or *Limnoscelis* (Reisz, 2007:
fig. 6.1; Berman, Reisz & Scott, 2010: fig. 4A).

State 1 is found in *Acanthostega* (weakly expressed: Porro, Rayfield & Clack, 2015), *Edops* (Romer & Witter, 1942: fig. 3B; D. M., pers. obs. of MCZ 1378), *Neldasaurus* (very
weakly expressed: Chase, 1965), *Trimerorhachis* (weakly expressed: Milner & Schoch, *Balanerpeton* (Milner & Sequeira, 1994), *Pelodosotis* (CG78: fig. 48), *Rhynchonkos*(Szostakiwskyj, Pardo & Anderson, 2015), *Hyloplesion* (in the largest of the three specimens)

drawn in CG78: fig. 89; photographed in Olori, 2015: fig. 30A), Diceratosaurus (Jaekel, 3773 3774 1903: pl. III), Diplocaulus (Bossy & Milner, 1998: fig. 57C) where the process is very broad rostrocaudally but no less distinct than elsewhere, *Diploceraspis* (Beerbower, 1963: fig. 4A) 3775 where the same situation prevails (partly obscured by the fact that the quadrate ramus is 3776 3777 situated so far rostrally), Ptyonius (Bossy, 1976: fig. 44, 49), and Capetus (Sequeira & 3778 Milner, 1993). The process is apparently very short but nonetheless distinct in Batropetes 3779 (Glienke, 2013), so we have assigned state 1 to it as well.

3780 The palate of *Keraterpeton* appears to be entirely unknown (Huxley & Wright, 1867; 3781 Jaekel, 1903). 3782

State 0 makes a surprise appearance in Lethiscus (Pardo et al., 2017).

3783 *Micropholis is polymorphic (Schoch & Rubidge, 2005). So is *Sclerocephalus 3784 (Schoch & Witzmann, 2009a: fig. 6).

Although likely shorter than implied by Maddin, Olori & Anderson (2011: fig. 7B), 3785 3786 the process is clearly present (state 1) in *Carrolla.

3787 We have also assigned state 1 to the special case of *Quasicaecilia, where the process 3788 is very long and clearly distinct, but points straight caudally because the jaw articulation is so 3789 far rostral (Pardo, Szostakiwskyj & Anderson, 2015).

3790 Although very wide rostrocaudally, the process is present (state 1) in *Australerpeton 3791 (Eltink & Langer, 2016).

3792 Even though this character is inapplicable to Hapsidopareion, *Llistrofus has state 1 3793 (Bolt & Rieppel, 2009). 3794

3795 123. PTE 14: Quadrate ramus of pterygoid more than (0) or at most twice as long as 3796 maximally broad (1). The original wording was more impressionistic: "Pterygoid quadrate 3797 ramus a robust structure, indistinctly merging into basal and palatal processes: absent (0); 3798 present (1)", explained in the next sentence as the quadrate ramus being "a stout structure, 3799 slightly longer than wide and without a neat separation from the rest of the bone". We have 3800 reduced this to the length/width ratio, which we have changed because the quadrate ramus is 3801 considerably longer than broad in most OTUs that were scored 1 in RC07 (all lissamphibians, 3802 *Micromelerpeton*, and all branchiosaurids were scored 1, everything else was given state 0).

3803 State 0 as defined by us occurs in *Micromelerpeton* (Boy, 1995), all branchiosaurids 3804 (Boy, 1986, 1987), and the lissamphibians Eocaecilia (Jenkins, Walsh & Carroll, 2007), 3805 Triadobatrachus (Roček & Rage, 2000; Ascarrunz et al., 2016; D. M. and M. L., pers. obs. of 3806 MNHN F.MAE.126), and Valdotriton (Evans & Milner, 1996) as well as *Liaobatrachus 3807 (Dong et al., 2013). Less surprisingly, it is known from Ventastega (Ahlberg, Lukševičs & 3808 Lebedev, 1994) and Lethiscus (Pardo et al., 2017).

We find state 1 in Baphetes (Beaumont, 1977), Eucritta (Clack, 2001), Isodectes 3809 3810 (Sequeira, 1998), Platyrhinops (borderline; Clack & Milner, 2010), Caerorhachis (Ruta, Mil-3811 ner & Coates, 2002), Eoherpeton (Smithson, 1985), Pholiderpeton atthevi (Panchen, 1972), 3812 Ph. scutigerum (Clack, 1987b), Asaphestera, Micraroter (marginally) and Cardiocephalus 3813 (CG78), Scincosaurus (Milner & Ruta, 2009), Batrachiderpeton (Bossy & Milner, 1998), 3814 Diceratosaurus (Jaekel, 1903), Diplocaulus (the pterygoids of which which look like those of the salamander Karaurus: Bossy & Milner, 1998), Diploceraspis (Beerbower, 1963), Capetus 3815 3816 (Sequeira & Milner, 1993) and Silvanerpeton (Ruta & Clack, 2006) as well as, unexpectedly, *Palaeoherpeton (Panchen, 1964: fig. 13). 3817 3818 *Euryodus* is polymorphic (CG78).

3819 The condition is unknown in Anthracosaurus (Panchen, 1977), Odonterpeton (CG78: 3820 fig. 99A), Adelospondylus (Andrews & Carroll, 1991; it is too difficult to decide how to 3821 measure the reconstruction drawing and how to interpret it in relation to the specimen 3822 drawings), Keraterpeton (Huxley & Wright, 1867; Jaekel, 1903), and inapplicable in Batro*petes*, which likely lacks a quadrate ramus (Glienke, 2013), and *Brachydectes*, which clearly lacks a quadrate ramus (Wellstead, 1991; Pardo & Anderson, 2016), as well as in *Oestocephalus* (Carroll, 1998a), which lacks clear sutures between the pterygoid and other bones such as the epipterygoid and the quadrate.

Apparently borderline in the incompletely preserved **Neopteroplax* (Romer, 1963:
fig. 2); we have scored it as unknown.

3830 deleted PTE 15: Pterygoid quadrate ramus straight, rod-like and gently tapering distally 3831 in ventral aspect: absent (0); present (1). The ventral surface of the quadrate ramus further "is parallel-sided for most of its length and narrows smoothly in its rearmost part" in state 1, 3832 3833 which is supposed to be present in "some dissorophoids and *Eocaecilia*". This unquantified 3834 description, which is strongly reminiscent of PTE 14, turns out to be difficult to apply to many (if not most) OTUs, or at least to the line drawings that fail to show that the quadrate 3835 3836 ramus is a more or less vertical lamina rather than a rod. The visible tapering of the process 3837 further depends strongly on diagenetic compression. We fail to see a difference between the 3838 conditions of Broiliellus (scored 0 by RC07), Platyrhinops (0), Eoscopus (1), Doleserpeton 3839 (1), or probably even *Eocaecilia* (1). For the time being, we have therefore deleted this 3840 character.

3842 124. PTE 16: Pterygoid palatal ramus without (0) or with (1) distinct, anterior and
3843 unornamented digitiform process. State 1 requires that the pterygoids meet rostral to the
3844 parasphenoid; where this is not the case (VOM 5-10/PTE 10-12-18/INT VAC 1 having a state
3845 other than 0 or 1), this character is inapplicable.

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3846State 0 is found in Ventastega (Ahlberg, Lukševičs & Lebedev, 1994), Microbrachis3847(Vallin & Laurin, 2004; Olori, 2015) and Ossinodus (Warren 2007).

3848The condition of *Westlothiana* is unknown (Smithson et al., 1994) in addition to being3849inapplicable. The palate of *Keraterpeton* appears to be entirely unknown (Huxley & Wright,38501867; Jaekel, 1903).

We have counted the condition of **Chroniosaurus* (Klembara, Clack & Čerňanský,
2010) as state 1, although it may not be unornamented enough.

3854 125. PTE 17: Basal region of pterygoid immediately anterior to quadrate ramus without
3855 (0) or with (1) sharply defined, elongate longitudinal groove.

3856 State 0 is present in *Ventastega* (Ahlberg, Lukševičs & Lebedev, 1994) and *Lethiscus* 3857 (Pardo et al., 2017).

3858 State 1 is known in *Euryodus* (CG78) and makes a surprise appearance in **Liaobatra-*3859 *chus* (Dong et al., 2013).

Edops is probably best scored as unknown (D. M., pers. obs. of MCZ 1378).

The palate of *Keraterpeton* appears to be entirely unknown (Huxley & Wright, 1867;
Jaekel, 1903).

3864 126. PTE 19: Robust, strut-like pterygoid–squamosal process providing support for quadrate: absent (0); present (1). This refers to the condition seen today in salamanders, where the quadrate process of the pterygoid is largely parallel to the ventrolateral process of the squamosal (= its main body), and the two together almost completely encase the (often partly or wholly unossified) quadrate for its entire length or nearly so.

3869State 0 is present in Ventastega (Ahlberg, Lukševičs & Lebedev, 1994), Lethiscus3870(Pardo et al., 2017) and, surprisingly, *Chelotriton (Schoch, Poschmann & Kupfer, 2015).

3871 As preserved, *Triadobatrachus* comes close to state 1; this is almost certainly due to 3872 crushing, however (Ascarrunz et al., 2016: 3D model 1), so we have kept state 0. 3873The palate of *Keraterpeton* appears to be entirely unknown (Huxley & Wright, 1867;3874Jaekel, 1903).

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127. INT VAC 2: Interpterygoid vacuities and cultriform process together occupy at 3876 3877 least half of palatal width: absent (0); present (1). We have added the cultriform process of 3878 the parasphenoid to make clear that we measured the distance between the lateral extremities 3879 of the vacuities; as a side-effect, this increases the applicability of this character – specifically, 3880 Brachydectes has state 1 despite lacking interpterygoid vacuities (Wellstead, 1991; Pardo & 3881 Anderson, 2016). On the other hand, while a width of zero could be measured and scored, it 3882 follows automatically from state VOM 5-10/PTE 10-12-18/INT VAC 1(0); we have scored 3883 these OTUs as inapplicable, as RC07 did in a few cases.

State 1 is also found in *Cochleosaurus* (Sequeira, 2004), Albanerpetidae (McGowan, 2002; Maddin et al., 2013a: fig. 5H, I), *Eocaecilia* (Jenkins, Walsh & Carroll, 2007) and *Batropetes*, the only OTU in this matrix that is known to combine state 1 with convex pterygoid margins (INT VAC 3(0)) (Glienke, 2013). *Lethiscus* appears to reach state 1 as well (Pardo et al., 2017; J. Pardo, pers. comm.).

3889 *Whatcheeria* has state 0 (Lombard & Bolt 1995). So do *Bruktererpeton* (Boy & Bandel, 1973), *Diadectes* (Berman, Sumida & Martens, 1998) and *Diceratosaurus* (Jaekel, 1903; D. M., pers. obs. of MB.Am.778).

**Carrolla* shares state 0: the vacuities are probably considerably less wide than half of
the palate (D. M., pers. obs. of TMM 40031-54; contra Maddin, Olori & Anderson, 2011: fig.
7B).

3895 The palate of *Keraterpeton* appears to be entirely unknown (Huxley & Wright, 1867;
3896 Jaekel, 1903).
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128. INT VAC 3: Interpterygoid vacuities concave along their whole margins: absent (0);
present (1). We count missing parts of margins as concave (for instance in salamanders where the palatine is absent and the pterygoid does not reach the maxilla). In the absence of interpterygoid vacuities, however (VOM 5-10/PTE 10-12-18/INT VAC 1(0)), this character is inapplicable.

3903 *Batropetes* is the only OTU in this matrix, with the possible exception of *Eocaecilia*, 3904 that combines convex pterygoid margins (state 0 of the present character) with vacuities that 3905 are together half as wide as the palate (INT VAC 2(1)) (Glienke, 2013).

Albanerpetidae has state 0: the only known margins are very slightly convex in their
caudal half (McGowan, 2002; Maddin et al., 2013a: PDF version of fig. 5H, I at 500%). So do *Bruktererpeton* (Boy & Bandel, 1973), *Diadectes* (Berman, Sumida & Martens, 1998), *Dice-*ratosaurus (Jaekel, 1903; D. M., pers. obs. of MB.Am.778) and *Lethiscus* (Pardo et al., 2017).

3910 *Eocaecilia* is borderline (Jenkins, Walsh & Carroll, 2007: fig. 3); we have scored it as 3911 unknown. *Phlegethontia*, too, is borderline (Anderson, 2002: fig. 8.2), so we have kept the 3912 score as unknown.

3913 State 1 is arguably found in *Caerorhachis* (Ruta, Milner & Coates, 2002: fig. 5c), 3914 apparently in *Stegotretus* (Berman, Eberth & Brinkman, 1988), almost certainly in *Asaphes-*3915 *tera* (CG78: fig. 6F, 7), borderline but certainly in *Ptyonius* (Bossy & Milner, 1998: fig. 75B), 3916 perhaps less certainly but not borderline in *Urocordylus* (Bossy & Milner, 1998: fig. 55A), 3917 and definitely in *Capetus* (Sequeira & Milner, 1993: fig. 7, pl. 3). It further occurs in *Tudi-*3918 *tanus* (Carroll & Baird, 1968: fig. 5); the reconstruction (fig. 9) shows state 1 on the anatom-3919 ical right and 0 on the left side, but the left pterygoid is entirely unknown (fig. 5).

3920 *Sclerocephalus is polymorphic (Schoch & Witzmann, 2009a: fig. 4, 6). So is
3921 apparently *Pantylus* (left and right side of the specimen reconstructed by Romer, 1969: fig. 5;
3922 copied by CG78: fig. 25).

3923 **Carrolla* has state 0: the vacuity margins are partly straight (D. M., pers. obs. of 3924 TMM 40031-54; only stippled by Maddin, Olori & Anderson, 2011: fig. 7B). Unknown in *Eoherpeton* (Smithson, 1985). The palate of *Keraterpeton* appears to be 3925 3926 entirely unknown (Huxley & Wright, 1867; Jaekel, 1903). 3927 3928 129. INT VAC 4: Interpterygoid vacuities and cultriform process together broader than 3929 long: absent (0); present (1). We have added the cultriform process of the parasphenoid to 3930 make clear that we measured the distance between the lateral extremities of the vacuities; as a 3931 side-effect, it increases the applicability of this character – *Brachydectes* in particular has state 3932 0 (Wellstead, 1991; Pardo & Anderson, 2016). On the other hand, while a width of zero could 3933 be measured and scored, it is already coded as state VOM 5-10/PTE 10-12-18/INT VAC 1(0); 3934 we have scored these OTUs as inapplicable for the present character, as RC07 did in some 3935 cases. 3936 The combination of state 1 with INT VAC 3(0) does not occur in this matrix, but is 3937 known in larvae and some adults of **extant caecilians (Reiss, 1996); we have therefore not 3938 merged these characters. 3939 Cochleosaurus has state 0 (Sequeira, 2004), as do Bruktererpeton (Boy & Bandel, 3940 1973), Diadectes (Berman, Sumida & Martens, 1998), Batropetes (Glienke, 2013), 3941 Diceratosaurus (Jaekel, 1903; D. M., pers. obs. of MB.Am.778) and Lethiscus (Pardo et al., 3942 2017). 3943 State 1 is found in Albanerpetidae (McGowan, 2002; Maddin et al., 2013a: PDF 3944 version of fig. 5I at 500%), almost certainly in Asaphestera (CG78: fig. 6F, 7), and most 3945 likely in Hyloplesion (Olori, 2015: fig. 30C, ?A). The palate of *Keraterpeton* appears to be entirely unknown (Huxley & Wright, 1867; 3946 3947 Jaekel, 1903). 3948 We have scored state 0 for *Coloraderpeton following the matrix by Pardo et al. 3949 (2017).3950 3951 130. CHO 1: Choana wider in its anterior half than in its posterior half: no (0); yes (1). 3952 State 0 is found in Crassigyrinus (Clack, 1998), Platyrhinops (Clack & Milner, 2010), 3953 Albanerpetidae (Maddin et al., 2013a: PDF version of fig. 5I at 500%), Bruktererpeton (Boy 3954 & Bandel, 1973: 51), Kotlassia (Bulanov, 2003: fig. 30), Seymouria (Laurin, 2000; Klembara 3955 et al., 2007), Batropetes (most likely; Glienke, 2013, 2015), Lethiscus (Pardo et al., 2017), 3956 Orobates (Nyakatura et al., 2015: digital reconstruction) and Silvanerpeton (Ruta & Clack, 3957 2006). 3958 State 1 occurs throughout Dendrerpetidae (Godfrey, Fiorillo & Carroll, 1987; Milner, 3959 1996: Holmes, Carroll & Reisz, 1998) and is shared by Acheloma (Polley & Reisz, 2011), 3960 Ecolsonia (Berman, Reisz & Eberth, 1985), Amphibamus (Schoch & Milner, 2014: fig. 30B), 3961 Doleserpeton (Sigurdsen & Bolt, 2010), Limnoscelis (Berman, Reisz & Scott, 2010), Pantylus 3962 (Romer, 1969; CG78) and Stegotretus (Berman, Eberth & Brinkman, 1988). Judging from the 3963 shape of the vomer, it is also a safe bet in Vieraella (Báez & Basso, 1996). 3964 Unknown in Saxonerpeton (CG78: fig. 21), Micraroter (CG78) and Scincosaurus 3965 (Milner & Ruta, 2009). *Sclerocephalus is polymorphic (Schoch & Witzmann, 2009a: fig. 4). 3966 3967 3968 131. CHO 2: Choana expanded transversely along its medial margin: absent (0); present 3969 (1). We cannot see a difference between the taxa that were scored 1 and most of the ones that 3970 were scored 0. We have therefore tried to define state 1 as a choana that is wide linguolabially 3971 compared to the palatine and any teeth it may bear; there do not seem to be many borderline 3972 cases.

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- We count the absence of a medial wall (as in *Valdotriton*) as state 1.

3973 3974 Platyrhinops (Clack & Milner, 2010) and Bruktererpeton (Boy & Bandel, 1973: 51) 3975 have state 0.

3976 State 1 is found in Colosteus (Hook, 1983), Crassigyrinus (Clack, 1998), Edops 3977 (Romer & Witter, 1942; D. M., pers. obs. of MCZ 1378), Chenoprosopus (Langston, 1953), 3978 Cochleosaurus (Sequeira, 2004), Trimerorhachis (Milner & Schoch, 2013), Balanerpeton 3979 (Milner & Sequeira, 1994), Dendrerpetidae (Godfrey, Fiorillo & Carroll, 1987; Milner, 1996; Holmes, Carroll & Reisz, 1998), Eryops (Sawin 1941), Acheloma (Polley & Reisz, 2011), 3980 3981 Phonerpeton (Dilkes, 1990), Ecolsonia (Berman, Reisz & Eberth, 1985), Broiliellus (even 3982 though the choana is extremely long and therefore looks narrow: Carroll, 1964: fig. 10; 3983 Schoch, 2012: fig. 2F), Micromelerpeton (Boy, 1995; Schoch, 2009b), Albanerpetidae 3984 (Maddin et al., 2013a: PDF version of fig. 5I at 500%), Caerorhachis (Ruta, Milner & Coates, 3985 2002), Eoherpeton (Panchen, 1975; Smithson, 1985), Proterogyrinus (Holmes, 1984), Pholid-3986 erpeton scutigerum (Clack, 1987b), Gephyrostegus (Klembara et al., 2014), Kotlassia (Bula-3987 nov, 2003: fig. 30), Discosauriscus and Seymouria (Klembara et al., 2007; though borderline 3988 in S. baylorensis: Laurin, 2000), Limnoscelis (Berman, Reisz & Scott, 2010), Batropetes 3989 (Glienke, 2013, 2015), Pantylus (CG78), Stegotretus (Berman, Eberth & Brinkman, 1988), 3990 apparently Rhynchonkos (Szostakiwskyj, Pardo & Anderson, 2015), Brachydectes (Wellstead, 3991 1991; Pardo & Anderson, 2016), Diceratosaurus (D. M., pers. obs. of MB.Am.778), Diplo-3992 caulus (Bossy & Milner, 1998), Diploceraspis (Beerbower, 1963), Lethiscus (Pardo et al., 2017), Orobates (Nyakatura et al., 2015: digital reconstruction) and Silvanerpeton (Ruta & 3993 3994 Clack, 2006). Judging from the shape of the vomer, it is also a safe bet in Vieraella (Báez & 3995 Basso, 1996). *Saharastega most likely shared it (Damiani et al., 2006; D. M., pers. obs. of 3996 MNN MOR 73).

3997 Unknown in Pholiderpeton attheyi, where it may have been borderline (Panchen, 1972); further unknown in Saxonerpeton (CG78: fig. 21), Micraroter (CG78) and 3998 3999 Scincosaurus (Milner & Ruta, 2009).

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*Sclerocephalus is polymorphic (Schoch & Witzmann, 2009a: fig. 4).

4002 132. ANT VAC 2: Anterior palatal vacuity present and single (0), present and double (1), 4003 or absent (2) (unordered). RC07 created this character by merging ANT VAC 1 and ANT 4004 VAC 2 of Ruta, Coates & Quicke (2003). We have not ordered this character because no 4005 sequence is obvious. We interpret "vacuity" to mean "fenestra" exclusively; fossae not 4006 pierced by fenestrae are scored as state 2.

- 4007 State 0 or 1 is present in Ventastega (Ahlberg, Lukševičs & Lebedev, 1994).
- 4008 Colosteus (Hook, 1983) and Crassigyrinus (Clack, 1998) have state 1.
- 4009 Not described or illustrated in Whatcheeria (Lombard & Bolt, 1995; Bolt & Lombard, 4010 2000).
- 4011 One specimen of Megalocephalus has state 1, unlike the others that have state 0 (Beaumont, 1977) as previously scored; we have changed the score to polymorphism. 4012
- 4013 Karaurus was scored as possessing state 2 in RC07, but has only been reconstructed 4014 (Ivachnenko, 1978) with a very large, single vacuity, thus state 0; Bruktererpeton shares state 4015 0 (Boy & Bandel, 1973: 51), and apparently so does Vieraella (Báez & Basso, 1996: fig. 5, 4016 7).
- 4017 State 2 is known in Batropetes (Glienke, 2013), Diceratosaurus (D. M., pers. obs. of 4018 MB.Am.778) and Orobates (Nyakatura et al., 2015: digital reconstruction).
- 4019 Lethiscus appears to have state 0 (Pardo et al., 2017; also scored in their matrix).
- 4020 The condition is unknown in Edops (Romer & Witter, 1942; D. M., pers. obs. of MCZ
- 1378 the tip of the snout consists only of plaster), Gephyrostegus (Klembara et al., 2014: 4021

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States 0 and 2 are both known to occur in **Micropholis* (Schoch & Rubidge, 2005).

4025 State 0 was reconstructed for **Liaobatrachus* (*L. zhaoi*: Dong et al., 2013: fig. 7B), 4026 but the photos show that the vacuity, if present, must have been smaller than reconstructed; 4027 because the text does not mention the vacuity at all, we have scored it as unknown.

4028 For **Pholidogaster* we have followed Panchen (1975: 625), who considered state 1 4029 "the most probable" condition. For **Coloraderpeton* we have followed the matrix of Pardo et 4030 al. (2017) in scoring state 0.

4032 133. SUPOCC 1: Caudal exposure of separately ossified supr[...]occipital: absent (0);
4033 present (1). The caudal exposure has to be specified because a suproccipital – or in any case
4034 an ossification of the synotic tectum – can be present and form the roof of the braincase
4035 without being visible from the outside at all (Olson, 1941: 162, fig. 8; Bystrow, 1944;
4036 Berman, Eberth & Brinkman, 1988; Maddin, Reisz & Anderson, 2010; Polley & Reisz, 2011,
4037 and references therein – though some of these cases may represent the suprotic rather than the
4038 suproccipital: compare Grande & Bemis, 1998, and Cubbage & Mabee, 1996).

Damiani et al. (2006) cited Sequeira (1998) for the claim that *Isodectes* has a caudally exposed suproccipital (though not necessarily as a separate bone, and thus not necessarily state 1 of the present character). Not only did Sequeira (1998) not mention or illustrate such an ossification, but her fig. 4B shows a median suture between the exoccipitals dorsal to the foramen magnum, continuous with the median suture between the postparietals, leaving no space for a suproccipital. We have therefore kept the score of 0 for *Isodectes*.

4045 State 0 is apparently present in Dendrerpetidae (Robinson, Ahlberg & Koentges, 2005) 4046 and *Diplocaulus* (Douthitt, 1917).

4047 Bolt (1969: 889) stated explicitly that *Doleserpeton* clearly shows state 0: "There is no 4048 supraoccipital bone, and indeed no room for one, as the opisthotics cover the tops of the 4049 exoccipitals and, in maturer specimens, fuse above the foramen magnum." This is confirmed 4050 by Sigurdsen (2008) and Sigurdsen & Bolt (2010).

4051 *Eocaecilia* shares state 0, as demonstrated by the median dorsal suture in the braincase 4052 (Jenkins, Walsh & Carroll, 2007) – the suproccipital is a single median bone and would make 4053 such a suture impossible. The same holds for *Notobatrachus*, at least in the reconstructions by 4054 Estes & Reig (1973) and Báez & Nicoli (2004), but apparently also in fig. 4 of the latter (a 4055 photograph of a cast of the holotype).

4056 Although *Stegotretus* has a suproccipital (or some other ossification in that area), it 4057 appears not to have been exposed, but completely covered by the postparietals in caudal view 4058 (Berman, Eberth & Brinkman, 1988: 310). This constitutes state 0.

4059 *Euryodus* was scored as unknown in RC07, but we cannot distinguish its condition 4060 from that of *Cardiocephalus* which was scored 0 (both according to CG78); we have assigned 4061 state 0 to both.

Unknown in Eusthenopteron, where the entire braincase is fused (Carroll & Chorn, 4062 4063 1995), Megalocephalus (similarly due to fusion: Beaumont, 1977: 65f.), Phonerpeton (Dilkes, 4064 1990), Eoscopus, where "[b]raincase bones [...] were unossified in all specimens" (Daly, 4065 1994: 8), Platyrhinops (Clack & Milner, 2010), Eoherpeton (Holmes, 1984: fig. 4; Smithson, 1985), Westlothiana, where the bone interpreted as such by Smithson et al. (1994) could just 4066 4067 as well be e.g. a part of the otic capsules (as previously noted by Laurin & Reisz, 1999), and 4068 Lethiscus (Pardo et al., 2017; as already scored) and Phlegethontia (Anderson, 2002), where 4069 the braincase roof is thin but fused.

4070 Panchen (1964) first described state 1 in **Palaeoherpeton*, but later regarded this as 4071 "an artefact of preservation" (Clack & Holmes, 1988: 91). We have scored state 0. 4072

4073 134. EXOCC 2-3-4-5/BASOCC 1-5: Basioccipital not restricting notochord (0); single 4074 occipital cotyle (with or without notochordal funnel) (1); single occipital condyle (with or 4075 without notochordal pit) (2); exoccipital articulating surfaces dorsolateral or lateral to 4076 basioccipital, basioccipital cotyle articulating with interglenoid tubercle (3); 4077 basioccipital not participating in articulation or absent, two exoccipital condyles or flat 4078 surfaces not touching each other (4); two condyles or flat surfaces touching each other, "exoccipital-basioccipital complex" without sutures (5) (stepmatrix). We have merged six 4079 4080 correlated characters (see below for the seventh), each of which had only one of its two states 4081 described; state 1 of each of these characters made state 1 of all five (indeed six) others 4082 impossible. State 0 of the present character is BASOCC 1(0), which was originally called "basioccipital notochordal", an imprecise term; state 5 is a modification of EXOCC 2(1) and 4083 4084 EXOCC 5(1) and occurs in Acheloma (Olson, 1941: fig. 8; Polley & Reisz, 2011), 4085 Phonerpeton (Dilkes, 1990; D. M., pers. obs. of MCZ 2313), Ecolsonia (Berman, Reisz & 4086 Eberth, 1985; D. M., pers. obs. of CM 38017) and Doleserpeton (Sigurdsen, 2008) as well as 4087 *Konzhukovia (with a dorsal incisure that connects to the notochordal pit) and 4088 *Platyoposaurus (Gubin, 1991). See below for Eryops. The stepmatrix for this character is 4089 Appendix-Table 4.

Within state 1, it might be possible to distinguish a closed cotyle from a deep funnel as found in the aïstopods (*Lethiscus*: Pardo et al., 2017; *Oestocephalus*: Carroll, 1998a; *Phlegethontia*: Anderson, 2002, and references therein). We speculate that this distinction may have been the original point of BASOCC 6 (see below). However, incomplete ossification, bad preservation and inadequate illustration would prevent us from scoring almost any other of the OTUs currently scored 1 as having a cotyle or a funnel.

4096 OTUs known to possess an intercotylar tubercle on the atlas (CER VER 4(1), see ch. 4097 253) are scored as having state 1, 3, 4 or 5 of the present character if it is in fact unknown, 4098 because only these four states can occur in that case. The only occurrences of this situation are 4099 *Saxonerpeton* (made explicit by CG78: 34), **Gerobatrachus* (Anderson et al., 2008a) and 4100 **Beiyanerpeton* (Gao & Shubin, 2012: fig. 3).

4101 Because four (and not just one) states can occur together with it, we have not merged 4102 CER VER 4 with the present character. For convenience, however, we have ignored the fact 4103 that CER VER 4(0) makes state 3 of the present character impossible (a partial uncertainty of 4104 five states is probably more trouble than it is worth, and the two states in question occur in 4105 separate areas of the tree).

4106 State 1 is present in Dendrerpetidae (Robinson, Ahlberg & Koentges, 2005). It also 4107 appears to occur in *Ariekanerpeton* (Klembara & Ruta, 2005a) and probably *Utegenia* 4108 (Klembara & Ruta, 2004a); the same seems to hold for *Discosauriscus*, where the poorly 4109 ossified basioccipital is a caudally flat plate, but the exoccipitals appear to participate in the 4110 cotyle (Klembara, 2007).

4111 The taphonomically crushed *Tseajaia* appears to possess state 2, as far as we can tell 4112 from Moss (1972).

We have also assigned state 2 to *Captorhinus* because it has a condyle, even though no sutures can be traced in its "exoccipital-basioccipital complex", and to *Orobates*, even though the notochordal pit, though shallow, is large and even though the digital reconstruction by Nyakatura et al. (2015) does not show sutures (generally) and does not compensate for all deformation and disarticulation.

Hapsidopareion and **Llistrofus* (CG78: 27, 28; Bolt & Rieppel, 2009) are borderline
between states 3 and 4, but we have stayed conservative and assigned state 3 to both because
the basioccipital does seem to have participated in the articulation.

4126 State 4 is found in *Batropetes* (Carroll, 1991: fig. 5; Glienke, 2013: fig. 4, showing a
4127 ventral suture between the exoccipitals) and *Diceratosaurus* (D. M., pers. obs. of CM 72608).
4128 Outside the original taxon sample, it is standard in lissamphibians and also occurs in most
4129 *stereospondylomorph temnospondyls.

4130 Asaphestera has a unique state (D. M., pers. obs. of NMC 10041 with J. Anderson). The drawing of the same specimen in CG78 (fig. 6E) is accurate as a two-dimensional 4131 4132 projection in strict caudal view. In other words, state 3 (which RC07 had scored) is not reached: on its ventral side, the basioccipital sends a prong far caudal, while the dorsal side is 4133 4134 flat until very far rostral, where it curves dorsally. To articulate with this latter surface, an 4135 interglenoid tubercle would have had to be much longer than known in any other vertebrates; 4136 realistically, only the dorsal surface of the prong could have articulated with the ventral side -4137 not the rostral end - of such a tubercle on the atlas. We have scored state 4: although the 4138 basioccipital is present and bears the mentioned large caudal process, it does not participate in 4139 an articular surface together with the widely spaced exoccipitals.

4140 *Eryops* appears to be quite variable and generally transitional. A dorsoventrally 4141 compressed, bilobed version of state 1, with a median constriction, is known to occur (Sawin, 4142 1941; D. M., pers. obs. of the large skull TMM 40349-20 and the smaller skull MCZ 2766); however, TMM 31226-12 and MCZ 1129 have state 4, AMNH 23529 has state 5 (unless it 4143 can be interpreted as having state 2 with a very large notochordal pit), AMNH 4673 has state 4144 4145 5 bordering on 4, the partially encrusted AMNH 4180 most likely has state 4 or 5, as does 4146 AMNH 4186, AMNH 4183 has 5 or possibly 1, and the uncatalogued USNM specimens "Texas '84 #40" and "Texas '86 #77" have or come close to states 4 and/or 5 (all pers. obs. 4147 4148 by D. M.). It should be investigated whether all these skulls should continue to be referred to 4149 the same species. Unfortunately we have not been able to rigorously examine whether this 4150 variation correlates with the neat division into a narrow-headed and a broad-headed morph 4151 (Werneburg, 2007b; Schoch & Milner, 2014; D. M., pers. obs. of USNM, TMM, AMNH and MCZ specimens), although there is currently no reason to think it does: for example, AMNH 4152 4153 4673, AMNH 4180 and AMNH 4183 are narrow-headed, while the enormous AMNH 4186 is 4154 broad-headed. Incomplete ossification and difficult preservation (such as the common 4155 presence of an ironstone crust) contribute to the confusion; unfortunately, this is the case for 4156 the type specimen of the type and possibly only species E. megacephalus, the narrow-headed 4157 AMNH 4189, which could have any of the three states in question (D. M., pers. obs.). For the 4158 time being, we have scored *Ervops* as possessing all three states: 1, 4 and 5.

Entirely unknown in *Baphetes* (Beaumont, 1977), apparently *Amphibamus* (Watson, 1940; Carroll, 1964; Daly, 1994), *Caerorhachis* (Ruta, Milner & Coates, 2002) and *Hyloplesion* (CG78). Contrary to Carroll (1970: 274, fig. 5), Klembara et al. (2014: 787–788) have further argued that the entire braincase is unknown in *Gephyrostegus*.

- 4163 *Cochleosaurus* has state 1 or 3 (Sequeira, 2004).
- 4164

4 *Platyrhinops* appears to have state 4 or 5 (Clack & Milner, 2010).

4165 *Diadectes* may be said to change from state 1 to state 2 in ontogeny. In AMNH 4839 4166 (D. M., pers. obs.), the convexity that defines state 2 is hard to find, only what must be the in-4167 completely ossified exoccipitals are slightly convex in lateral view; the articulation as a whole 4168 may be interpreted as state 2 with a giant conical notochordal pit that takes almost all the 4169 convexity away. This interpretation is confirmed by the considerably larger specimen AMNH 4170 4352 (D. M., pers. obs.), in which the notochordal pit is considerably smaller and surrounded
4171 by a thick convex rim. We have thus kept state 2 for *Diadectes*.

The preservation of *Limnoscelis* (Berman, Reisz & Scott, 2010: fig. 10, 12) is insufficient to distinguish states 1, 2, 3 and 5. We have scored partial uncertainty. Interestingly, Berman, Reisz & Scott (2010: fig. 4) reconstructed a condition intermediate between all four of those states – a flat plate with the notochordal pit that is visible in the specimen (fig. 10, 12).

4177 *Odonterpeton* has state 1 or 3; CG78 (145) suggested that it has 2, but that is almost 4178 certainly incorrect – the most evident candidate for a median condyle is simply the anatomi-4179 cally left rim of the cotyle, against which the vertebral column has slipped to the right (D. M., 4180 pers. obs. of USNM 4465+4467). The other candidate consists of two tiny grains that are 4181 probably not part of a condyle. – As mentioned above, fig. 99A of CG78 is idealized and 4182 simplified to the extent of being unreliable.

We have scored *Ptyonius*, *Sauropleura* and *Urocordylus* as possessing state 1 or 3 based on Bossy & Milner (1998: 86, 91). Bossy & Milner (1998: 91) appear to rule out state 4 shortly after mentioning that the median part of the cranial face of the atlas centrum can be "somewhat protruding" in some or all of these taxa; probably this only means that the interglenoid tubercle (see CER VER 4) cannot be as large as it often is in "microsaurs" – it is quite small in many lissamphibians and in the "microsaur" *Odonterpeton* (see CER VER 4 below).

4190

Silvanerpeton has state 0 or 1 (Ruta & Clack, 2006).

4191State 1 is almost certain in *Nigerpeton (D. M., pers. obs. of MNN MOR 69 and MNN4192MOR 70).

4193 **Iberospondylus* appears to have the version of state 1 sometimes seen in *Eryops* (D.
4194 M., pers. obs. of PU-ANF 15 with Rodrigo Soler-Gijón).

4195 **Utaherpeton*, which has lateral facets for the exoccipitals on the basioccipital, is 4196 scored 1 or 3 because Carroll, Bybee & Tidwell (1991) did not explicitly argue against the 4197 version of state 2 sometimes seen in *Eryops*.

4198 *Sparodus appears to have states 3 or 4 (Carroll, 1988: fig. 1A), although a suture
4199 between the possible occipital condyles and the postparietals cannot be determined (D. M.,
4200 pers. obs. of NHMW 1899/0003/0006).

We have assigned states 3, 4 or 5 to **Acanthostomatops* because its basioccipital was
probably small, judging from the size of the facet for it on the parasphenoid (Witzmann &
Schoch, 2006a).

4204 The CT scans of *Carrolla (only known specimen: TMM 40031-54) by Maddin, Olori & Anderson (2011) seem to only distinguish finished bone surfaces from everything else, and 4205 4206 not to distinguish spongy bone from the matrix. Thus, the figures of Maddin, Olori & 4207 Anderson (2011), including the reconstruction (fig. 7B), fail to show some bone that is clearly present. This includes unfinished bone between the finished lateral extremities of the occipital 4208 4209 articulation (D. M., pers. obs. of TMM 40031-54). As there is no interruption in the almost 4210 flat unfinished surface of this articulation, while there is a strong median constriction, the 4211 state shown by the only known specimen of *Carrolla is best called 5, making *Carrolla the 4212 only non-temnospondyl in this matrix to possess this state. However, it is entirely possible 4213 that further ossification would have transformed this into state 4. We have scored this as 4214 partial uncertainty. The strong constriction makes it unlikely that state 3 (expected for a "microsaur") would have developed. 4215

4216

4217 For Analysis EB, this character was split as follows:

4218 BASOCC 1-5: Occipital articulation absent (unrestricted notochord) (0); concave 4219 (occipital cotyle) (1); convex (occipital condyle) (2) (ordered). These states correspond to 4220 states 0, 1+3 and 2+3+4+5 of the merged character, respectively; state 3 of the merged 4221 character is scored as partial uncertainty of the present one.

4222 EXOCC 2-3-5: Occipital articulation single (0); bilobed (1); double (2) (ordered). These 4223 states correspond to states 1+2, 3+5 and 3+4 of the merged character, respectively. The 4224 present character is inapplicable to OTUs with state 0 of the preceding and thus the merged 4225 character; state 3 of the merged character is scored as partial uncertainty of the present one.

4226 EXOCC 4: **Basioccipital participates in articulation: yes (0); no (1).** Only applicable to 4227 double occipital articulations, so that the states correspond to states 3 and 4 of the merged 4228 character.

4229

4230 deleted BASOCC 6: Articulation surface of the basioccipital circular and recessed: 4231 absent (0); present (1). This character was originally explained as follows: "In aïstopods and adelospondyls, the basioccipital has a circular outline and carries a funnel-like excavation." 4232 4233 Specifically, state 1 was assigned to Oestocephalus, Phlegethontia and Adelogyrinus; the 4234 other aïstopods and adelospondyls were (correctly) scored as unknown. However, Oestocephalus and Phlegethontia (with the possible exception of one specimen: Anderson, 4235 4236 2002) lack sutures in the braincase, making it impossible to determine which bones make up 4237 their circular occipital cotyle; they have to be scored as unknown as well. (The same holds for Lethiscus, which was already scored as unknown: Pardo et al., 2017.) This leaves state 1 to 4238 4239 Adelogyrinus alone (if that, given the damage mentioned by Andrews & Carroll, 1991: 250), 4240 rendering the character parsimony-uninformative. We have accordingly deleted it.

4241

4242 Appendix-Table 4: Stepmatrix for character 134 (EXOCC 2-3-4-5/BASOCC 1-5). 4243

from \downarrow to \rightarrow	0	1	2	3	4	5	
0	0	1	2	2	3	3	
1	1	0	1	1	2	2	
2	2	1	0	2	2	1	
3	2	1	2	0	1	2	
4	3	2	2	1	0	1	
5	3	2	1	2	1	0	

4244

4245

4246 135. OPI 2, POSPAR 5: Exoccipitals contact postparietals or parietals (0); opisthotics
4247 and/or suproccipital separating exoccipitals from postparietals or parietals (1); separate
4248 opisthotics absent (2) (unordered). No sequence for ordering suggests itself.

4249 OPI 2 was originally worded "Opisthotic[s] forming a thickened plate together with 4250 the supraoccipital, preventing the exoccipitals from contacting the skull table: absent (0); 4251 present (1)" in RC07: 102, but whether a "plate" is present depends on PTF 1, and the 4252 presence of the suproccipital is already another character (SUPOCC 1), so, in order to avoid 4253 redundancy, it should not be mentioned here.

4254 POSPAR 5 was worded "Postparietal/exoccipital suture: absent (0); present (1)" in 4255 RC07:96. This was not applicable to taxa without postparietals (POSPAR 1-2(2)), but other-4256 wise identical to OPI 2 with inverted state numbers: when the postparietals contact the exoc-4257 cipitals (POSPAR 5(1)), OPI 2(1) is impossible, and when they do not (POSPAR 5(1)), OPI 4258 2(1) is unavoidable – once the "thickened plate" and the suproccipital are removed from consideration – because nothing other than the opisthotics and/or the suproccipital ever intervenes 4260 between the postparietals (or parietals when postparietals are absent) and the exoccipitals.

4261 Merging the present character with SUPOCC 1 is not an option, because *Archeria* 4262 (which was correctly scored as having state OPI 2(1), POSPAR 5(0)) possesses huge 4263 opisthotics that separate the postparietals from the exoccipitals, but there is just a narrow
4264 unossified slit where a cartilaginous suproccipital may have been (Holmes, 1989: fig. 10A),
4265 showing that SUPOCC 1(0) and OPI 2, POSPAR 5(1) can occur together.

4266 State 2 is new and accounts for taxa in which the opisthotics are absent or fused to the exoccipitals, including of course those with completely fused otoccipital parts of the 4267 4268 braincase. These are Eusthenopteron (Carroll & Chorn, 1995), Ichthyostega (reconstruction 4269 drawing and photo in Jarvik, 1996, assuming the coarse-grained photo which does not show 4270 any sutures can be taken at face value; also suggested by Clack et al., 2003: fig. 3a, c; not 4271 mentioned or illustrated by Clack & Milner, 2015), Albanerpetidae (Maddin et al., 2013a), 4272 Eocaecilia, Valdotriton, Lethiscus (Pardo et al., 2017), Oestocephalus, Phlegethontia, and Notobatrachus (Estes & Reig, 1973; Báez & Nicoli, 2004, did not mention opisthotics, but 4273 4274 mentioned that the exoccipitals usually fuse to the prootics in adults, which implies there were no opisthotics in between) as well as *Liaobatrachus, *Carrolla and *Chelotriton; state 0 or 2 4275 4276 occurs in Odonterpeton (CG78: 145f.), *Sclerocephalus and *Australerpeton.

4277 State 0 occurs in *Chenoprosopus* (Hook, 1993), Dendrerpetidae (Robinson, Ahlberg & 4278 Koentges, 2005), *Pelodosotis* (CG78: fig. 48), apparently *Hyloplesion* (CG78: 137), 4279 *Batrachiderpeton* if the opisthotic is correctly identified (Bossy & Milner, 1998: fig. 57B) and 4280 *Ariekanerpeton* (made explicit by Klembara & Ruta, 2005a) as well as **Lydekkerina* 4281 (Hewison, 2007: 26–27).

4282 *Greererpeton* was reconstructed as having state 0 by Smithson (1982) based on 4283 crushed specimens; less crushed ones have revealed state 1 (Bolt & Lombard, 2001: 1041; 4284 Clack, 2003). State 1 is also present in *Acanthostega* and *Whatcheeria* according to the latter 4285 paper.

Eoherpeton was scored in RC07 as POSPAR 5(?) (presence of exoccipital/postparietal suture unknown), but OPI 2(1). The latter is correct, except that the presence of a suproccipital cannot be ascertained (Smithson, 1985: 338; already correctly scored as SUPOCC 1(?)); we have therefore scored state 1 of the present character.

We have assigned state 1 to *Batropetes*: although the exoccipitals and the opisthotics fuse dorsally, the suture persists ventrally, and in caudal or dorsal view it seems that the exoccipitals are growing around the foramen magnum much as in later ontogenetic stages of *Acheloma* (Maddin, Reisz & Anderson, 2010).

4294 State 1 also occurs in *Brachydectes* (Pardo & Anderson, 2016) and *Tseajaia* (Moss, 4295 1972).

4296 *Ptyonius* appears to have state 0 or 1 on account of having separate opisthotics (Bossy
4297 & Milner, 1998: 86). The same appears to hold for **Palaeoherpeton* (compare Panchen,
4298 1964: fig. 2, to Clack & Holmes, 1988: 91, fig. 1).

We have scored *Doleserpeton* as possessing state 0 or 2. The postparietals have tall occipital flanges that overlie the opisthotics caudally and reach the exoccipitals (Sigurdsen & Bolt, 2010; Sigurdsen & Green, 2011), corresponding to state 0; however, in the most mature specimens, the dorsal parts of the exoccipitals fuse to the opisthotics (Sigurdsen, 2008; Sigurdsen & Bolt, 2010), raising the question if *Doleserpeton* should be considered to have state 2.

Perhaps similarly, *Diplocaulus* is illustrated as having state 2 by Bossy & Milner (1998: fig. 57C), but Beerbower (1963: 59) reports that "[a]lthough Douthitt reports the exoccipital and opisthotic as fused in *Diplocaulus*, sutures can be distinguished in many specimens of that genus", frustratingly not mentioning if there are any in which fusion can be ascertained. We have scored *Diplocaulus* as having state 0 or 2.

4310 Unknown in *Proterogyrinus* (Holmes, 1984: fig. 4) and *Pederpes* (Clack & Finney, 4311 2005).

4312

4313 136. PASPHE 1: Cultriform process gradually tapering to a rostral point (0) or parallel4314 sided along most of its length (1). This is a rewording of the original name of this character
4315 and its explanation; the process cannot help being "elongate", because taxa where it does not
4316 reach the vomers are not included in this matrix. State 1 includes cases where the process is
4317 biconcave, wider at its rostral end than in the middle.

4318 Ventastega (Ahlberg, Lukševičs & Lebedev, 1994), Doleserpeton (Sigurdsen & Bolt,
4319 2010), Solenodonsaurus (Danto, Witzmann & Müller, 2012) and Lethiscus (Anderson, Carroll
4320 & Rowe, 2003) have state 0. State 0 is also found in Leptorophus tener (Schoch & Milner,
4321 2008); L. raischi does have state 1 (Schoch, 2014a) as scored in RC07, but because it is only
4322 known from skeletally less mature (and smaller) specimens than L. tener, we have scored
4323 Leptorophus as having state 0.

4324 Ruta, Coates & Quicke (2003) and Ruta & Coates (2007) scored all PASPHE characters of Phlegethontia as unknown (even PASPHE 11, which does not depend on the 4325 4326 presence of the parasphenoid). Anderson (2002), however, maintained that the parasphenoid, 4327 although indistinguishably fused to the endochondral braincase, is present in *Phlegethontia*: in particular, there is a cultriform process (Anderson, 2002: fig. 4.2, 4.3, 8.2). Ruta, Coates & 4328 4329 Quicke (2003) cited Anderson (2002 - as "in press") as their source for several scores of 4330 Phlegethontia, but did not cite it in any context involving the parasphenoid. We have therefore scored those few parasphenoid characters that do not depend on where the 4331 4332 boundaries of the basal plate were. (Comparison to other aïstopods - Pardo et al., 2017 -4333 suggests that the basal plate was much smaller than expected.) For the present character, 4334 Phlegethontia has state 0.

4335 State 1 is present in *Greererpeton* (Smithson, 1982; D. M., pers. obs. of TMM 415744336 1), *Karaurus* (biconcave: Ivachnenko, 1978: fig. 1b!), *Triadobatrachus* (Roček, 2000;
4337 Ascarrunz et al., 2016), *Valdotriton* (Evans & Milner, 1996), *Hyloplesion* (Olori, 2015: fig.
4338 30A, table S3) and arguably *Notobatrachus* (Báez & Nicoli, 2004); **Liaobatrachus* has state
4339 0, however (Dong et al., 2013).

4340 *Microbrachis* is somewhat borderline (Olori, 2015: fig. 10); following the 4341 recommendation of Olori (2015: 56), we have scored state 0.

4342Not described or illustrated in *Whatcheeria* (Lombard & Bolt, 1995; Bolt & Lombard,43432000); unclear in *Hapsidopareion* (CG78: fig. 13A, 14E; Bolt & Rieppel, 2009: 475).

Given the state of preservation of **Quasicaecilia* (Pardo, Szostakiwskyj & Anderson, 2015: fig. 2, 4), we have scored this character as unknown rather than going with the reconstruction (fig. 3, which shows state 0 without indicating any uncertainty) or the statement on p. 12 that the process is "parallel-sided".

4348

137. PASPHE 2-12: Base of cultriform process and area between basipterygoid
processes: no ridges (0); rostromedian-to-caudolateral ridges forming a V (1); state 1
plus a caudal ridge, together delimiting a raised triangular area (2) (ordered). State 1 is
the "anterior wedge-like process" of Klembara & Ruta (2004a), which can hardly be called a
process. It occurs in several seymouriamorphs, but so does state 2 contrary to the scoring of
RC07.

4355 States 1 and 2 cannot be distinguished when the median depression (PASPHE 6(1)) is
4356 too large. This is the case in several taxa that (contrary to the scoring of RC07) clearly do not
4357 have state 0, namely *Proterogyrinus* (Holmes, 1984), *Archeria* (Clack & Holmes, 1988),
4358 *Pholiderpeton scutigerum* (Clack, 1987b) and *Limnoscelis* (Berman, Reisz & Scott, 2010),
4359 and also in **Chroniosaurus* (Clack & Klembara, 2009).

The raised area in state 2 usually bears denticles, and usually the rest of the parasphenoid is then toothless. *Limnoscelis* is an exception where the raised area is rough but apparently toothless (Berman, Reisz & Scott, 2010), and in *Utegenia* the area is almost 4363 toothless while the cultriform process is (otherwise) densely denticulated (Klembara & Ruta, 4364 2004a: fig. 10, 14). RC07 treated the raised area and its dentition as a single character (which 4365 may be the reason why they gave our state 1 to Utegenia); these are clearly two independent characters, so we have excluded the dentition from consideration. We have, somewhat 4366 4367 similarly, assigned state 2 to Trimerorhachis where it is not known if a denticle field was 4368 present (Milner & Schoch, 2013: 107, fig. 1D), and to *Glanochthon, where a well-defined 4369 triangular denticle field was lost in ontogeny but a well-defined raised area which we count as triangular persisted in adults (Schoch & Witzmann, 2009b: 126, fig. 4C, D). Further, we 4370 4371 assign state 2 to Balanerpeton (Milner & Sequeira, 1994: fig. 1A).

4372 State 0 is present in *Ventastega* (Ahlberg et al., 2008), apparently *Ecolsonia* (D. M.,
4373 pers. obs. of CM 38017), *Eocaecilia* (Jenkins, Walsh & Carroll, 2007), *Solenodonsaurus*4374 (Danto, Witzmann & Müller, 2012), seemingly *Kotlassia* (Bulanov, 2003: S54, fig. 30),
4375 *Diceratosaurus* (D. M., pers. obs. of several CM specimens), *Lethiscus* (Pardo et al., 2017),
4376 *Phlegethontia* (Anderson, 2002: fig. 4.2), *Microphon* (Bulanov, 2003) and *Tseajaia* (Moss,
4377 1972).

4378 Schoch & Milner (2014: fig. 30) reconstructed a condition for *Amphibamus* that may
4379 count as state 2, but we count the condition in the most mature known specimen (Daly, 1994:
4380 fig. 21 right side) as state 1. State 1 is furthermore found in *Caerorhachis* (Ruta, Milner &
4381 Coates, 2002), *Pholiderpeton attheyi* (Panchen, 1972) and *Gephyrostegus* (Klembara et al.,
4382 2014).

4383 State 2 is not limited to temnospondyls. Apart from *Utegenia*, it makes surprise 4384 appearances in *Pelodosotis* (CG78: fig. 48) and *Rhynchonkos* (Szostakiwskyj, Pardo & 4385 Anderson, 2015) and shows up in later ontogenetic stages of *Discosauriscus* (Klembara et al., 4386 2006) as well as its fellow seymouriamorphs **Karpinskiosaurus* (Klembara, 2011) and 4387 ***Biarmica* (Bulanov, 2003).

Using a generous interpretation, we have assigned state 2 to **Acanthostomatops*; some specimens fit even under a strict one (Witzmann & Schoch, 2006a). State 2 is also seen in **Platyoposaurus*: although the area is not triangular, all three ridges are present (Eltink et al., 2016: fig. 12B).

4392 4393 Unknown in Colosteus (Hook, 1983: 16) and Anthracosaurus (Panchen, 1977: 469).

4394 138. PASPHE 3: Parasphenoid without (0) or with (1) a pair of posterolaterally
4395 orientated, ventral thickenings (ridges ending in basal tubera). This character is only
4396 applicable to OTUs whose parasphenoids are long enough caudally, i.e. those that have or
4397 may have PASPHE 9(2).

Greererpeton has state 1 (Smithson, 1982; D. M., pers. obs. of TMM 41574-1). So do
the largest specimens of *Acheloma* (Olson, 1941; Maddin, Reisz & Anderson, 2010), making
the scores of many other temnospondyls suspect. Indeed, MNN MOR 70 appears to have state
1, and so might MNN MOR 69 (D. M., pers. obs.); we have scored state 1 for **Nigerpeton*.
State 1 further makes a surprise appearance in **Liaobatrachus* (Dong et al., 2013: fig. 6B).

State 0 is known in Albanerpetidae (Estes & Hoffstetter, 1976; Maddin et al., 2013a).
In *Asaphestera*, a partial parasphenoid is preserved in NMC 10041 (D. M., pers. obs. with J.
Anderson) and seems to show state 0 as well.

4406 We have assigned state 1 to *Gephyrostegus*, which has very pronounced ridges, 4407 although they fade into flat, short triangular processes caudally and basal tubera are absent 4408 (Klembara et al., 2014).

4409 Inapplicable to *Phlegethontia* (as already scored), where there is no space for such 4410 ridges (Anderson, 2002: fig. 4.2, 4.3).

4411 The drawings and even the photos by Moss (1972) are not three-dimensional enough 4412 to show which state *Tseajaia* has, and the text does not mention it; in CM 38033 (D. M., pers.

obs.), most of the palate is covered by the lower jaws, matrix, and miscellaneous fragments; 4413 4414 we have therefore scored *Tseajaia* as unknown.

4415 The basal tubera are apparently unknown in *Archegosaurus, but the ridges are there 4416 (Witzmann, 2006).

4417 Incompletely ossified (Maddin, Reisz & Anderson, 2010) but present in 4418 *Erpetosaurus (Milner & Sequeira, 2011: fig. 2C).

4419

4420 139. PASPHE 4: Parasphenoid without elongate, broad posterolateral processes (0), or 4421 with processes that are less than (1), or at least half as wide as (2) the parasphenoid plate (ordered). We have ordered this character because it is continuous. This character is only 4422 4423 applicable to OTUs whose parasphenoids are long enough caudally, i.e. those that have or 4424 may have PASPHE 9(2). It is further inapplicable in taxa where the fenestrae ovales/vestibuli 4425 are (proportionally) too large to allow anything other than state 0, like Albanerpetidae (Estes 4426 & Hoffstetter, 1976; Maddin et al., 2013a; already scored as unknown), Triadobatrachus 4427 (where, in addition, the margins of the putative fenestra ovalis are unossified: Ascarrunz et al., 4428 2016) or Hyloplesion (CG78: fig. 89E, H); similarly, there is no space for processes in 4429 Eocaecilia (Jenkins, Walsh & Carroll, 2007).

4430

State 0 occurs in *Batropetes* (Glienke, 2013, 2015).

4431 State 1 is found in Greererpeton (D. M., pers. obs. of TMM 41574-1), Edops (D. M., 4432 pers. obs. of USNM 23309), apparently Cochleosaurus (Sequeira, 2004), Balanerpeton (Milner & Sequeira, 1994), Dendrerpetidae (Robinson, Ahlberg & Koentges, 2005), Eryops 4433 4434 (Sawin, 1941: pl. 2, 8), Acheloma (Olson, 1941; Maddin, Reisz & Anderson, 2010), Broiliellus (Schoch, 2012: fig. 2F), Gephyrostegus (Klembara et al., 2014), *Nigerpeton (D. 4435 M., pers. obs. of MNN MOR 69 and MNN MOR 70), *Platyoposaurus (Eltink et al., 2016: 4436 fig. 12B) and *Australerpeton (Eltink et al., 2016: fig. 9A). 4437

Microbrachis has state 2 (Vallin & Laurin, 2004: fig. 4A; Olori, 2015: fig. 12A).

4439 The state is apparently unknown in Megalocephalus (Beaumont 1977: 63), Ecolsonia 4440 (Berman, Reisz & Eberth, 1985: fig. 6) and Hapsidopareion (CG78: fig. 13A); it has also not 4441 been described or illustrated in Whatcheeria (Lombard & Bolt, 1995; Bolt & Lombard, 2000).

*Erpetosaurus seems to just reach state 2 (Milner & Sequeira, 2011: fig. 2, 5).

4442 4443

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4444 140. PASPHE 6: Parasphenoid without (0) or with (1) single median depression. Clack et 4445 al. (2016) merged this character with the following one (as their ch. 77), and indeed no taxon 4446 in our matrix is known to have state 1 of both; it is not clear to us whether such a condition is 4447 impossible, however, or whether paired lateral depressions can form by subdivision of a 4448 median one (or vice versa), so we prefer to keep these characters separate for now.

4449 Albanerpetidae has state 0 (Estes & Hoffstetter, 1976; Maddin et al., 2013a), as do Solenodonsaurus (Danto, Witzmann & Müller, 2012), Lethiscus (Pardo et al., 2017) and 4450 4451 apparently Phlegethontia (Anderson, 2002: fig. 4.2).

4452 State 1 is known in Broiliellus (Schoch, 2012: fig. 2F), most likely Gephyrostegus 4453 (Klembara et al., 2014), Seymouria (Laurin, 1996a, 2000) and Limnoscelis (Berman & Sumi-4454 da, 1990) as well as *Platvoposaurus (Eltink et al., 2016: fig. 12B) and apparently *Coloraderpeton (Pardo et al., 2017: video). 4455

4456 Inapplicable to Acanthostega, where the parasphenoid is not long enough (Porro, 4457 Rayfield & Clack, 2015); not described or illustrated in Whatcheeria (Lombard & Bolt, 1995; 4458 Bolt & Lombard, 2000).

4459

We have scored state 0 for *Diploradus after Clack et al. (2016: matrix). 4460

4461 141. PASPHE 7: Parasphenoid without (0) or with (1) paired lateral depressions. 4462 Cochleosaurus has state 0 (Sequeira, 2004). So do Albanerpetidae (Estes & 4463 Hoffstetter, 1976; Maddin et al., 2013a), Gephyrostegus (Klembara et al., 2014), Solenodonsaurus (Danto, Witzmann & Müller, 2012) and Lethiscus (Pardo et al., 2017). 4464 4465

State 1 makes a surprise appearance in *Liaobatrachus (Dong et al., 2013: fig. 6B).

4466 Inapplicable to Acanthostega, where the parasphenoid is not long enough (Porro,

4467 Rayfield & Clack, 2015); not described or illustrated in Whatcheeria (Lombard & Bolt, 1995; 4468 Bolt & Lombard, 2000).

4469 4470 We have scored state 0 for *Diploradus after Clack et al. (2016: matrix).

4471 142. PASPHE 9: Intracranial joint (0); ventral cranial suture visible in ventral view, caudal margin of parasphenoid lying rostral to or at it (1); parasphenoid extending 4472 4473 caudal to suture (2) (ordered). We have reworded this character to make clear what state 2, 4474 originally "Ventral cranial fissure [...] not traceable", means in practice - fusion of the 4475 basisphenoid and the basioccipital is rare, and when it occurs, it is hardly ever determinable in 4476 a fossil (except by tomography), let alone described or illustrated, but the caudal extent of the 4477 parasphenoid is fairly readily observable (except in *Phlegethontia*, which we have kept as 4478 unknown even though no trace remains of any cranial fissure). Because the states of this 4479 character form a sequence of progressively firmer immobilization of the ventral cranial fissure 4480 (which forms part of a joint in Eusthenopteron and Panderichthys), we have ordered the 4481 character.

4482 Ventastega (Ahlberg et al., 2008), Ichthyostega (Clack, 2000) and Lethiscus (Pardo et 4483 al., 2017) show state 1; although apparently not sutured, the fissure of *Lethiscus* is not a joint, 4484 so we have not scored state 0.

The suture between basisphenoid and basioccipital is still partially exposed in the 4485 4486 smallest specimen of Acheloma shown by Maddin, Reisz & Anderson (2010: fig. 4, 5), as 4487 well as in one of the largest ones (fig. 4). In those specimens the parasphenoid only covers the median third of the suture; the parasphenoid completely overgrows it in some but not all of 4488 4489 the largest specimens (fig. 4, 5). Nonetheless, the definition of state 2 is fulfilled, so we have 4490 kept the score of 2.

4491 The braincase is probably altogether unknown in Gephyrostegus (Klembara et al., 4492 2014).

4493 Diadectes is polymorphic, having states 1 and 2 (Moss, 1972), with only state 1 being 4494 documented in D. absitus (Berman, Sumida & Martens, 1998). 4495

Limnoscelis has state 1 or 2 (Berman, Reisz & Scott, 2010: fig. 4A, 10).

4496 Asaphestera (D. M., pers. obs. of NMC 10041 with J. Anderson) and Pelodosotis 4497 (CG78: fig. 48) have state 2.

4498 Unknown in Adelospondylus; Adelogyrinus appears to have state 1 or 2 (Andrews & 4499 Carroll, 1991).

4500 Pederpes was scored 1 in RC07, but may just as well have had state 0, because the 4501 basioccipital is not preserved (Clack & Finney, 2005); we have accordingly scored partial 4502 uncertainty.

4503 Tseajaia has state 1 (Moss, 1972: fig. 2, 4A, 15B; pl. 4; and various allusions in the 4504 text).

4505 We have scored state 1 for *Pseudophlegethontia: a line that may be the ventral cranial suture is visible between the two caudal processes of the parasphenoid (Anderson, 4506 4507 2003b: fig. 2A), much like in *Coloraderpeton (Pardo et al., 2017), and in any case the gap 4508 between these two processes extends very far rostral. 4509

4510 143. PASPHE 11: Basipterygoid processes of the basisphenoid shaped like anterolaterally directed stalks, subtriangular to rectangular in ventral view and 4511

projecting anterior to the insertion of the cultriform process: absent (0); present (1). This is one of the more unnerving characters: state 1 is a carefully explained combination of

states of two characters (shape and orientation of basipterygoid processes) which may or may
not correlate – no demonstration of this was attempted by RC07 or Ruta, Coates & Quicke
(2003) –, and state 0 comprises everything else, potentially a large number of distinguishable
states. More attention will have to be paid to the present character (and to its conditions of
applicability) in the future.

4519 Naturally, the basisphenoid is seldom observable; in such cases we have resorted to 4520 the parasphenoid (to which the basisphenoid very often fuses indistinguishably).

4521 *Microbrachis* shows state 1 (Olori, 2015: fig. 12A), as apparently does the larger 4522 *Hapsidopareion* individual illustrated by CG78 (fig. 14E). Very mild cases are present in 4523 *Platyrhinops* (Clack & Milner, 2010) and *Batropetes* (Glienke, 2013, 2015); we have scored 4524 these as state 1 in order to retain this score for *Doleserpeton* (see Sigurdsen & Bolt, 2010: fig. 4525 4) and especially *Karaurus*, which barely counts at best (Ivachnenko, 1978: fig. 1b).

4526 State 0 is present in *Ventastega* (Ahlberg et al., 2008), Albanerpetidae (Maddin et al., 4527 2013a), *Lethiscus* (Pardo et al., 2017) and *Phlegethontia* (Anderson, 2002).

4528 Thoroughly obscured by crushing, breakage and the large fenestrae ovales in 4529 *Triadobatrachus* (Ascarrunz et al., 2016: 3D model 1).

Danto, Witzmann & Müller (2012) scored *Solenodonsaurus* as having state 0, while noting in the text that the basipterygoid processes and indeed the basisphenoid as a whole are not preserved; likewise, the pertinent parts of the parasphenoid are unknown (Danto, Witzmann & Müller, 2012: fig. 8A). Clearly, the correct score is unknown (unchanged from RC07). It is likewise unknown in *Scincosaurus* (Milner & Ruta, 2009) and inapplicable to *Brachydectes* (Pardo & Anderson, 2016).

4536

Micraroter and Cardiocephalus are both polymorphic (CG78: fig. 30, 52, 55).

4537 A very wide version of state 1 is found in **Liaobatrachus zhaoi* (Dong et al., 2013: 4538 fig. 6B – differing greatly from the reconstruction in fig. 7B); **L. macilentus* (fig. 5B), 4539 however, has a different shape, so we have scored polymorphism.

**Palaeoherpeton* appears to have a mild case of state 1 (Panchen, 1964: fig. 13).

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4513

4542 144. PASPHE 13: Parasphenoid much wider than long immediately posterior to level of
4543 basal articulation: absent (0); present (1).

4544 State 0 is found in *Ventastega* (Ahlberg et al., 2008), *Platyrhinops* (Clack & Milner, 4545 2010), *Gephyrostegus* (Klembara et al., 2014) and *Lethiscus* (Anderson, Carroll & Rowe, 4546 2003; Pardo et al., 2017).

Acheloma (Polley & Reisz, 2011) and Albanerpetidae (Estes & Hoffstetter, 1976;
Maddin et al., 2013a) have state 1. **Nigerpeton* very clearly shares it (D. M., pers. obs. of
MNN MOR 69 and MNN MOR 70).

4550 Not applicable to *Phlegethontia* (as already scored in RC07; Anderson, 2002: fig. 4.2,
4551 4.3), **Beiyanerpeton* (Gao & Shubin, 2012: fig. 3) and apparently **Chelotriton* (Schoch,
4552 Poschmann & Kupfer, 2015), where the area in question is taken up by the fenestrae ovales.
4553

145. PASPHE 14: Ventral plate of parasphenoid (caudal to basal articulations) more or
less triradiate/triangular (0), rectangular (1), or rectangular with a caudal lobe (2)
(unordered). Dividing this character into states (RC07 distinguished only two:
"subrectangular" and everything else) is difficult because such a wide continuum of shapes
exists – notably, state 2 includes pentaradiate conditions that can look like part of an octogon,
as well as hexaradiate shapes, and state 0 encompasses di-, tri-, and tetraradiate shapes; this
diversity of shapes is also why we have not ordered this character.

99

4561 We have ignored the relatively huge fenestrae ovales of salientians and albanerpetids 4562 for the purposes of scoring this character. This allows state 1 in Triadobatrachus and 4563 Notobatrachus (Estes & Reig, 1973; Báez & Nicoli, 2004) and 1 or 2 in Albanerpetidae (Estes & Hoffstetter, 1976; Maddin et al., 2013a). Much smaller excavations of the 4564 parasphenoid plate for the fenestrae ovales occur in Archeria (Holmes, 1989) and the 4565 4566 temnospondyl ** Tersomius (Carroll, 1964).

4567 State 0: Greererpeton, Crassigyrinus, Whatcheeria (Lombard & Bolt, 1995), Baphetes, Megalocephalus, Eucritta if the reconstruction by Clack (2001) can be trusted, 4568 4569 Isodectes, Neldasaurus, Anthracosaurus (Panchen, 1977), Pholiderpeton scutigerum, apparently Gephyrostegus (Klembara et al., 2014), Discosauriscus, Seymouria, Captorhinus, 4570 Petrolacosaurus, 4571 Paleothvris, Tuditanus, Pantvlus, Saxonerpeton, Pelodosotis. 4572 Cardiocephalus, Ariekanerpeton, Leptoropha, Microphon (borderline; Bulanov, 2003), Pederpes, Tseajaia (Moss, 1972: fig. 2), Utegenia. 4573

4574 State 1: the four OTUs mentioned above, *Panderichthys* (though the plate is very 4575 short), Edops (Romer & Witter, 1942; D. M., pers. obs of USNM 23309), Chenoprosopus (Langston, 1953), Cochleosaurus (Sequeira, 2004), Trimerorhachis (Milner & Schoch 2013), 4576 Eryops (Sawin, 1941), Phonerpeton (Dilkes, 1990: fig. 1B), Ecolsonia (Berman, Reisz & 4577 4578 Eberth, 1985), Broiliellus (Schoch, 2012: fig. 2F), Amphibamus (Daly, 1994: fig. 21 right 4579 side), Doleserpeton, Micromelerpeton, Apateon, Leptorophus and Schoenfelderpeton (Boy, 4580 1987), Eoherpeton, Proterogyrinus, Pholiderpeton atthevi, Micraroter, Rhynchonkos (Szosta-4581 kiwskyj, Pardo & Anderson, 2015), Brachydectes, Scincosaurus, Sauropleura.

4582 State 2: Platyrhinops (Clack & Milner, 1994, 2010), Karaurus, Valdotriton, 4583 Batropetes (Carroll, 1991; Glienke, 2013; D. M., pers. obs. of MB.Am.1232 contradicting Glienke, 2015: fig. 3F), Microbrachis (Olori, 2015: fig. 12A), Diploceraspis, Oestocephalus 4584 4585 (Carroll, 1998a).

4586 Dendrerpetidae is polymorphic, having states 1 and 2 (Godfrey, Fiorillo & Carroll, 4587 1987; Milner, 1996; Robinson, Ahlberg & Koentges, 2005); Euryodus is likewise 4588 polymorphic, with E. dalyae possessing state 2 and E. primus displaying state 0.

4589 Acheloma has a condition intermediate between states 0 and 1 (Olson, 1941: fig. 8; 4590 Maddin, Reisz & Anderson, 2010: fig. 5I); we have scored partial uncertainty.

4591 Similarly, Balanerpeton is reconstructed as intermediate between states 1 and 2 4592 (Milner & Sequeira, 1994); we have scored partial uncertainty.

4593 Unknown (and not already so scored in RC07): Eusthenopteron (inapplicable because 4594 there only are two caudal processes that are together narrower than at the basal articulation: 4595 Ahlberg, Clack & Lukševičs, 1996), Acanthostega (inapplicable because the parasphenoid 4596 barely extends caudally beyond the basal articulation: Clack, 1994a; Porro, Rayfield & Clack, 4597 2015), Ichthvostega (inapplicable because the parasphenoid does not extend caudally beyond 4598 the basal articulation at all), Hapsidopareion (CG78: fig. 13A, 14E), Adelospondylus 4599 (Andrews & Carroll, 1991: fig. 13C), Batrachiderpeton, Lethiscus (the parasphenoid - parabasisphenoid? - is too short and caudally pointed: Pardo et al., 2017) and Capetus (Sequeira 4600 4601 & Milner, 1993).

4602

Vieraella has state 1 or 2 (Báez & Basso, 1996).

State 1, implied by Damiani et al. (2006: fig. 4B), is probably safe to score for 4603 4604 *Saharastega (D. M., pers. obs. of MNN MOR 73). Following the text of Gubin (1991), we 4605 have also assigned state 1 to *Konzhukovia, though the state shown in drawing 15 is 4606 borderline to state 0.

4607 Schoch, Poschmann & Kupfer (2015) figured state 1 in a specimen drawing, but state 4608 2 in two reconstructions; given the state of preservation of the specimens, we have scored 4609 partial uncertainty for *Chelotriton.

4610

4611 146. JAW ART 1/SQU 2/DEN 8: Jaw articulation lying caudal to (0), level with (1), or rostral to occiput but with rostrodorsally to caudoventrally inclined or vertical 4612 4613 caudolateral edge of squamosal (2), or caudolateral edge of squamosal caudodorsally to rostroventrally inclined (3), or even dentary shorter than half of distance between snout 4614 and occiput (4) (ordered). State 3, the previous SQU 2(1), required JAW ART 1(2), and 4615 4616 state 4, the previous DEN 8(1) which is limited to *Batropetes* and *Brachydectes* in the original 4617 taxon sample, required SQU 2(1), so we have merged these characters. (State 4 is also found in *Carrolla [Maddin, Olori & Anderson, 2011] and is inevitable in *Quasicaecilia, where 4618 4619 the lower jaw is almost wholly unknown but the distance between the tip of the snout and the 4620 jaw joints is less than that between the jaw joints and the occiput [Pardo, Szostakiwskyj & Anderson, 2015].) Because the present character is continuous, we have ordered it and 4621 4622 interpreted state 1 as meaning that the distance between the midpoints of the jaw joints and the occipital condyle(s)/cotyle is less than 5% of the distance between the latter and the tip of 4623 4624 the snout; this gives state 1 to Eoherpeton (Smithson, 1985: fig. 8A), which was originally 4625 scored as unknown for JAW ART 1.

RC07 commented JAW ART 1 (their ch. 187) as follows: "There appears to be no 4626 4627 clear signal associated with the distribution of different character-states, even within the same 4628 clade." Indeed, this character is somewhat labile. Still, states other than 0 occur (in the 4629 original taxon sample) only in Eusthenopteron, Eoherpeton, Cochleosaurus, Trimerorhachis, Isodectes and the seymouriamorph-diadectomorph-amniote-amphibian clade, augmented in 4630 4631 the expanded taxon sample only by the temnospondyls *Saharastega, *Lydekkerina, 4632 *Palatinerpeton and *Acanthostomatops and the chroniosuchian *Bystrowiella; states 2 and 3 4633 are limited to amphibians, Orobates and Isodectes, and state 0 occurs at least twice in the urocordylid-aïstopod clade. Despite its five states, the present character has only 38 steps on 4634 4635 the shortest trees from Analysis R4; reversals from state 1 to 0 are only seen six times, state 2 4636 appears seven or eight times and reverses at most twice, state 3 or higher appears five or six 4637 times and reverses at most once, state 4 appears once and never reverses. This is far from a 4638 random distribution.

4639 State 0 is found in *Ventastega* (Ahlberg, Lukševičs & Lebedev, 1994; Ahlberg et al.,
4640 2008), *Phonerpeton* (Dilkes, 1990), *Eoscopus* (Daly, 1994), *Bruktererpeton* (Boy & Bandel,
4641 1973: pl. 7), *Gephyrostegus* (Carroll, 1970: fig. 6A; D. M., pers. obs. of TMM 41773-1),
4642 Westlothiana (Smithson et al., 1994: text and fig. 2), and Oestocephalus (Carroll, 1998a).

4643 *Cochleosaurus* (Sequeira, 2004), *Trimerorhachis* (Milner & Schoch, 2013), *Lethiscus*4644 (Pardo et al., 2017; J. Pardo, pers. comm.) and *Tseajaia* (Moss, 1972: fig. 2; Berman, Sumida
4645 & Lombard, 1992: fig. 9; D. M., pers. obs. of CM 38033) have state 1.

4646 *Isodectes* (Sequeira, 1998) and *Keraterpeton* (Bossy & Milner, 1998: fig. 57A, 78) 4647 show state 2. So does even the largest known skull of *Orobates* (Berman et al., 2004: fig. 8A).

4648 State 3 occurs in Albanerpetidae, *Karaurus, Valdotriton* and *Scincosaurus*, as well as 4649 in **Beiyanerpeton*.

4650 *Batrachiderpeton*, *Diplocaulus* and *Diploceraspis* possess state 2 or 3; *Diceratosaurus*4651 has state 3 or 4.

4652 *Urocordylus* has state 0, 1, or 2.

4653

The condition is entirely unknown in *Dolichopareias* (Andrews & Carroll, 1991).

4654 States 2 and 3 cannot be distinguished in *Phlegethontia* due to the unique shape of the 4655 squamosal (Anderson, 2002).

4656 Many taxa go from a higher to a lower state in ontogeny. Accordingly, we have scored 4657 *Schoenfelderpeton* as possessing state 0, 1, or 2 (instead of just the observed 2). *Micromeler-*4658 *peton* (Boy, 1995) and *Apateon* (Schoch & Fröbisch, 2006) are scored 0 based on the most

4659 mature specimens. *Leptoropha* and *Microphon* are scored as unknown because the halfway 4660 complete skull roofs known of them do not come from adult individuals (Bulanov, 2003). 4661 **Gerobatrachus* has state 0 or 1 based on the different possibilities for where the 4662 occiput could have been in life.

In **Lydekkerina*, the occipital condyles lie rostral to the jaw joints, but the distance is
less than 5% of the distance between the jaw joints and the rostral end of the skull (Shishkin,
Rubidge & Kitching, 1996; Jeannot, Damiani & Rubidge, 2006); we have scored this as state
1.

4667 State 4 can be excluded for the *St. Louis tetrapod; the other four states remain 4668 possible (Clack et al., 2012b: fig. 2A).

4669 **Bystrowiella* almost certainly falls within the range of state 1 (Witzmann & Schoch, 2017: fig. 15).

4671

4672 147. PSYM 1: Parasymphysial plate: present (0); absent (1).

4673 State 1 is found in *Acheloma* (Polley & Reisz, 2011), apparently *Schoenfelderpeton* 4674 (Boy, 1986: 154, fig. 15b), *Limnoscelis* (Berman & Sumida, 1990: fig. 5A), *Batropetes* 4675 (Glienke, 2013, 2015) and *Notobatrachus* (Báez & Nicoli, 2008).

Kotlassia was scored as unknown in RC07. Ruta, Coates & Quicke (2003) cited 4676 4677 Bystrow (1944) as their only source for scoring Kotlassia; they did not mention having seen 4678 any specimens. Bystrow (1944: fig. 6) very clearly illustrated state 1; unfortunately, as we have not seen specimens either, we have no way of telling to which extent that figure can be 4679 4680 trusted on features that are not mentioned in the text. None of the figures of Bystrow (1944) indicate any part of the skull or lower jaw as unknown; there is no indication in the legends or 4681 4682 in the illustrations themselves as to which, if any, extent they are reconstructions or specimen 4683 drawings. - Because Bystrow (1944: fig. 6) illustrated state 1, the text (p. 389-390) does not explicitly mention any part of the lower jaw as unknown and says that "a complete 4684 description of the structural details of the lower jaw" is possible, and RC07 and Ruta, Coates 4685 4686 & Ouicke (2003) did not indicate any reason for why they scored this character as unknown 4687 instead, we have changed the score to 1. We are aware, however, that the skull roof is not as 4688 well preserved as Bystrow (1944) drew it (Bystrow, 1944: 409; Bulanov, 2003). - Bystrow 4689 (1944) did not distinguish Kotlassia from *Karpinskiosaurus, but used (p. 389) the holotypes 4690 of both Ko. prima and *Ka. secundus for describing the lower jaw, and the possibly 4691 composite drawing (fig. 6) labeled "Lower jaw of Kotlassia prima" shows clear differences to 4692 the reconstruction of *Karpinskiosaurus by Klembara (2011: fig. 9D, E), so we infer that the 4693 lower jaw of Kotlassia is reasonably well known in general; furthermore, Klembara (2011) 4694 did not use the holotype of *Ka. secundus in his reconstruction of the lower jaw, which he 4695 based on two other specimens, leading us to conclude that the holotype does not provide 4696 much information on the lower jaw.

For the time being, we accept the interpretation that the lump of bone in *Lethiscus* and **Coloraderpeton* visible not only in dorsal and lingual, but even ventral and labial views is a huge toothless parasymphysial (Pardo et al., 2017) and have therefore scored state 0 for both OTUs. However, we consider it at least as likely that this bone is a mentomandibular (an ossification of the mesial end of Meckel's cartilage).

4702 We have been very cautious in interpreting the lower jaw of **Carrolla*, in which some 4703 fragments are missing and several bones are distorted (Maddin, Olori & Anderson, 2011); for 4704 example, we have scored the present character as unknown.

However, we accept the "brassicate structure" at the symphysis of the *St. Louis
tetrapod (Clack et al., 2012b; D. M., pers. obs. of MB.Am.1441) as evidence of state 0.
Sutures around this "structure" cannot be seen, but sutures cannot be seen almost anywhere
else on the specimen either.

4709

RC07 cited Ahlberg & Clack (1998) as saying that Megalocephalus has state 1, but Milner & Lindsay (1998: 220) stated that it has state 0 and cited a pers. comm. by Ahlberg & Clack. We have accordingly changed the score of Megalocephalus to 0. Lethiscus shares state 0 (Pardo et al., 2017; see PSYM 1). Bolt & Lombard (2001) stated in table 1 that *Deltaherpeton (FM PR 1637) lacks parasymphysial fangs like all other colosteids. The text (p. 1036), however, maintains that this cannot be determined. Their fig. 7 does not help, so we have gone with the text rather than the table and have scored *Deltaherpeton as unknown. 149. PSYM 3: Parasymphysial plate without (0) or with (1) anteroposterior tooth row oriented subparallel to marginal dentary teeth and the basal diameter and/or height of which [= of the teeth in the parasymphysial toothrow] is 30% or greater than that of marginal teeth and twice or more that of denticles, if present. Lethiscus has state 0 (Pardo et al., 2017; see PSYM 1).

4726 Bolt & Lombard (2001) stated in table 1 that *Deltaherpeton (FM PR 1637) possesses two parasymphysial teeth like all other colosteids. The text (p. 1036), however, maintains that

size with or greater than dentary teeth.

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4727 4728 this cannot be determined. Figure 7 does not help, so we have gone with the text rather than 4729 the table and have scored *Deltaherpeton as unknown. 4730

**Ymeria* is probably polymorphic (Clack et al., 2012a).

4732 150. PSYM 4: Parasymphysial plate with (0) or without (1) small teeth (denticles) 4733 forming continuous shagreen or discrete patches and the basal diameter and/or height of 4734 which is less than 30% of that of adjacent marginal dentary teeth.

4735 The resolution of the scans published by Pardo et al. (2017; see PSYM 1) is low 4736 enough that we keep this character unknown for *Lethiscus*.

4737 On the only known parasymphysial of *Densignathus, there is just a single denticle 4738 (Daeschler, 2000); because denticles are usually completely absent when they are not 4739 "forming continuous shagreen or discrete patches", we have scored state 0. 4740

4741 deleted DEN 1: Dentary with (0) or without (1) accessory toothrows. According to RC07, 4742 state 0 occurs in Captorhinus and Pantylus. In fact, Pantylus has a single toothrow on the 4743 dentary – the additional toothrows (insofar as rows can be recognized) of the lower jaw all lie 4744 on the (single) coronoid (Williston, 1916: fig. 27; Romer, 1969: fig. 14; CG78: fig. 25 bottom middle, 25 bottom right, and 114C). This makes the character parsimony-uninformative, so 4745 4746 we have deleted it. For the sake of completeness, we would further like to mention that state 0 4747 is limited to one of the three species of *Captorhinus* and autapomorphic for it even if the other 4748 clade of captorhinids with multiple toothrows, not sampled in this matrix, is taken into 4749 account (Kissel, Dilkes & Reisz, 2002).

4750 "The dorsal edge of the dentary carries a marginal row of closely spaced homodont 4751 teeth. Some, but apparently not all, individuals have a secondary row of much smaller teeth outside the principal row" in Panderichthys (Ahlberg & Clack, 1998: 14). By comparison to 4752 4753 other characters in this matrix, we consider the "smaller teeth" denticles, so Panderichthys, 4754 originally scored as polymorphic, has only state 1 of this character. Alternatively, it may be that Ruta, Coates & Quicke (2003) intended state 0 to mean the condition of some Pander-4755 4756 ichthys individuals (and a few taxa not included in the matrix of RC07, like the explicitly 4757 mentioned *Elginerpeton: Ahlberg, 1995; Ahlberg & Clack, 1998); but if so, Captorhinus 4758 could not be counted, and Pantylus would have state 1 anyway, rendering the character 4759 parsimony-uninformative again (state 0 would be restricted to part of one OTU).

148. PSYM 2: Parasymphysial plate without (0) or with (1) paired fangs, comparable in

Our addition of **Elginerpeton* has not rendered this character parsimony-informative
if *Panderichthys* is scored as polymorphic, because PAUP* cannot reconstruct ancestors as
polymorphic: even if *Panderichthys* and **Elginerpeton* were sister-groups, two steps (one of
them within *Panderichthys*) would be needed to explain the distribution of state 1 regardless
of which state their last common ancestor would have had.

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4766 151. DEN 2: Dentary with anterior fangs generally comparable in size with, or greater 4767 than, other dentary teeth and lying close to symphysial region and lingual to marginal dentary teeth (0); with fangs/tusks/incisiforms that are part of the marginal toothrow 4768 4769 (1); without fangs (2) (unordered). Instead of "lingual", RC07 had "mesial". The distinction between states 0 and 1 is new; state 1 occurs in Ichthyostega (Jarvik, 1996: fig. 31, pl. 31; 4770 4771 Clack et al., 2012a: fig. 5C), Colosteus (Hook, 1983), Greererpeton and *Deltaherpeton (Bolt & Lombard, 2001), Diadectes, Limnoscelis, Captorhinus, Pantylus, Stegotretus and Orobates. 4772 4773 (The caniniform teeth of some Oedaleops specimens [Sumida, Pelletier & Berman, 2014] are 4774 too far from the symphysis to count as state 1; we have scored state 2 for *Caseasauria. The 4775 same holds for the caniniform region of Hapsidopareion (already scored in RC07) and 4776 *Llistrofus [CG78: fig. 13F; Bolt & Rieppel, 2009].)

4777 *Eusthenopteron* has state 2 (Ahlberg & Clack, 1998: 15); so do *Triadobatrachus*4778 (Ascarrunz et al., 2016), *Solenodonsaurus* (Danto, Witzmann & Müller, 2012), *Microbrachis*4779 (CG78: fig. 80) and *Scincosaurus* (Milner & Ruta, 2009).

Baphetes has state 0 (Milner & Lindsay, 1998; Milner, Milner & Walsh, 2009), as do *Acheloma* (Polley & Reisz, 2011), *Ecolsonia* (D. M., pers. obs. of CM 38017 and CM 38024), *Eoscopus* (Daly, 1994: 10), *Platyrhinops* (Clack & Milner, 2010), *Schoenfelderpeton* (Boy,
1986: 154, fig. 15b) and *Gephyrostegus* (Klembara et al., 2014).

Archeria shows both state 0 and state 2 in different individuals (Holmes, 1989).

4785 *Anthracosaurus* appears to have had state 1 and state 2 in different individuals (Panchen, 1977: 475).

4787 *Kotlassia* was scored as unknown in RC07. Following Bystrow (1944: 392, fig. 6), we 4788 have changed the score to 2, but see PSYM 1.

4789 *Acherontiscus* was scored as having state 0; state 2 is much more likely (Carroll, 4790 1969a).

Unknown in Leptoropha (Bulanov, 2003) and Silvanerpeton (Ruta & Clack, 2006).

**Glanochthon* has two teeth per dentary that lie lingual to the mesialmost marginal
teeth but are only as tall as the smallest (distalmost) marginal dentary teeth. Still, we count
this as "generally comparable in size with [...] other dentary teeth" and have assigned state 0
to **Glanochthon*.

4796 We accept the inference of state 0 in **Erpetosaurus* from the holes in the ventral and 4797 the dorsal surface of the premaxillae (Milner & Sequeira, 2011).

Panchen (1975: 619) considered the inference of a tusk in **Pholidogaster* somewhat
uncertain; however, we consider the damage to the roof of the snout (Panchen, 1975: 617;
compare Bolt & Lombard, 2010) evidence for state 0 or 1.

**Platyoposaurus* and **Australerpeton* have states 0 and 1: there are tusks both in the
toothrow and lingual to it (Gubin, 1991; Eltink & Langer, 2014).

4803

4804 152. DEN 3: Dentary without (0) or with (1) 'chamfered' margin.

4805 State 0 is documented in *Cochleosaurus* (Sequeira, 2004), *Solenodonsaurus* (Danto,
4806 Witzmann & Müller, 2012), *Scincosaurus* (Milner & Ruta, 2009) and *Lethiscus* (Pardo et al.,
4807 2017), and also known in *Nigerpeton* (D. M., pers. obs. of MNN MOR 70).

4808 "In some *Ichthyostega* specimens, it [the chamfered margin] seems restricted to the 4809 posterior portion of the dentary" (Clack et al., 2012a: 77). This strongly implies that state 1 is 4810 always present.

- 4811 Not applicable to *Phlegethontia*, where all dermal postdentary bones are absent 4812 (Anderson, 2002, and references therein).
- 4814 153. DEN 4: Dentary without (0) or with (1) U-shaped notch for premaxillary tusks.
- 4815 *Karaurus* has state 0 (D. M., pers. obs. of unnumbered MNHN cast of PIN 2585/2); so 4816 do *Solenodonsaurus* (Danto, Witzmann & Müller, 2012) and *Lethiscus* (Pardo et al., 2017).
- **Nigerpeton* has a condition similar to but different from state 1 (D. M., pers. obs. of
 MNN MOR 108); we have scored this as state 0.

We accept the interpretation by Clack et al. (2012b) that the *St. Louis tetrapod has state 1, though the notch is shaped less like a U and more like an asymmetric W; a similar shallow but sharp-edged notch may even be visible in the same position on the other dentary (D. M., pers. obs. of MB.Am.1441.2).

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4813

4824 154. DEN 7: **Dentary toothed (0) or toothless (1).**

4825 State 0 is documented in *Chenoprosopus* (Hook, 1993), *Solenodonsaurus* (Danto, 4826 Witzmann & Müller, 2012) and *Scincosaurus* (Milner & Ruta, 2009), and also known in 4827 **Saharastega* (pers. obs. of MNN MOR 73).

4828 *Kotlassia* was scored as unknown in RC07. However, Bystrow (1944: 390) stated: 4829 "There is a row of conical slightly recuved sharp teeth all along the upper edge of the 4830 dentary." We have changed the score to 0; see PSYM 1 for discussion.

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4832 155. SPL 2: Posteriormost extension of splenial lingual lamina closer to anterior margin of adductor fossa than to anterior extremity of jaw, when the lower jaw ramus is 4833 observed in me[d]ial aspect and in anatomical connection (i.e. symphysial region 4834 4835 orientated towards the observer): absent (0); present (1). We follow RC07 and many other 4836 sources in homologizing the single splenial of amniotes, diadectomorphs and others with the 4837 presplenial and not the postsplenial, though we are not aware of any evidence for or against 4838 this other than the fact that this single splenial often participates in the symphysis. Unlike all 4839 other amniotes, Petrolacosaurus was reported to possess a (uniquely small) postsplenial 4840 (Reisz, 1981); following a pers. comm. by R. R. Reisz in about 2008, we have kept POSPL 1(0) for *Petrolacosaurus*, but we still wonder if the supposed postsplenial might actually be a 4841 4842 fragment of the angular instead.

4843 *Whatcheeria* has state 1 (Lombard & Bolt, 2006). So do *Limnoscelis* (Reisz, 2007; 4844 Berman, Reisz & Scott, 2010), *Batropetes* (Glienke, 2015), *Diplocaulus* (Douthitt, 1917) and 4845 *Lethiscus* (Pardo et al., 2017: ext. data fig. 6, contradicting their matrix).

Inapplicable (unknown) in all lissamphibians, because there is no evidence for a
splenial in any of them. (The occasional reports from caecilian ontogeny in fact refer to a
coronoid: Müller, Oommen & Bartsch, 2005; Müller, 2006.)

4849 *Kotlassia* was scored as unknown in RC07. Following Bystrow (1944: fig. 6), we have 4850 changed the score to 1, but see PSYM 1.

4851 No splenials can be confidently identified in *Rhynchonkos* (Szostakiwskyj, Pardo &
4852 Anderson, 2015); we have therefore scored all SPL and POSPL characters as well as
4853 PREART 5 (all below) as unknown.

4854 Remarkably, state 0 was scored in RC07 for *Phlegethontia*, which has just two bones
4855 in the lower jaw (Anderson, 2002, and references therein): one is the dentary, the other is
4856 most likely a purely Meckelian ossification – no lamina and no splenial are remotely
4857 identifiable, leaving us no way to apply this character.

It appears (D. M., pers. obs. of MB.Am.1441.2) that the *St. Louis tetrapod had a long
distal process of the splenial overlying the prearticular near the dorsomesial edge of the
Meckelian fenestra, very similar to what is seen in *Greererpeton* (Bolt & Lombard, 2001: fig.
5.2). We have therefore scored state 1.

4862

4863 156. SPL 3-4: Splenial separated from anterior and middle coronoids by prearticular 4864 (0); splenial contacts anterior but not middle coronoid (1); splenial contacts both 4865 anterior (if present) and middle coronoid (2) (ordered). The splenial never contacts the 4866 middle coronoid without also contacting the anterior one (even though the latter contact lies 4867 entirely on the symphysial surface in **Platyoposaurus*: Gubin, 1991: drawing 20) unless of 4868 course if the anterior one is absent; the ordering reflects a gradual shortening of the 4869 prearticular.

4870 We assume that the three denticle-covered areas in the coronoid series of *Platyrhinops* 4871 (Clack & Milner, 2010) correspond to the three coronoids; this allows us to keep state 2.

4872 Milner & Schoch (2013: fig. 7B) reconstructed state 0, which was scored in RC07, for
4873 *Trimerorhachis* without mentioning this character in the text; following a pers. comm. by R.
4874 Schoch (April 2015), however, we have scored *Trimerorhachis* as unknown.

4875 State 0 is, however, found in *Sclerocephalus (Schoch & Witzmann, 2009a; tentatively confirmed by D. M., pers. obs. of MB.Am.1346) and in the *Parrsboro jaw: the 4876 denticulated mystery element that could be part of the prearticular or of the splenial (Sookias, 4877 4878 Böhmer & Clack, 2014) appears continuous, except for diagenetic deformation, with the prearticular (the middle part of which has been bent deep into the Meckelian fenestra), and 4879 4880 Caerorhachis (Ruta, Milner & Coates, 2002) is the only case known to us where the denticle field of the lower jaw extends, just barely, onto the splenial, while in the *Parrsboro jaw a 4881 4882 large area is covered by denticles.

4883 Acanthostega has state 1 (Porro, Rayfield & Clack, 2015), as does Whatcheeria 4884 (Lombard & Bolt, 2006). Edops shares state 1, though for an unusual reason: the suture 4885 between the anterior and the middle coronoid and the one between splenial and postsplenial 4886 are about at the same level, but separated by the posterior coronoid, which has a long suture 4887 with the anterior one (D. M., pers. obs. of USNM 23309, impossible to tell in MCZ 1378; not 4888 described by Romer & Witter, 1942, not visible in their fig. 3A). This condition (and thus state 1) is also found in Eryops (Sawin, 1941), Pholiderpeton attheyi (Panchen, 1972), 4889 4890 Anthracosaurus (Panchen, 1977) and possibly Proterogyrinus (compare Holmes, 1984: fig. 4891 15, to Panchen, 1972 and 1977), though we have kept partial uncertainty (state 1 or 2) for the 4892 last of these.

4893 *Kotlassia* was scored as unknown in RC07. Following Bystrow (1944: fig. 6), we have 4894 changed the score to 2, but see PSYM 1.

4895 *Limnoscelis* (Reisz, 2007; Berman, Reisz & Scott, 2010), *Ariekanerpeton* (Klembara 4896 & Ruta, 2005: fig. 6D) and *Tseajaia* (Moss, 1972: 19) show state 2 as well. We have further 4897 scored state 2 for *Lethiscus*; although the middle coronoid has not been identified, there is a 4898 large distance between the mesial end of the prearticular and the distal end of the putative 4899 anterior coronoid, all of it filled by the lingual lamina of the splenial (Pardo et al., 2017).

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Acheloma has state 1 or 2 (Polley & Reisz, 2011).

4901 **Nigerpeton* has state 1 (D. M., pers. obs. of MNN MOR 70), as does **Saharastega*4902 (pers. obs. of MNN MOR 73).

4903 It appears that the prearticular separates the splenial from the anterior coronoid in
4904 **Elginerpeton* (Ahlberg & Clack, 1998: fig. 12B; Ahlberg, Friedman & Blom, 2005: fig. 2B),
4905 so we have scored state 0.

4906 *Lydekkerina (Jeannot, Damiani & Rubidge, 2006: fig. 4D) and *Australerpeton 4907 (Eltink & Langer, 2014) have a point contact between the splenial, the postsplenial and both 4908 pertinent coronoids; we have scored state 1 or 2 for both.

- 4909 *Aytonerpeton appears to have state 0 (Clack et al., 2016: fig. 4c, supplementary video 4910 2).
- 4911

4912 157. POSPL 1: Separately ossified postsplenial: present (0); absent (1).

4913 State 0 is, surprisingly, found in *Diplocaulus* (Douthitt, 1917). It is further said to be 4914 present in *Densignathus (Daeschler, 2000); we have followed this, although the illustrations 4915 do not show the suture to the angular (except as a stippled line in reconstructions). 4916 *Nigerpeton (D. M., pers. obs. of MNN MOR 70) and *Saharastega (D. M., pers. obs. of 4917 MNN MOR 73) have state 0 as well.

Batropetes has state 1 (Glienke, 2013). We have also followed Pardo et al. (2017) in 4918 4919 scoring it for Lethiscus, although fully articulated sutures are at best difficult to identify in 4920 their scans; their extended data figure 2 and the accompanying supplementary videos show a 4921 failed attempt to identify separate postsplenials (in pink). In *Coloraderpeton, absence of the 4922 postsplenial is indicated by the long distance between the splenial (and its facet) and the 4923 angular. Note that all this contradicts the matrix by Pardo et al. (2017), where both Lethiscus 4924 and *Coloraderpeton are scored as having two splenials.

4925 Based on the figures and videos of Clack et al. (2016), we tentatively accept state 0 for 4926 *Aytonerpeton. 4927

4928 158. POSPL 2: Postsplenial without (0) or with (1) lingual lamina.

Whatcheeria has state 0 (Lombard & Bolt, 2006).

State 1 is just barely found in Chenoprosopus (D. M., pers. obs. of USNM 437646) 4930 4931 and clearly in Isodectes (D. M., pers. obs. of unnumbered MCZ cast of AMNH 6935 before 4932 etching), Doleserpeton (Sigurdsen & Bolt, 2010: fig. 3B), Gephyrostegus (Klembara et al., 4933 2014), Diplocaulus (Douthitt, 1917), *Nigerpeton (D. M., pers. obs. of MNN MOR 70) and 4934 *Saharastega (D. M., pers. obs. of MNN MOR 73).

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4936 159. POSPL 3: Postsplenial with (0) or without (1) pit line.

4937 State 1 is found in Whatcheeria (Lombard & Bolt, 2006), Ecolsonia (D. M., pers. obs. 4938 of CM 38024), Doleserpeton (Sigurdsen & Bolt, 2010: fig. 3B) and apparently Diplocaulus 4939 (Douthitt, 1917). 4940

Unknown in Panderichthys (Ahlberg & Clack, 1998) and Ossinodus (Warren, 2007).

4942 160. ANG 1: Separately ossified angular: present (0); absent (1).

4943 State 0 is known in Baphetes (Milner & Lindsay, 1998: fig. 5; Milner, Milner & 4944 Walsh, 2009), Diceratosaurus (D. M., pers. obs. of CM 72608), Diplocaulus (Douthitt, 1917) 4945 and Lethiscus (Anderson, Carroll & Rowe, 2003).

4946 State 1 is found in Albanerpetidae (Estes & Hoffstetter, 1976; Gardner, 2001; Venczel 4947 & Gardner, 2005).

4948 Unclear in Triadobatrachus (Ascarrunz et al., 2016).

4949 Schoch, Poschmann & Kupfer (2015) described a bone in *Chelotriton that they 4950 identified as the surangular. According to their reconstruction (Schoch, Poschmann & Kupfer, 4951 2015: fig. 4f), however, this bone lies unambiguously in the position of an angular, at the 4952 ventral edge of the lower jaw, entirely ventral to the prearticular and the articular. "The 4953 angular and surangular" are mentioned in the text (p. 82), but there is no "angular" in the 4954 illustrations, the list of abbreviations, or anywhere in the text outside the above quote. 4955 Personal communication of D. M. with R. Schoch has not so far clarified this matter; for the

time being, we therefore interpret **Chelotriton* as possessing an angular – unique though this
is among urodeles, as discussed by Marjanović & Witzmann (2015) – and lacking a
surangular; we have scored state 0 of the present character and have also scored **Chelotriton*for other ANG characters based on the supposed "surangular".

Judging from the starburst ornamentation (supplementary video 2), the suture between
the angular and the postsplenial of **Aytonerpeton* postulated in fig. 4b of Clack et al. (2016)
goes straight through the angular.

4964 161. ANG 2-3: Angular-prearticular contact: entirely at caudoventral edge of jaw (0);
absent, Meckelian bone or cartilage continuously exposed from the jaw joint to the
splenial (1); on the lingual side, where the angular has a lingual lamina (2) (unordered).
The contact (explicitly called a suture) and the lingual ("mesial") lamina of the angular were
treated as separate characters by RC07, but the latter never seems to occur without the former;
we therefore follow Ahlberg, Clack & Blom (2005) and the matrix of Ahlberg et al. (2008),
Callier, Clack & Ahlberg (2009) and Clack et al. (2012a) in merging these characters.

4971

State 0 is now known in Lethiscus (Pardo et al., 2017).

4972 RC07 claimed that the absence of a contact (ANG 3(1)) was limited to Acanthostega 4973 in their taxon sample; had that been correct, the character would have been parsimonyuninformative. However, state 1 does occur in Eusthenopteron (Zupiņš, 2008: fig. 4) and 4974 4975 Whatcheeria (Lombard & Bolt, 2006), where the surangular, the angular and the postsplenial are wholly separated from the prearticular by exposed Meckelian bone continuous with the 4976 4977 articular, and in *Pederpes*, where the prearticular, "[a]s its ventral border is very simple and 4978 delicate, it clearly did not suture with the surangular or angular and possibly not with the 4979 postsplenial" (Clack & Finney, 2005). Incidentally, state 1 appears plesiomorphic for 4980 Sarcopterygii (Worobjewa, 1975: fig. 3; Long, Barwick & Campbell, 1997: fig. 38; Friedman, 4981 2007: fig. 5).

4982 State 2 is known to occur in *Chenoprosopus* (Hook, 1993; D. M., pers. obs. of USNM
4983 437646, though the sutures are difficult to trace), *Isodectes* (D. M., pers. obs. of unnumbered
4984 MCZ cast of AMNH 6935 before etching, though the sutures are nigh impossible to trace),
4985 *Doleserpeton* (Sigurdsen & Bolt, 2010; Sigurdsen & Green, 2011: appendix 2),
4986 *Gephyrostegus* (Klembara et al., 2014), *Batropetes* (Glienke, 2013, 2015), *Cardiocephalus*4987 (CG78) and *Diplocaulus* (Douthitt, 1917).

Inapplicable in Albanerpetidae, see ANG 1; "always unclear" (Bossy & Milner, 1998:
in *Sauropleura* (which was already scored as unknown for ANG 2, but not for ANG 3).

4990 Following Ahlberg, Friedman & Blom (2005), we have scored state 1 for 4991 **Elginerpeton*.

There may not be a prearticular in **Coloraderpeton* or **Pseudophlegethontia*: the supposed fusion of the prearticular and the Meckelian bone in the former (Pardo et al., 2017) is probably just Meckelian bone, and the supposed suture at the cranial end of the supposed left prearticular of the latter (absent on the right side; Anderson, 2003b: fig. 2A) could be a break in the Meckelian bone. However, the angular clearly lacks a lingual lamina, so we have scored state 0 or 1 for both.

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4999 162. ANG 4: Angular not reaching (0) or reaching (1) lower jaw posterior end.

5000Baphetes has state 0 (Milner, Milner & Walsh, 2009). So do Chenoprosopus (Hook,50011993) and Platyrhinops (Clack & Milner, 2010).

5002 State 1 is found in *Batropetes* (Glienke, 2015), *Diceratosaurus* (D. M., pers. obs. of 5003 CM 72608), *Diplocaulus* (Douthitt, 1917) and *Lethiscus* (Pardo et al., 2017).

5004 *Kotlassia* was scored as unknown in RC07. Following Bystrow (1944: fig. 6), we have 5005 changed the score to 0, but see PSYM 1. 5006 The condition of *Westlothiana* is probably not known, judging from the specimen drawings in Smithson et al. (1994).

5008

5009 163. SURANG 1: Separately ossified surangular: present (0); absent (1).

5010State 0 is documented in Whatcheeria (Lombard & Bolt, 2006), Baphetes (Milner,5011Milner & Walsh, 2009), Batropetes (Glienke, 2015), Diceratosaurus (D. M., pers. obs. of CM501272608), and Lethiscus (Anderson, Carroll & Rowe, 2003; Pardo et al., 2017).

5013 *Diplocaulus* and *Diploceraspis* have state 1; we have, however, kept the scores of 5014 SURANG 3 and 5 for the latter and scored the former (which was scored as unknown in 5015 RC07 for most of the lower jaw) because at least part of the unitary "articular" must be 5016 homologous to the surangular (Douthitt, 1917; Beerbower, 1963: 68, fig. 7).

- 5017 Schoch, Poschmann & Kupfer (2015) described a bone in *Chelotriton that they 5018 identified as the surangular. According to their reconstruction (Schoch, Poschmann & Kupfer, 5019 2015: fig. 4f), however, this bone lies unambiguously in the position of an angular, at the 5020 ventral edge of the lower jaw, entirely ventral to the prearticular and the articular. "The 5021 angular and surangular" are mentioned in the text (p. 82), but there is no "angular" in the 5022 illustrations, the list of abbreviations, or anywhere in the text outside the above quote. Per-5023 sonal communication of D. M. with R. Schoch has not clarified this matter; for the time being, 5024 we therefore interpret *Chelotriton as possessing an angular – unique though this is among 5025 urodeles, as discussed by Marjanović & Witzmann (2015) - and lacking a surangular like all other lissamphibians; we have, in short, scored state 1 of the present character, and have 5026 5027 correspondingly scored the other SURANG characters as unknown.
- 5028 Like Witzmann & Schoch (2017), we infer the presence of the surangular in 5029 **Bystrowiella* from the serrated, apparently sutural dorsal margin of the angular. 5030
- 5031 164. SURANG 3: Surangular with (0) or without (1) pit line. Ahlberg, Friedman & Blom
 5032 (2005) suggested that the surangular pit line was homologous with the oral sulcus of the
 1033 lateral-line system; this is clearly not the case, because *Eusthenopteron* possesses both
 5034 (Schultze & Reed, 2012: fig. 10A).
- *Whatcheeria* has state 1 (Lombard & Bolt, 2006), as do *Baphetes* (Milner, Milner & Walsh, 2009), *Batropetes* (Glienke, 2015), *Diplocaulus* (Douthitt, 1917), apparently *Lethiscus* (Pardo et al., 2017; though scored as unknown in their matrix) and *Ossinodus* (Warren, 2007: fig. 8A) judging from their fig. 7P, the "pit line" mentioned by Warren & Turner (2004: 158) refers to the two pores that are part of the lateral-line system in the surangular figured by Warren (2007: fig. 8A) and do not lie in a position where a pit line would be expected. We have followed the matrix of Pardo et al. (2017) in scoring state 1 for **Coloraderpeton*.
- 5042 *Kotlassia* was scored as unknown in RC07. Following Bystrow (1944: fig. 6), we have 5043 changed the score to 1, but see PSYM 1.

5044 Unknown in *Westlothiana* where the surface of the bone is unknown (Smithson et al.,5045 1994).

5047 165. SURANG 5: Surangular lateral exposure much smaller than angular lateral 5048 exposure: no (0); yes (1).

Whatcheeria has state 0 (Lombard & Bolt, 2006), as do Baphetes (Milner, Milner &
Walsh, 2009), Batropetes (Glienke, 2015), Brachydectes (Wellstead, 1991; Pardo &
Anderson, 2016), Diplocaulus (Douthitt, 1917) and Lethiscus (Anderson, Carroll & Rowe,
2003; Pardo et al., 2017). Following the illustrations by Berman et al. (2004) against the text,
we have also scored Orobates as possessing state 0.

5054 State 1 is found in *Cochleosaurus* (Sequeira, 2004) and *Diploceraspis* (Beerbower, 5055 1963: 68).
5056 *Kotlassia* was scored as unknown in RC07. Following Bystrow (1944: fig. 6), we have 5057 changed the score to 0, but see PSYM 1.

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5059 166. PREART 5: **Prearticular/splenial suture: present (0); absent (1).** The possible 5060 correlations with SPL 3-4 and POSPL 1 remain to be investigated; more states of this 5061 character and/or SPL 3-4 should perhaps be distinguished.

5062 State 0 is found in *Whatcheeria* (Lombard & Bolt, 2006), *Diplocaulus* (Douthitt, 5063 1917) and *Lethiscus* (Pardo et al., 2017). We have also scored it for **Coloraderpeton* (Pardo 5064 et al., 2017), though there it seems likely that the prearticular is altogether absent rather than 5065 fused to Meckel's bone (Pardo et al., 2017: video).

5066 Sigurdsen & Green (2011) reported state 1 in *Doleserpeton*. State 1 also occurs in 5067 *Nigerpeton* (D. M., pers. obs. of MNN MOR 70) and *Saharastega* (D. M., pers. obs. of 5068 MNN MOR 73).

5069 Cochleosaurus bohemicus was scored in RC07 as having state 0, possibly after the 5070 reconstruction of C. florensis by Godfrey & Holmes (1995: fig. 5); however, the text (p. 17) 5071 and the specimen drawing (fig. 2) make clear that the area in question is not preserved. In her 5072 description of the skull of C. bohemicus, Sequeira (2004) showed a clear case of state 1 (fig. 5073 12D) in a specimen that appears to be split through the bone, so it may not show the sutures at the lingual surface (fig. 12B); in another specimen, Sequeira (2004: fig. 13) showed a point 5074 5075 contact if the dashed suture between the splenial and the postsplenial is taken for granted, did 5076 not elaborate on this in the reconstruction (fig. 8C), and mentioned in the text (p. 30) that 5077 "[a]n elongate prearticular extends beneath [= ventral to] the short posterior coronoid and continues forward for some distance beneath the middle coronoid, apparently terminating 5078 close to the common splenial suture [between splenial and postsplenial] in a subadult 5079 specimen (Fig. 13)". We have changed the score of the Cochleosaurus OTU to unknown. 5080

5081 Following a pers. comm. by R. Schoch (April 2015), we have scored *Trimerorhachis* 5082 as unknown. 5083

5084 167. ANT COR 1: Separately ossified anterior coronoid: present (0); absent (1).

5085Acheloma has state 0 (Polley & Reisz, 2011), as do Lethiscus (apparently: Pardo et al.,50862017), *Nigerpeton (D. M., pers. obs. of MNN MOR 70) and *Saharastega (D. M., pers. obs.5087of MNN MOR 73).

5088 Hook (1983) stated: "The sutures subdividing the coronoid series cannot be traced and 5089 the tusk-bearing anterior coronoid of *Greererpeton* is not preserved [in *Colosteus*]." 5090 Nevertheless, we agree with RC07 that all three coronoids were probably present: the mesial 5091 end of the coronoid series as preserved, whether complete or not, is very far mesial, easily far 5092 enough to belong to the anterior coronoid, while the distal end of the lower-jaw fragment in 5093 Hook (1983: fig. 3A) is too far distal to belong to the anterior coronoid by comparison to e.g. 5094 Greererpeton (Bolt & Lombard, 2001); another lower-jaw fragment shows that the coronoid 5095 series reached the adductor fossa (Hook, 1983: fig. 9), so that the posterior coronoid should 5096 have been present; and a complete lower jaw (Hook, 1983: fig. 6B) does not show any 5097 interruption in the middle of the coronoid series.

5098 State 1 is found in *Limnoscelis* (Reisz, 2007; Berman, Reisz & Scott, 2010) and 5099 apparently *Batropetes* (Glienke, 2013, 2015).

5100 Daly (1994: 11) described the situation in *Eoscopus* as follows: "Sharp, recurved 5101 denticles cover the dorsomedial part of the jaw and extend from the region of the symphysis 5102 to the presumed position of the adductor fossa. The coronoid bones that bear the denticles 5103 cannot be described because of their position." To be on the safe side, we have kept only the 5104 scores for the presence and the denticles of the posterior coronoid of *Eoscopus*, and have 5105 changed all other coronoid characters to unknown. 5106

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as unknown in *Kotlassia*. However, Bystrow (1944: 390) described "three toothless
coronoids" and added (p. 414): "All endeavors to find traces of teeth on any of the coronoids
of *Kotlassia* have yielded no results." We have scored all eleven characters accordingly; see
PSYM 1.

5111 Szostakiwskyj, Pardo & Anderson (2015) identified two coronoids in *Rhynchonkos*, 5112 separated by a large gap and a break in the specimen. It remains possible that all three 5113 fragments belonged to a single bone (J. Pardo, pers. comm., 2015); however, if they do 5114 represent two separate coronoids, it is not clear if the mesial one is the anterior coronoid or 5115 the middle coronoid. We have accordingly scored all ANT COR and MID COR characters as 5116 unknown.

- 5117 Douthitt (1917: 17) stated that the anterior and middle coronoids of *Diplocaulus* were 5118 most likely absent. Considering how unusually wide the dentary is in dorsal view (Douthitt, 5119 1917: fig. 2.5) and that the area is damaged in all specimens (Douthitt, 1917: 17), we prefer to 5120 keep ANT COR 1 and MID COR 1 as unknown: maybe part of the "dentary" actually belongs 5121 to a coronoid or several, and the suture is too eroded to remain visible.
- 5122Unknown in Dendrerpetidae (Godfrey, Fiorillo & Carroll, 1987; Holmes, Carroll &5123Reisz, 1998), Doleserpeton (Sigurdsen & Bolt, 2010) and Orobates (Berman et al., 2004).
- 5124 We have scored all three coronoids as present in **Ymeria* as suggested by Clack et al. 5125 (2012a).
- 5126 Similarly, while the illustrations of **Densignathus* (Daeschler, 2000) do not show the 5127 sutures (except as stippled lines in the reconstructions), the text is so confident about their 5128 locations that we have scored all three coronoids as present in **Densignathus*. Daeschler 5129 (2000: 304) even stated: "*Coronoids*.—There are three coronoids. The posterior coronoid is 5130 the longest and [...]" (italics in the original).
- 5131 The same may hold for **Mordex*, where the sutures are not shown in the specimen 5132 drawings (there are no reconstructions) by Milner & Sequeira (2003) or Werneburg (2012a), 5133 but the latter (p. 27) stated that all three coronoids bear denticles all over; we have thus scored 5134 all three as present, consistent with the fact that the denticle field extends from the adductor 5135 fossa to the symphysis (Werneburg, 2012a: fig. 19c).
- 5136 Clack et al. (2012b: 22) confidently stated that "a fragment of the first coronoid, bearing denticles, is visible" in the *St. Louis tetrapod, but their fig. 2C only labels it 5137 5138 "coronoid", and no denticles are indicated. It appears (D. M., pers. obs. of MB.Am.1441.2) 5139 that the labial (as well as the lingual) margin of the parasymphysial is visible. Labial to it, the ragged edge of the "?coronoid" (Clack et al., 2012b: fig. 2C) actually consists of spikes that 5140 may well be denticles, although the pterygoid denticles are hemispherical; this morphology is 5141 5142 readily interpretable by comparison to Greererpeton (Bolt & Lombard, 2001: fig. 5.2, 5.3). 5143 We have thus scored state 0 of the present character and of ANT COR 3.
- 5144 In **Coloraderpeton* it seems to be impossible to tell if there were sutures in the "long 5145 coronoid series" (Pardo et al., 2017: 643, ext. data fig. 6, video); however, the series is so long 5146 that we have scored all three coronoids as present (as Pardo et al., 2017, did in their matrix). 5147 We have done the same for the similar situations of **Doragnathus* and **Diploradus* 5148 (Smithson, 1980; Clack et al., 2016).
- 5149 "Cor 2 tooth" of **Aytonerpeton* (Clack et al., 2016: fig. 4c) is the fang on the fairly 5150 well discernible anterior, not middle, coronoid; we have scored state 0 of this and the next 5151 character. 5152
- 5153 168. ANT COR 2: Anterior coronoid with (0) or without (1) fangs comparable in size to 5154 or larger than marginal dentary teeth.
- 5155 State 0 makes a surprise appearance in *Leptorophus* (Boy, 1986: 144, fig. 7b).

Acheloma (Polley & Reisz, 2011), *Platyrhinops* (Clack & Milner, 2010), *Lethiscus*(Pardo et al., 2017), *Nigerpeton* (D. M., pers. obs. of MNN MOR 70) and *Saharastega* (D.
M., pers. obs. of MNN MOR 73) have state 1.

5159 Best scored as unknown in *Colosteus*, where the pertinent part of the anterior coronoid 5160 may have broken off (Hook, 1983).

5161 The part of the coronoid where the fangs would be expected is not preserved in 5162 MB.Am.1441 (D. M., pers. obs.), unless a mysterious multipartite hole is part of an alveolus; 5163 we have scored the *St. Louis tetrapod as unknown.

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5165 169. ANT COR 3: Anterior coronoid with (0) or without (1) small teeth (denticles) 5166 forming continuous shagreen or discrete patches and the basal diameter and/or height of 5167 which is less than 30% of that of adjacent marginal dentary teeth.

Clack et al. (2016: 6) wrote: "Some colosteids lack coronoid teeth, and instead bear 5168 5169 shagreen, a variable condition among individuals", citing Bolt & Lombard (2001), who in fact 5170 reported no such individual variation, indeed no variation at all between the specimens they studied except for the presence of "denticles" on the middle coronoid in *Deltaherpeton and 5171 5172 their absence in Greererpeton (Bolt & Lombard, 2001: table 1: ch. 89); "teeth" on the middle 5173 coronoid are present in both taxa (ch. 87), and in both taxa the "smallest teeth" on that bone are arranged in more than one row (ch. 88). While RC07 used 30% of the size of the marginal 5174 5175 teeth as the cutoff point between "teeth" and "denticles", Bolt & Lombard (2001) used 10%. Accepting, like RC07, the inference (Bolt & Lombard, 2001, based on comparison to 5176 5177 *Deltaherpeton) that Greererpeton had both middle and posterior coronoids, we find that 5178 RC07 scored the denticles and toothrows of *Greererpeton* accurately except for missing the rows of very small teeth, which nonetheless seem to count as such under their/our definition, 5179 5180 on the middle and posterior coronoids (see MID COR 4 and POST COR 4 below).

5181 We have kept state 1 for the toothrow of *Colosteus*; although the teeth are small 5182 enough to count as denticles when compared to the dentary teeth, many or all of the upper 5183 marginal teeth would be denticles by comparison to the dentary teeth as well. Because the 5184 dentary teeth of *Colosteus* are unusually large, we have ignored the size criterion in this 5185 instance.

- 5186 State 0 is known in *Acheloma* (Polley & Reisz, 2011), *Platyrhinops* (Clack & Milner, 5187 2010) and **Saharastega* (D. M., pers. obs. of MNN MOR 73).
- 5188 *Whatcheeria* has state 1 (Lombard & Bolt, 2006), as does *Trimerorhachis* (Milner & 5189 Schoch, 2013).
 - *Eryops* is polymorphic (Werneburg, 2007b).

The coronoid teeth of **Sigournea*, **Diploradus* and arguably **Doragnathus* are (just barely) large enough not to be considered denticles (Bolt & Lombard, 2006: fig. 2; Clack et al., 2016: fig. 3d; Smithson, 1980: fig. 2); we have scored absence of denticles and presence of a toothrow (see below) for all three OTUs and all three coronoids, even though **Diploradus* and, for a short stretch on the middle coronoid, **Sigournea* have two rows instead of the usual one.

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5198 170. ANT COR 4: Anterior coronoid with (0) or without (1) anteroposterior tooth row 5199 orientated sub-parallel to marginal dentary teeth and the basal diameter and/or height 5200 of which is 30% or greater than that of marginal teeth and twice or more that of 5201 denticles, if present.

5202 State 1 is now documented in *Trimerorhachis* (Milner & Schoch, 2013), *Acheloma* 5203 (Polley & Reisz, 2011), *Platyrhinops* (Clack & Milner, 2010) and *Lethiscus* (Pardo et al., 5204 2017) and is also preserved in **Nigerpeton* (D. M., pers. obs. of MNN MOR 70) and 5205 **Saharastega* (D. M., pers. obs. of MNN MOR 73). 5206 Jeannot, Damiani & Rubidge (2006: 831) stated that **Lydekkerina* has state 0; 5207 Hewison (2007: 35) quoted that, but illustrated state 1 in fig. 34. Given the polymorphism that 5208 **Lydekkerina* shows in many other characters (such as POST COR 4), we have tentatively 5209 scored polymorphism here as well.

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5211 171. MID COR 1: Separately ossified middle coronoid: present (0); absent (1).

Baphetes has state 0 (Milner, Milner & Walsh, 2009), as do **Nigerpeton* (D. M., pers. obs. of MNN MOR 70) and **Saharastega* (D. M., pers. obs. of MNN MOR 73).

5214 *Batropetes* apparently has state 1 (Glienke, 2013, 2015), as does *Orobates* (Berman, 5215 Reisz & Scott, 2010).

5216 Unknown in Dendrerpetidae (Godfrey, Fiorillo & Carroll, 1987; Holmes, Carroll & 5217 Reisz, 1998); see ANT COR 1 for *Diplocaulus*.

Pardo et al. (2017) reconstructed only one coronoid (here interpreted as the anterior one, see above) in *Lethiscus*, followed distally by a long gap. This gap may of course have been filled in life by further coronoids which may well be too crushed to identify in the CT scan; we have therefore kept the middle and the posterior coronoid as unknown. Note that Pardo et al. (2017) scored *Lethiscus* as having three coronoids without discussing this decision.

- 5225 172. MID COR 2: Middle coronoid with (0) or without (1) fangs comparable in size to or 5226 larger than marginal dentary teeth.
- 5227 State 0 makes a surprise appearance in AMNH 4565, the type specimen of 5228 *Trimerorhachis insignis* (D. M., pers. obs.), and most likely in AMNH 4572. This was scored 5229 as MID COR 4(0) in RC07, but does not fulfill its definition: the fang is not larger than the 5230 marginal teeth. – At the same time, Milner & Schoch (2013) strongly implied the absence of 5231 fangs in a different specimen; we have scored *Trimerorhachis* as polymorphic. The mention 5232 of "no coronoid fangs" in their diagnosis of *Trimerorhachis* (p. 115) may assume a different 5233 definition of "fang" than the strictly size-based one used by RC07.
- Accepting, like RC07, that the middle coronoid is present in *Colosteus* (see ANT COR 1 above), state 1 is strongly suggested by Hook (1983: fig. 3A, 6B).
- 5236 *Balanerpeton* (Milner & Sequeira, 1994), *Doleserpeton* (Sigurdsen & Bolt, 2010), 5237 *Nigerpeton* (D. M., pers. obs. of MNN MOR 70) and *Saharastega* (D. M., pers. obs. of 5238 MNN MOR 73) have state 1 in any case.

Ahlberg & Clack (1998: fig. 10A) explicitly indicated a pair of fangs on the middle coronoid of **Elginerpeton*, but stated in the text (p. 27): "The middle and posterior coronoids do not carry distinct fang pairs." Because not only the two teeth indicated in the figure, but the entire toothrow (MID COR 4) would count as fangs under the definition used here, we have scored state 0; we have scored POST COR 2 as unknown, because the part of the posterior coronoid where fangs would be expected is not known (Ahlberg, Friedman & Blom, 2005).

5247 173. MID COR 3: Middle coronoid with (0) or without (1) small teeth (denticles) forming 5248 continuous shagreen or discrete patches and the basal diameter and/or height of which 5249 is less than 30% of that of adjacent marginal dentary teeth.

5250 *Baphetes* has state 0 (Milner, Milner & Walsh, 2009). So do *Trimerorhachis* (Milner 5251 & Schoch, 2013; D. M., pers. obs. of AMNH 4565) and **Saharastega* (D. M., pers. obs. of 5252 MNN MOR 73).

5253 *Eryops* is polymorphic (Werneburg, 2007b).

5254 "The middle coronoid of *Doleserpeton* has either large denticles or small teeth", so
5255 Sigurdsen & Green (2011: appendix 2: 14) recommended to score it as unknown; we have
5256 followed this.
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5258 174. MID COR 4: Middle coronoid with (0) or without (1) anteroposterior tooth row 5259 orientated subparallel to marginal dentary teeth and the basal diameter and/or height of 5260 which is 30% greater than that of marginal teeth and twice or more that of denticles, if 5261 present.

5262 State 0 is apparently found in *Greererpeton*, in that some of the teeth in the row fulfill 5263 the size criterion (Bolt & Lombard, 2001: fig. 1, 2, 5). We have also scored it in *Colosteus* 5264 (Hook, 1983: fig. 3A, 6B; see ANT COR 1, ANT COR 3 and MID COR 2 above).

5265 *Trimerorhachis* has state 1, see MID COR 2. So do *Balanerpeton* (Milner & Sequeira, 5266 1994), **Nigerpeton* (D. M., pers. obs. of MNN MOR 70) and **Saharastega* (D. M., pers. obs. 5267 of MNN MOR 73).

5268 "The middle coronoid of *Doleserpeton* has either large denticles or small teeth", so
5269 Sigurdsen & Green (2011: appendix 2: 14) recommended to score it as unknown; we have
5270 followed this.
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5272 175. POST COR 1: Separately ossified posterior coronoid: present (0); absent (1).

5273 *Baphetes* has state 0 (Milner, Milner & Walsh, 2009), as do *Trimerorhachis* (Milner & 5274 Schoch, 2013; D. M., pers. obs. of AMNH 4565), *Brachydectes* (Pardo & Anderson, 2016) and likely *Diplocaulus* (Douthitt, 1917: 17), although we prefer to keep all POST COR characters unknown for the latter.

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Batropetes apparently has state 1 (Glienke, 2013, 2015).

5278 The coronoid of *Pantylus* is so large that it may well represent a fusion of all three 5279 coronoids, or the crowded teeth may simply obscure the sutures between two or three 5280 coronoids; but because it has not been possible to trace sutures (Romer, 1969: 24; CG78) and 5281 because the coronoid participates in the coronoid process, we here homologize it with the 5282 posterior coronoid and have scored the other two coronoids as absent (keeping the scores of 5283 RC07 for ANT COR 1, MID COR 1 and POST COR 1).

The evidence for any coronoids in **Sparodus* is limited to a pair of tusks (Fig. 4; Carroll, 1988) and a probable suture between the bone that bears them and the dentary (D. M., pers. obs. of NHMW 1899/0003/0006; Fig. 4). Parsimoniously, we assume that these tusks are homologous to those of *Pantylus*, so we have scored **Sparodus* as possessing a posterior coronoid and fangs on it (see POST COR 2 below) and have scored all other coronoid characters as unknown.

5290 As *Stegotretus* had coronoid tusks that look homologous to those of *Pantylus* and 5291 **Sparodus* (see POST COR 2), we have assigned state 0 to *Stegotretus* as well.

It is not clear which coronoid(s) is/are preserved in the *Goreville microsaur (Lombard & Bolt, 1999), but the posterior one is probably the safest bet because it is the most common one to occur in complete specimens of other OTUs.

- 5295 Similarly, *Diceratosaurus* has two toothrows in each lower jaw ramus, and sutures are 5296 not visible (D. M., pers. obs. of CM 29593, CM 29876 and CM 34668); because they extend 5297 equally far caudally, we assign the lingual one to the posterior coronoid.
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5299 176. POST COR 2: Posterior coronoid with (0) or without (1) fangs comparable in size to5300 or larger than marginal dentary teeth.

5301RC07 copied the scores of Ahlberg & Clack (1998), but used a different definition of5302"fangs". Ch. 15 of Ahlberg & Clack (1998: 43) reads: "Fangs on posterior coronoid5303recognisable because much bigger than marginal teeth: yes (0); no (1)." Under the definition

of RC07, *Ventastega* has state 0, because the largest two alveoli on the posterior coronoid are much larger than most and larger than most or all alveoli on the dentary (Ahlberg & Clack, 1998: fig. 14B), in addition to being much larger than all other alveoli on the posterior coronoid itself. They are part of the toothrow on that bone, but this is also the case for the considerably larger fang pairs on the other two coronoids, which were scored as fangs.

5309 State 0 makes a surprise appearance in AMNH 4565, the type specimen of 5310 *Trimerorhachis insignis* (D. M., pers. obs.): the caudalmost member of the denticle field 5311 reaches the size of a dentary tooth. This is not apparent from the illustration of this specimen 5312 – or at least a specimen with the same number – by Milner & Schoch (2013: fig. 7C), where 5313 the entire field is only shown as black spots symbolizing alveoli, or in their reconstruction 5314 (fig. 7B). As explained under MID COR 2, we have scored *Trimerorhachis* as possessing 5315 state 0.

5316 Boy (1986: fig. 15b) showed one tooth on the posterior coronoid of 5317 Schoenfelderpeton; he called it "a large denticle" on p. 154, but added that it is "not smaller 5318 than the dentary teeth". It is thus large enough to count as state 0 of this character. Unfortunately it is not clear if the preservation of that specimen is good enough to rule out a 5319 5320 toothrow (POST COR 4(0)), but in the drawing the sutures between the dentary, the posterior 5321 coronoid and the prearticular are shown as unbroken lines well anterior (mesial) to the tooth, 5322 implying that the space where a toothrow would have one or two alveoli is preserved and does 5323 not bear teeth. We have scored state 0 for Schoenfelderpeton.

5324 State 0 is moreover found in *Pantylus*, *Stegotretus* and **Sparodus* (see POST COR 1 sbove).

5326 *Whatcheeria* (Lombard & Bolt, 2006) and *Doleserpeton* (Sigurdsen & Bolt, 2010) 5327 have state 1, as do *Brachydectes* (Pardo & Anderson, 2016) and *Diceratosaurus* (see POST 5328 COR 1).

5329 Under the present definition, at least the first two teeth on the posterior coronoid of 5330 **Densignathus* are fangs (Daeschler, 2000: fig. 2).

5331 We have scored **Elginerpeton* as unknown (see MID COR 2), although most of the 5332 toothrow (POST COR 4) counts as fangs under the definition used here.

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5334 177. POST COR 3: Posterior coronoid with (0) or without (1) small teeth (denticles) 5335 forming continuous shagreen or discrete patches and the basal diameter and/or height of 5336 which is less than 30% of that of adjacent marginal dentary teeth.

Baphetes has state 0 (Milner, Milner & Walsh, 2009). So do Dendrerpetidae (Godfrey,
Fiorillo & Carroll, 1987) and *Pantylus* (see POST COR 1 above).

5339 *Doleserpeton* (Sigurdsen & Bolt, 2010), *Diadectes* (Berman, Sumida & Martens, 5340 1998: fig. 11), *Rhynchonkos* (Szostakiwskyj, Pardo & Anderson, 2015) and *Brachydectes* 5341 (Pardo & Anderson, 2016) show state 1.

5342 *Colosteus* may have a double toothrow like **Diploradus*; whether additional denticles 5343 were present is not clear from the published drawing (Hook, 1983: fig. 9). Ignoring the size 5344 criterion (see ANT COR 3 above), we have therefore scored *Colosteus* as unknown.

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5346 178. POST COR 4: Posterior coronoid with (0) or without (1) anteroposterior tooth row 5347 orientated sub-parallel to marginal dentary teeth and the basal diameter and/or height 5348 of which is 30% or greater than that of marginal teeth and twice or more that of 5349 denticles, if present.

5350 *Greererpeton* has a row of three fairly large teeth and thus state 0 (Bolt & Lombard, 5351 2001).

5352 *Colosteus* lacks that row, but may have a double row of smaller teeth like **Diploradus* 5353 (Hook, 1983: fig. 9; see POST COR 3 immediately above); we have scored it as unknown.

Trimerorhachis (Milner & Schoch, 2013; D. M., pers. obs. of AMNH 4565) and 5354 5355 Doleserpeton (Sigurdsen & Bolt, 2010) have state 1, as do Anthracosaurus (Panchen, 1977: 5356 fig. 10), Limnoscelis (Reisz, 2007; Berman, Reisz & Scott, 2010), Rhynchonkos (Szostakiwskyj, Pardo & Anderson, 2015) and Brachydectes (Pardo & Anderson, 2016). 5357 5358 Pantylus has state 0 (Romer, 1969; CG78 - at least the labialmost seven teeth may be 5359 considered a row), as do Batrachiderpeton (Bossy & Milner, 1998 - two rows surrounding a 5360 denticle field) and Diceratosaurus (see POST COR 1 above).

5361 *Glanochthon is polymorphic, with *G. latirostris having state 1 and *G. angusta 5362 having state 0 (Boy, 1993; Schoch & Witzmann, 2009b).

*Lydekkerina appears to be polymorphic as well (Hewison, 2007).

5365 179. POST COR 5-7: Posterior coronoid without posterodorsal process (0); with a process that does not contribute to the tallest point of lateral margin of adductor fossa 5366 5367 (1); or with a process that does (2) (ordered). This is a continuous character (gradual 5368 enlargement of the posterodorsal process).

Whatcheeria has state 2 (Lombard & Bolt, 2006), and so do Isodectes (D. M., pers. 5369 5370 obs. of unnumbered MCZ cast of AMNH 6935 before etching), Ecolsonia (D. M., pers. obs. 5371 of CM 38024), Doleserpeton (Sigurdsen & Bolt, 2010: fig. 3C), Brachvdectes (Pardo &

- Anderson, 2016) and *Nigerpeton (D. M., pers. obs. of MNN MOR 70). 5372 5373 Cochleosaurus has state 1 (Sequeira, 2004), as do Limnoscelis (Reisz, 2007) and
- 5374 Rhynchonkos (Szostakiwskyj, Pardo & Anderson, 2015).

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5375 State 0 is found in Trimerorhachis (Milner & Schoch, 2013; D. M., pers. obs. of 5376 AMNH 4565). 5377

Gephyrostegus has state 1 or 2 (Klembara et al., 2014: fig. 3, 6).

5378 We follow the text (p. 509) rather than the label in fig. 4D of Schoch & Rubidge 5379 (2005) in scoring state 2 for **Micropholis*.

- 5380 Hewison (2007) claimed state 0 for *Lvdekkerina. The accompanying reconstruction 5381 drawing (Hewison, 2007: fig. 34), however, shows state 2, even though the process is very 5382 low.
- 5383 The lower jaw of *Neopteroplax is so strongly C-shaped that the meaning of "tallest 5384 point" is unclear. Measuring more or less along the curve, we have scored state 2, in keeping with the fact that the surangular crest is unusually low for an anthracosaur (Romer, 1963: 429, 5385 5386 fig. 6). 5387
- 5388 180. POST COR 6: Posterior coronoid exposed in lateral view: no (0); yes (1).

5389 Baphetes has state 0 (Milner, Milner & Walsh, 2009). So do Edops (as far as D. M. 5390 can tell from pers. obs. of MCZ 1378, where the area is partly covered by upper-jaw fragments), Cochleosaurus (Sequeira, 2004), Limnoscelis (Reisz, 2007; Berman, Reisz & Scott, 5391 5392 2010), Rhynchonkos (Szostakiwskyj, Pardo & Anderson, 2015) and Tseajaia (Berman, Reisz 5393 & Scott, 2010).

- 5394 Phonerpeton (D. M., pers. obs. of MCZ 1414), Ecolsonia (D. M., pers. obs. of CM 5395 38024), Doleserpeton (Sigurdsen & Bolt, 2010: fig. 3C), Pantylus (Romer, 1969: 24), Brachydectes (Pardo & Anderson, 2016), Orobates (Berman, Reisz & Scott, 2010) and 5396 5397 *Nigerpeton (D. M., pers. obs. of MNN MOR 70) show state 1.
- 5398 We follow the text (p. 509) rather than the label in fig. 4D of Schoch & Rubidge 5399 (2005) in scoring state 2 for *Micropholis. 5400
- 181. ADD FOS 1: Adductor fossa facing dorsally (0) or lingually (1). This is actually a 5401 5402 continuous character, and it is not clear where the line is supposed to be drawn. Fairly much is 5403 visible of the adductor fossa of Whatcheeria in medial view, yet Lombard & Bolt (2006: 26f.)

stated that "[t]he adductor fossa opens mostly dorsally, as in other early tetrapods and the 5404 5405 osteolepiform sarcopterygians related to them", in other words counting Whatcheeria as 5406 possessing state 0 (as scored by RC07).

Even so, state 1 is found in Greererpeton (Bolt & Lombard, 2001), Baphetes (Milner, 5407 5408 Milner & Walsh, 2009), Doleserpeton (Sigurdsen & Bolt, 2010), Lethiscus (Pardo et al., 2017) 5409 - contrary to their matrix), and Eocaecilia (Jenkins, Walsh & Carroll, 2007), although we wonder if the latter should be scored as inapplicable because its subtemporal fenestra faces 5410 5411 labioventrally rather than just ventrally.

5412 Yet, state 0 occurs in Albanerpetidae (Albanerpeton inexpectatum: Estes & 5413 Hoffstetter, 1976: pl. VII; Gardner, 2001: fig. 5), Batropetes (Glienke, 2013, 2015), Pantylus (Romer, 1969: fig. 15), Rhynchonkos (Szostakiwskyj, Pardo & Anderson, 2015: fig. 5D - the 5414 5415 labial rim is drawn out into a tall crest, but the lingual rim is straight rather than embayed 5416 ventrally), Brachydectes (Pardo & Anderson, 2016), Batrachiderpeton (Bossy & Milner, 5417 1998), Diplocaulus (Douthitt, 1917), *Carrolla (Maddin, Olori & Anderson, 2011) and 5418 *Chelotriton (Schoch, Poschmann & Kupfer, 2015).

5419 Following the reconstructions in CG78: fig. 114, we have also tentatively assigned 5420 state 0 to Hapsidopareion (which was scored as unknown in RC07), Micraroter, 5421 Cardiocephalus and Euryodus, where the labial rim of the adductor fossa is much taller than the lingual one only because of the tall coronoid process, while the lingual rim is more or less 5422 5423 on the same level with the articular and the toothrow.

5424 Bystrow (1944: fig. 6) showed state 0 in Kotlassia as well. Note that this is not shared 5425 by *Karpinskiosaurus (Klembara, 2011: fig. 9D, E). 5426

Unknown in Stegotretus (Berman, Eberth & Brinkman, 1988).

5427 *Lydekkerina appears to change from state 1 (Jeannot, Damiani & Rubidge, 2006: fig. 5428 4D) to state 0 as seen in Whatcheeria (Hewison, 2007: fig. 34) in ontogeny. We have scored 5429 state 0. 5430

5431 182. TEETH 1: Marginal tooth pedicely at any point in ontogeny: absent (0); present (1). 5432 This character is usually difficult to score in small animals unless sections and electron 5433 micrographs are made – or unless the tooth crowns have fallen off post mortem, leaving the 5434 pedicels in place (a very common occurrence in lissamphibian fossils). When the tooth crowns are in place, ambiguity is common. As an example, there is a consensus (Clack & 5435 5436 Milner, 2010: 288, fig. 6, 8; and references therein) that *Platyrhinops* shows state 0 (as scored 5437 by RC07 – Pardo, Small & Huttenlocker [2017: supplementary information part E] mentioned 5438 state 1 in passing, but this is an error). Yet, the lingual side of CM 72646 (a natural mold of the mesial part of a lower jaw; D. M., pers. obs.) has two mesiodistal breaks, one distal to the 5439 5440 other, that run through several teeth each, giving the impression of pedicely at first glance. 5441 These breaks, however, continue through the matrix between the teeth and have crooked, 5442 jagged, parallel edges instead of straight or rounded smooth ones. They probably follow, more 5443 or less, the labial jaw margin, which is much taller than the lingual one; the labial side of the 5444 specimen shows no breaks and preserves only the tips of the teeth. In a smaller specimen, 5445 where the edges of the breaks would be more difficult to see and/or there would be less space 5446 between the teeth, it might not be possible to determine whether the teeth were pedicellate.

5447 Most OTUs that are potentially relevant to lissamphibian origins remain to be 5448 investigated.

5449 We have added the specification about ontogeny because pedicely often appears 5450 during lissamphibian ontogeny and is commonly absent in neotenic salamanders.

5451 Bolt (1979: 545) wrote about the teeth of Amphibamus: "Some appear to be 5452 pedicellate (see Fig. 8 and discussion below), although it is difficult to be sure of this on the 5453 basis of a cast." The cited fig. 8 shows what looks at least as much like a break as like an unmineralized zone. We therefore follow Sigurdsen & Bolt (2010) and Sigurdsen & Green
(2011: appendix 2) in scoring *Amphibamus* as unknown.

5456 *Apateon* and *Schoenfelderpeton* were scored as unknown, but the only published 5457 report of pedicely in any branchiosaurid specimen (*Apateon*: Schoch & Carroll, 2003) looks 5458 very much like a preservational artefact to us. We have therefore scored both taxa as having 5459 state 0.

We have kept state 0 for *Diceratosaurus*, but it is noteworthy that each of its teeth is ringed by a constriction near the tip; postmortem breakage at this point, while by no means universal within an individual, appears to be common (D. M., pers. obs. of several CM specimens). Indeed, all marginal teeth of MB.Am.778 (D. M., pers. obs.) are broken at what seems to be the same height, making at least the anatomical left side look like most jaw specimens of fossil lissamphibians or *Doleserpeton*.

5466 The mode of preservation suggests state 0 in *Lethiscus* and **Coloraderpeton* (Pardo et 5467 al., 2017).

5468 Carroll (1998a: fig. 4B, 8A) illustrated a dentary and maxillae of *Oestocephalus* where 5469 many teeth appear to be broken at the same level, as if the crowns had fallen off of pedicels, 5470 and mentioned this similarity on p. 158. We have scored *Oestocephalus* as unknown, even 5471 though other specimens (such as CM 29596, CM 29891 and CM 68353; D. M., pers. obs.) do 5472 not show evidence of pedicely.

5473 Germain (2008b) cautiously suggested on the basis of electron micrographs that the 5474 teeth of *Phlegethontia* could be pedicellate, interpreting two possible breaks as the separation 5475 between tip and pedicel and between tooth and jawbone. We have therefore scored it as 5476 unknown.

5477 *Notobatrachus* has state 0 (Báez & Nicoli, 2004), a likely reversal also found in the 5478 **pipoids and ***Ascaphus*. We have further assigned state 0 to **Liaobatrachus*, where all 5479 tooth crowns appear to be preserved and there is no evidence for pedicels (figures in Dong et 5480 al., 2013), although Dong et al. (2013), surprisingly, did not mention this question at all.

5481 Anderson et al. (2008a) reported pedicely in *Gerobatrachus. However, as pointed out 5482 previously (Marjanović & Laurin, 2008), not one of the teeth is preserved as a lone pedicel -5483 there are only complete teeth and empty alveoli. Given the facts that the resolution of the 5484 photo (fig. 3a) is too low to tell, that we have not seen the specimen (the forthcoming detailed 5485 description by Anderson et al. will doubtless provide additional information) and that the 5486 single known specimen does not provide ontogenetic information, we have scored it as 5487 unknown, even though pedicellate teeth would not be surprising in a close relative of Doleserpeton (where they are indeed present, as scored by RC07 [Bolt, 1991: fig. 4; 5488 5489 Sigurdsen & Bolt, 2010]) - and even though Sigurdsen & Bolt (2010), who had seen the 5490 specimen, considered it to lack pedicely. - Very recently, Pardo, Small & Huttenlocker (2017: supplementary information part E) reported that "[p]edicellate morphology, but no clear 5491 5492 dividing zone between pedicel and crown, is seen in [...] Gerobatrachus", which - in the 5493 absence of ontogenetic information - confirms that the correct score is unknown.

5494Although most tooth crowns are not preserved, *Saharastega has state 0 (D. M., pers.5495obs. of MNN MOR 73).

5496 We interpret the complete teeth and empty alveoli of **Sparodus* (Carroll, 1988) as the 5497 unsurprising absence of pedicely in this "microsaur".

5498 We follow Maddin, Olori & Anderson (2011) in interpreting the teeth of **Carrolla* as 5499 possibly pedicellate, i.e., unknown for this character.

5500 One of the two lower jaws known from **Diploradus* was not figured by Clack et al. 5501 (2016), so we do not know if it preserves complete teeth, which are shown in the 5502 reconstruction drawing (bottom of fig. 3d). The lower jaw of the type specimen, drawn above the reconstruction, seems to show all teeth broken at a similar level. We have scored the present character (as well as the other tooth-tip characters: TEETH 3, 6, 7, 10) as unknown.

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183. TEETH 3: Maximum number of labiolingually arranged cusps per tooth at any point in ontogeny: one cusp (0); a ridge (1); two or three separate cusps (2) (ordered). We have ordered this partially meristic, partially continuous character.

The original wording was: "Marginal teeth without (0) or with (1) two cuspules 5509 5510 labiolingually arranged." RC07 went on to state that the mesiodistally arranged cusps of 5511 Batropetes and Albanerpetidae "cannot be treated as an alternative state, as they are not 5512 readily comparable". The two OTUs in question were scored 0. We do not understand why this condition was not treated as a third state of the same character (as done by Marjanović & 5513 5514 Laurin, 2008); however, given the diversity of cusp arrangements among the OTUs of this 5515 matrix (especially the OTUs we have added), we have instead split this character, treating the 5516 number of labiolingually (TEETH 3) and mesiodistally arranged cusps (the new character 5517 TEETH 10) separately. Taxa that have two or more cusps in both directions do not occur in this matrix, but exist - "HOMO nofce Te ipsum", as Linnaeus (1758) wrote ("**human, learn 5518 5519 to know yourself"; capitals and italics in the original).

5520 State 1 occurs in "cf. *Broiliellus* sp." according to Bolt (1977). Because Carroll (1964) 5521 explicitly reported state 0 for *Broiliellus brevis*, we think that the specimen Bolt described 5522 does not belong to the latter species, for which we have therefore kept the score of 0. State 1 5523 is, however, found in *Cardiocephalus* (Anderson & Reisz, 2003; Anderson, 2007b); as 5524 Anderson & Reisz (2003) pointed out, this state may be much more widespread but widely 5525 overlooked.

- 5526 State 2 is found in *Diadectes* (which has three cusps in a labiolingual row: Berman et 5527 al., 2004) and *Orobates* (Berman et al., 2004).
- 5528 *Lethiscus* has state 0 (Pardo et al., 2017).
- 5529 Unknown in *Pederpes* (Clack & Finney, 2005: 322).
 - *Saharastega has state 0 (D. M., pers. obs. of MNN MOR 73).

**Carrolla* has two cusps per teeth; according to Maddin, Olori & Anderson (2011), it
 is not clear if they were arranged labiolingually or mesiodistally in life. As for character
 TEETH 10, we have therefore assigned state 0 or 2 to **Carrolla*.

5534 Because crown-group salamanders replace mono- by bicuspid teeth during 5535 metamorphosis, we have scored the neotenic **Beiyanerpeton*, which has monocuspid teeth, as 5536 unknown. 5537

184. TEETH 4: Conspicuous peak involving one or more anterior maxillary teeth: absent (0); present (1).

Acanthostega has state 1: a clear caniniform region is preserved in the holotype of the only species, *A. gunnari* (D. M., pers. obs. of TMM 41766-1, a cast of MGUH VP 6033). This may also have been noted by Clack & Milner (2015: 18), who noted that the maxillary teeth are "largest at positions 7 to 11" (even though that contradicts their fig. 3A and 6A), and possibly by Porro, Rayfield & Clack (2015: 10). Given the (already scored) presence of state 1 in *Ventastega, Ichthyostega* and *Whatcheeria*, this is less surprising than it might look at first glance.

Chenoprosopus shares state 1 (Hook, 1993), and so do *Cochleosaurus* (Sequeira, 2004), *Acheloma* (Dilkes & Reisz, 1987: fig. 3), and *Phonerpeton* (Dilkes, 1990: fig. 1) as well as *Discosauriscus* (borderline: Klembara, 1997), *Ariekanerpeton* and *Utegenia* (Bulanov, 2003; figures in Klembara & Ruta, 2004a, 2005a). *Bruktererpeton* (Boy & Bandel, 1973) and *Hapsidopareion* (CG87: fig. 14D) have a weak version of state 1.

Cardiocephalus has state 0 (CG78), as do Lethiscus (Anderson, Carroll & Rowe, 5552 5553 2003; Pardo et al., 2017) and Vieraella (Báez & Basso, 1996).

Eurvodus is polymorphic; whether the caniniform tooth of one of the two species 5554 5555 counts as "anterior" is debatable, but the number of maxillary teeth rostral to it is low. Scincosaurus is unknown for this character (Milner & Ruta, 2009).

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5557 We have assigned state 0 to *Nigerpeton because its huge maxillary tusks are not part of the marginal toothrow in MNN MOR 70 (D. M., pers. obs.). This amounts, however, to an 5558 5559 ontogenetic hypothesis: the maxillary tusks are part of the toothrow in the smaller MNN 5560 MOR 69 and not preserved in the intermediate-sized MNN MOR 108 (D. M., pers. obs.).

5561 Judging from the reconstruction by Klembara (2011: fig. 3B), *Karpinskiosaurus had a very prominent caniniform region (state 1) in the adult stage; unfortunately, neither 5562 5563 Klembara (2011) nor Bulanov (2003) mentioned this character at all, and no photographs or 5564 specimen drawings that would show it appear to have been published - the published 5565 illustrations (Bulanov, 2003; Klembara, 2011) all show younger individuals which had state 5566 0. We have provisionally scored state 1.

States 0 and 1 appear to be found in different individuals of *Lydekkerina (Jeannot, 5567 5568 Damiani & Rubidge, 2006; Hewison, 2007).

5569 Unclear in the *St. Louis tetrapod; it is even possible that there was a caniniform region on the left but not the right side of the only known specimen (Clack et al., 2012b: fig. 5570 5571 2A; D. M., pers. obs. of MB.Am.1441.2). We have scored it as unknown.

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5573 185. TEETH 5: Dentary teeth larger than maxillary teeth: no (0); yes (1).

5574 We have scored *Crassigvrinus* as having state 1 because almost all dentary teeth are larger than all maxillary ones (Clack, 1998). A very similar condition, which we have also 5575 5576 scored as state 1, is found in Dendrerpetidae (Godfrey, Fiorillo & Carroll, 1987) and Caerorhachis (Ruta, Milner & Coates, 2002). 5577

5578 In *Neldasaurus*, only $\frac{1}{3}$ to $\frac{1}{2}$ of its dentary teeth are larger than the maxillary teeth 5579 (Chase, 1965: fig. 2, 6), but we count this as state 1 because the larger teeth do not form a 5580 specialized caniniform (or other) region.

Trimerorhachis has state 1 (Case, 1935: fig. 13, pl. VII; Milner & Schoch, 2013), as 5581 5582 does Platyrhinops (Clack & Milner, 2010).

"The individual teeth are definitely longer and have a greater diameter than those of 5583 5584 the upper jaw" (CG78); we have accordingly scored state 1 for Micraroter.

5585 State 0 is shown for Bruktererpeton in table 7 of Boy & Bandel (1973). It is also 5586 present in Solenodonsaurus (where the maxillary teeth are indeed larger than the dentary 5587 ones: Danto, Witzmann & Müller, 2012), Scincosaurus (from comparing fig. 2A and fig. 4 of 5588 Milner & Ruta, 2009), Diceratosaurus (D. M., pers. obs. of CM 67169), Lethiscus (Pardo et 5589 al., 2017), *Nigerpeton (D. M., pers. obs. of MNN MOR 70) and *Saharastega (D. M., pers. 5590 obs. of MNN MOR 73).

5591 Following Bystrow (1944) and DEN 7 (see above), we have scored state 0 for 5592 Kotlassia.

5593 Orobates was scored as polymorphic in RC07, presumably due to its long incisiform 5594 dentary teeth that are longer than the maxillary teeth (and oppose similarly long incisiform 5595 teeth on the premaxilla). We exclude incisiform teeth (a very rare specialization in this 5596 matrix) from consideration and therefore score Orobates as possessing only state 0.

5597 Sequeira & Milner (1993) reconstructed Capetus with a mild version of state 1 (in 5598 more than half of the toothrow).

5599 **Crinodon* is apparently borderline; we have scored it as unknown.

5600 The dentary teeth of *Palatinerpeton (Boy, 1996) vary in size, being smaller opposite 5601 the caniniform region of the maxilla and premaxilla but larger elsewhere. Many are larger than most of its right maxillary teeth, but this may not hold for the left side; we have scored **Palatinerpeton* as unknown.

5604 The few exposed dentary teeth of **Erpetosaurus* are no larger than the tiny maxillary 5605 teeth (Milner & Sequeira, 2011); however, the dentary teeth of the same region of *Isodectes* 5606 are no larger than the maxillary teeth either, while the remaining ones are easily twice as large 5607 (Sequeira, 1998), so we have scored **Erpetosaurus* as unknown.

5608 State 1 is strongly suggested for **Pholidogaster* by Romer (1964: fig. 3, alone and in 5609 comparison with pl. 1); we have scored **Pholidogaster* accordingly, even though Romer 5610 (1964) nowhere mentioned this character in the text.

5611 Unless the distalmost teeth in the right maxilla are all much less far erupted than the 5612 dentary teeth opposite them, the *St. Louis tetrapod has state 1; the discrepancy is larger than 5613 shown by Clack et al. (2012b: fig. 2A, B), because those are ventral and ventrolabial views 5614 rather than strictly labial ones (D. M., pers. obs. of MB.Am.1441.2). However, the 5615 discrepancy is still noticeably smaller than in Greererpeton (let alone Colosteus; Smithson, 5616 1982; Hook, 1983); in addition, the dentary teeth are distinctly smaller than the ectopterygoid fang next to them, quite unlike in Greererpeton and Colosteus. In order to emphasize this 5617 5618 difference, we have accepted the claim of "no clear discrepancy in tooth size between upper 5619 and lower jaw rami" (Clack et al., 2012b: 22) and scored state 0.

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5621 186. TEETH 6: Marginal tooth crowns chisel-tipped: no (0); yes (1).

5622 *Lethiscus* has state 0 (Pardo et al., 2017), as does **Saharastega* (D. M., pers. obs. of MNN MOR 73).

5624 *Oestocephalus* was scored in RC07 as having state 0 or 1; it has 0 and 1, respectively, 5625 in different specimens (species?) from different sites (Carroll, 1998a), so we have scored 5626 polymorphism. 5627

5628 187. TEETH 7: Marginal tooth crowns without (0) or with (1) 'dimple'.

*Saharastega has state 0 (D. M., pers. obs. of MNN MOR 73).

5631 188. TEETH 8: Marginal tooth crowns robust and conical: absent (0); present (1). Such 5632 teeth require so much space that not many of them fit into a maxilla (apparently never more than 12 or perhaps 15), so that state 1 makes TEETH 9 inapplicable. Simply adding this state 5633 5634 to TEETH 9, however, is not an option: in Batropetes, each maxilla bears 4 to 6 mostly 5635 cylindrical teeth (mostly or entirely individual variation) and is small enough to only have 5636 space for 10, yet the teeth are thin and cylindrical except for an expanded, tricuspid tip (Glienke, 2013, 2015); in Brachydectes and *Carrolla, each maxilla holds only 5-8 relatively 5637 5638 enormous teeth that are pointed but recurved and much taller (thus thinner) than in taxa with 5639 state 1 (Maddin, Olori & Anderson, 2011; Pardo & Anderson, 2016); in Scincosaurus, there are 8 slender, stalked teeth per maxilla (Bossy & Milner, 1998; Milner & Ruta, 2009); 5640 5641 Keraterpeton, Batrachiderpeton and Diceratosaurus have similarly few teeth of entirely 5642 plesiomorphic shape and size (Bossy & Milner, 1998; D. M., pers. obs. of Diceratosaurus 5643 specimens), while those of Diploceraspis are large and have an intermediate shape 5644 (Beerbower, 1963) - when teeth are very few in number, they are not necessarily robust and 5645 conical.

5646 Carroll (1969a) reconstructed *Acherontiscus* as having 15 maxillary teeth; the 5647 preserved teeth – the last 4 – are robust and bluntly conical. We count this as state 1. 5648

5649 189. TEETH 9: Number of maxillary teeth greater than 40 (0), between 30 and 40 (1), 5650 between 13 and 29 (2); smaller than 13 (3) (ordered). As this is a meristic (practically 5651 continuous) character, we have ordered it. Indeed, unambiguous changes between states 0 and 5652 2 are seen only three times in the shortest trees from Analysis R4, and state 3 only changes to 5653 (once) and from state 2 (twice), while the character as a whole has 48 steps.

5654 Even apart from this, the distribution of the states is nowhere near random. State 1 or higher is an autapomorphy (reversed a minimum of nine times) of the smallest clade that 5655 contains *Ymeria and the crown-group; state 2 is rare in temnospondyls, and state 3 is limited 5656 5657 to two clades of amphibians, while almost all members of the seymouriamorphdiadectomorph-amniote-amphibian clade have state 2 or 3 (where applicable - see above). 5658 Clearly, the claim that this character contains "little phylogenetic signal" (RC07) is not 5659 5660 tenable.

5661 State 3 is new, and found in Batropetes, Brachydectes, Scincosaurus, Keraterpeton, Batrachiderpeton, Diceratosaurus, Diploceraspis and *Carrolla (see TEETH 8); state 2 of 5662 RC07 was simply "smaller than 30". The cutoff is chosen so that Albanerpeton inexpectatum 5663 retains state 2; it has 15 to 23 teeth per maxilla (Estes & Hoffstetter, 1976: 312), while no 5664 5665 OTU in this matrix seems to have 13 or 14.

5666 Colosteus has at least 34 maxillary teeth (Hook, 1983: fig. 1), giving it state 0 or 1. 5667

Isodectes seems to have state 1 or 2 (Sequeira, 1998: 252 and fig. 9B, C).

5668 Trimerorhachis has state 0 (Milner & Schoch, 2013).

5669 Acheloma seems to have had 30 maxillary teeth at the most (Polley & Reisz, 2011), giving it state 1 or 2. 5670

Micromelerpeton was scored as unknown in RC07. Boy (1972: 25) reported state 1, 5671 5672 agreeing with the reconstruction (fig. 5) and possibly with a specimen drawing (fig. 4p) in the 5673 same paper, so we have scored state 1.

5674 Apateon, too, was scored as unknown. Schoch & Milner (2008: fig. 4E) reconstructed A. pedestris with 25 teeth on one maxilla and 26 on the other; this resolves to state 2. Boy 5675 5676 (1987: 84; translated by D. M.), however, ascribed "maximally 23-35 teeth" to A. pedestris, 5677 spanning states 1 and 2. State 2 was also reported for A. dracvi (as "A. dracviformis") by Boy 5678 (1986: 158, 1987: 90), although this may be due to skeletal immaturity (the maxilla is very 5679 short); state 1 was confirmed for A. caducus by Boy (1987: 88 – "Long, slender maxilla [...] 5680 bears more than 30 teeth"; translated by D. M.). Metamorphosed A. gracilis, however, has 5681 state 0 with about 50 maxillary teeth (Werneburg, 1991: 82); indeed, the maxilla grows with 5682 positive allometry (Werneburg, 1991: 82). We have scored state 0, because A. gracilis is the only species of A. known to undergo metamorphosis. 5683

5684 Leptorophus tener has state 0 or 1: "maxilla with maximally 37-42 teeth" (Boy, 1986: 5685 139; translated by D. M.). L. raischi has "space for about 30 teeth" in the maxilla (Schoch, 5686 2014a: 231), which would translate to state 1 or 2. Because the shorter snout of L. raischi 5687 compared to L. tener is a sign of relative skeletal immaturity and because polymorphism with 5688 partial uncertainty is impossible in PAUP*, we have ignored the possibility of state 2 and 5689 have scored Leptorophus as having states 0 and 1; Schoch (2014a) pointed out, however, that 5690 the teeth of L. raischi are larger than those of L. tener, so if the former continued to grow to 5691 the latter's snout length, it would still have fewer teeth.

5692 Bruktererpeton has "ca. 40 teeth" in the maxilla, giving it state 0 or 1 (Boy & Bandel, 5693 1973: 50, translation by D. M.).

In Kotlassia, "the number of marginal teeth remains uncertain" due to incomplete 5694 5695 preservation and incompetent preparation (Bulanov, 2003); Kotlassia was accordingly scored as unknown. However, a few maxillary teeth remain in the holotype (Bulanov, 2003); we 5696 5697 therefore trust Bystrow's (1944: fig. 2) reconstruction of state 1 even though the exact number 5698 of maxillary teeth is uncertain.

5699 State 2 is found in Cochleosaurus (Sequeira, 2004), Valdotriton (Evans & Milner, 5700 1996), apparently Lethiscus (Pardo et al., 2017) and Leptoropha (Bulanov, 2003). 5701

**Micropholis* is polymorphic, showing states 0 and 1 (Schoch & Rubidge, 2005).

5702 We estimate 20 to 25 maxillary teeth, thus state 2, for the *Goreville microsaur 5703 (Lombard & Bolt, 1999: fig. 2).

We have scored **Sigournea* as possessing state 0. The maxilla is unknown, but the dentary has so many tooth positions (88) that any other state would require the maxillary teeth to be implausibly large and/or widely spaced (Bolt & Lombard, 2006). The same holds for the 98 to 100 tooth positions in the dentary of **Doragnathus* (Smithson, 1980) and the about 90 to 100 known tooth positions in the dentary of **Elginerpeton* (Ahlberg, 1995; Ahlberg & 5709 Clack, 1998; Ahlberg, Friedman & Blom, 2005).

- 5710 Because of its paedomorphically short maxilla, we have scored **Beiyanerpeton* as 5711 having state 0 or the observed uncertainty of state 1 or 2.
- 5712States 1 and 2 are known in adult *Glanochthon (Schoch & Witzmann, 2009b: figs. 3,57134).
- 5714 Panchen (1964: fig. 13) reconstructed space for 32 teeth in **Palaeoherpeton*; we have 5715 cautiously scored state 1 or 2. 5716

5717 190. TEETH 10: Maximum number of mesiodistally arranged cusps per marginal tooth
5718 at any point in ontogeny: 1 (0), lozenge-shaped crown with mesial and distal ridges that
5719 lead to the mesial and distal corners or very short cusps (1), 3 (2), more (3) (ordered).
5720 This character is ordered for the same reasons as TEETH 3, from which it is split.

- 5721 State 0 is the plesiomorphy, found in all OTUs that preserve tooth crowns (including 5722 **Saharastega*: D. M., pers. obs. of MNN MOR 73) except for the following:
- 5723 State 1 is found in *Discosauriscus* (at least in the tooth in the third alveolus in fig. 10 5724 of Klembara 1997) and *Scincosaurus* (Milner & Ruta, 2009).
- 5725 State 2 occurs in *Batropetes* (Carroll, 1991; Glienke, 2013, 2015) and 5726 **Tungussogyrinus* (Werneburg, 2009).
 - State 3 is limited to *Leptoropha* and *Microphon* (Bulanov, 2003) in the present matrix.
- Albanerpetidae is polymorphic, with *Anoualerpeton* possessing state 1 (Gardner, Evans & Sigogneau-Russell, 2003) and its sister-group, composed of *Celtedens* and *Albanerpeton*, showing state 2 (e.g. Estes & Hoffstetter, 1976; Fox & Naylor, 1982; McGowan, 2002).
 - Westlothiana shows partial uncertainty between states 0 and 1 (Smithson et al., 1994).
- **Carrolla* has two cusps per tooth; according to Maddin, Olori & Anderson (2011), it is not clear if they were arranged labiolingually or mesiodistally in life. As for character TEETH 3, we have therefore assigned state 0 or 2 to **Carrolla* (3 cusps are the closest condition to 2).
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 5738 191. CLE 1: T-shaped dorsal expansion of cleithrum: absent (0); present (1).
- 5739 State 0 is known in *Ventastega* (Ahlberg et al., 2008), *Baphetes* (Milner & Lindsay, 5740 1998), *Cochleosaurus* (Sequeira, 2009), *Isodectes* (D. M., pers. obs. of CM 81512 and CM 5741 81430) and *Doleserpeton* (Sigurdsen & Bolt, 2010).
- 5742 CG78 (p. 60, fig. 31) identified an L- to C-shaped bone as the cleithrum in 5743 *Cardiocephalus*. We do not understand why and have kept the scores of all three CLE 5744 characters as unknown. It might be a clavicle (if so, we still cannot score the only CLA 5745 character) or an unrelated part of the fissure-fill taphocoenosis at Fort Sill.
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5732

5747 192. CLE 2: **Cleithrum with (0) or without (1) postbranchial lamina.** Probably unlike 5748 RC07, we count everything that is primarily homologous to a postbranchial lamina as state 0; 5749 this includes laminae that may have the wrong size or shape to function as a postbranchial 5750 lamina, so we do not hypothesize on which of the taxa we have scored 0 actually possessed 5751 internal gills in life. What sizes and shapes are possible for a functional postbranchial lamina

5752 has not, to the best of our limited knowledge, ever been investigated; conversely, the lamina is 5753 clearly not necessary for internal gills to function - even the lamina "of Eusthenopteron is very narrow and poorly differentiated from the cleithral blade" (Ahlberg, 1998: 113). 5754 Moreover, cleithra of limbed vertebrates are almost never illustrated or described in cranial or 5755 5756 caudal view (the postbranchial lamina is impossible to see in lateral view, and difficult or 5757 impossible to recognize in medial view at least in drawings); sometimes, like in the 5758 description of the postcranium of Greererpeton by Godfrey (1989), the lamina has been 5759 illustrated but not recognized (as previously noted by Lebedev & Coates, 1995, and Coates, 5760 1996). We suspect therefore that state 0 is more widespread than we have been able to score.

5761 Ch. 43 of Coates (1996) was called "Post-branchial lamina: present (0); absent (1)" in 5762 the character list (p. 417), but in the text Coates (1996: 400) specified "a broad postbranchial 5763 lamina (ch. 43)" (without attempting to define "broad"). This supports our interpretation that 5764 RC07 scored laminae that do not fulfill unspecified criteria of size and/or shape as state 1.

5765 Under our possibly expanded definition, state 0 is present in *Ventastega* (Ahlberg et 5766 al., 2008: fig. 2b, 3e – contradicting the text which evidently uses a stricter definition), 5767 *Baphetes* (Milner & Lindsay, 1998; Milner, Milner & Walsh, 2009), and *Archeria* (Pawley, 5768 2006: fig. 70-2.4); compare the conditions of *Ichthyostega* (Jarvik, 1996: pl. 45) and 5769 *Greererpeton* (Godfrey, 1989: fig. 17b), which were already scored 0.

5770 *Ossinodus* has a candidate lamina. Warren & Turner (2004) identified that lamina as 5771 the sutural surface for the clavicle; it is clear from Bishop (2014), however, that this can only 5772 be true for the ventralmost part, leaving the rest to function as a postbranchial lamina and us 5773 to score it as state 0. The similarity between the cleithra of *Ossinodus* (Warren & Turner, 5774 2004: fig. 9B, C; Bishop, 2014: fig. 8B, E) and *Archeria* (Pawley, 2006: fig. 70-2.4) is 5775 striking; contrast *Eryops* (Pawley & Warren, 2006: 4), which has state 1 as already scored.

5776 *Crassigyrinus* was scored as unknown in RC07. Laurin (2011: 57) wrote that it had a 5777 postbranchial lamina, citing Coates (1996) as his source, yet Coates (1996) did not mention 5778 *Crassigyrinus* in his discussion of the postbranchial lamina and scored it in his data matrix as 5779 lacking the lamina. Given that our definition of the postbranchial lamina is less strict than that 5780 of Coates (1996), we have kept the score as unknown.

5781 State 1 is preserved in *Cochleosaurus* (Sequeira, 2009: fig. 6, 7) and *Doleserpeton* 5782 (Sigurdsen & Green, 2011: appendix 2). In *Gephyrostegus*, state 1 seems to be preserved in 5783 TMM 41773-1, so we have scored state 1 as present, though crushing and the fact that this 5784 specimen is a cast leave doubts about this, in particular about the interpretation of the 5785 cleithrum as being preserved in medial view.

5786 Clack & Finney (2005) stated that the postbranchial lamina is absent in *Pederpes*, and 5787 illustrated this with a cross-section of the cleithrum (fig. 11 B). It is not at all obvious from 5788 the figure (including the photo: fig. 11 A) or the text if the very tall ridge is medial (thus 5789 potentially a postbranchial lamina) or lateral; however, personal observation by D. M. of the 5790 only known specimen (GLAHMS 100815) on exhibit in the Hunterian Museum, Glasgow, 5791 shows that it is lateral, meaning that there is no postbranchial lamina, so the score of 1 in 5792 RC07 is correct despite the occurrence of state 0 in *Whatcheeria* and *Ossinodus*.

5793 Unknown (or at least not sufficiently well illustrated and described) in *Proterogyrinus* 5794 (Holmes, 1984), *Pholiderpeton scutigerum* (Clack, 1987b), *Bruktererpeton* (Boy & Bandel, 5795 1973), *Kotlassia* (Bystrow, 1944) and *Adelogyrinus* (Andrews & Carroll, 1991: 252).

Perhaps surprisingly, **Casineria* has state 0 (Fig. 7), which we have therefore scored.
The condition appears to be quite similar to that seen in *Archeria* (Pawley, 2006: fig. 70-2.4);
see Discussion: Phylogenetic relationships: The interrelationships of Anthracosauria,
Silvanerpeton, Caerorhachis, Gephyrostegidae, Casineria and Temnospondyli.

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5801 193. CLE 3: Cleithrum co-ossified with scapulocoracoid: yes (0); no (1).

- 5802 State 0 is present in Ventastega (Ahlberg et al., 2008). 5803 Whatcheeria is polymorphic (Coates, 1996: 409). Surprisingly, so is Eryops (Pawley
- 5804 & Warren, 2006).
- 5805 Baphetes has state 1 (Milner & Lindsay, 1998; Milner, Milner & Walsh, 2009), as do 5806 Cochleosaurus (Sequeira, 2009) and Isodectes (D. M., pers. obs. of CM 81430).
- 5807 Inapplicable to salamanders, which lack cleithra entirely, and to aïstopods, which lack 5808 scapulocoracoids entirely.
- 5809 "In late adult individuals, the two bones are probably fused to each other" in 5810 *Sclerocephalus (Meckert, 1993: 123; translation by D. M.); we have stayed conservative and 5811 scored *Sclerocephalus as possessing state 1.
- 5812
- 5813 194. CLA 3: Clavicles meet anteriorly: yes (0); no (1).
- State 0 occurs in Diadectes (Case, 1911: 79, fig. 26) and Orobates (Berman et al., 5814 5815 2004: fig. 2B). It is most likely shared by Chenoprosopus, judging from the disarticulated 5816 clavicle of USNM 437646 (Hook, 1993: fig. 2; D. M., pers. obs.).
- 5817 State 1 is present in Ventastega (Ahlberg, Lukševičs & Lebedev, 1994; Ahlberg et al., 5818 2008). Baphetes shares state 1 (Milner & Lindsay, 1998), as do Cochleosaurus (Sequeira, 5819 2009), Isodectes (D. M., pers. obs. of USNM 4471, CM 81512 and CM 81430), Leptorophus (Werneburg, 2007a), Ossinodus (Bishop, 2014) and, judging from the shapes of clavicle and 5820 5821 interclavicle, Doleserpeton (Sigurdsen & Bolt, 2010) and *Sparodus (Carroll, 1988). Clack & 5822 Milner (2010) implied it for *Platyrhinops*.
- 5823 Unclear in Kotlassia (Bystrow, 1944: fig. 15); best scored as unknown in 5824 *Chroniosaurus and *Bystrowiella (Witzmann & Schoch, 2017).
- 5825 Apparently unknown in Notobatrachus (Báez & Nicoli, 2004); *Liaobatrachus has 5826 state 0 (Dong et al., 2013).
- 5827 *Lydekkerina is polymorphic (Shishkin, Rubidge & Kitching, 1996; Pawley & 5828 Warren, 2005; Hewison, 2007: 42). 5829
- 5830 195. INTCLA 1-2: Interclavicle posterior margin not drawn out into parasternal process 5831 (0), with parasternal process that is not parallel-sided (1), or with elongate, slender 5832 process that is parallel-sided for most of its length (2) (unordered). Although called INTCLA 1 by RC07, this character is a composite of INTCLA 1 and INTCLA 2 of Ruta, 5833 5834 Coates & Quicke (2003), which were still kept separate by Pawley (2006: 350). For the time 5835 being, we have not ordered it because we have yet to compare the data on its changes in 5836 ontogeny and phylogeny.
- 5837 State 0 is found in Cochleosaurus (Sequeira, 2009) and Doleserpeton (Sigurdsen & 5838 Bolt, 2010). 5839
 - Ventastega (Ahlberg et al., 2008) and Batropetes (Glienke, 2013, 2015) have state 1.
- 5840 Limnoscelis (Kennedy, 2010) and Tseajaia (Moss, 1972) show state 2; the process has 5841 a unique club-shaped expansion at the caudal end, but is otherwise parallel-sided.
- 5842 Baphetes (Milner, Milner & Walsh, 2009: fig. 3A, 4B) and Hyloplesion (Olori, 2015: 5843 57) have state 1 or 2.
- 5844
- 5845 196. INTCLA 3: Interclavicle wider than long (excluding parasternal process, if present): 5846 absent (0); present (1).
- 5847 Ventastega (Ahlberg et al., 2008), Cochleosaurus (Sequeira, 2009) and Bruktererpeton 5848 (Boy & Bandel, 1973: fig. 10) have state 0.
- 5849 As reconstructed by Pawley & Warren (2006) and mentioned in the text of their 5850 publication, *Ervops* shows state 1. The fimbriate rostral margin indicates that growth may 5851 have continued till state 0 was reached, and indeed state 0 is not far away, but there is no

- evidence that this happened, the known individuals all seem well advanced in age, and the
 fimbriation is much weaker than in *Microbrachis* or *Hyloplesion*. We have therefore scored *Eryops* as indeed possessing state 1.
- 5855 State 1 is further present in *Limnoscelis* (Kennedy, 2010), *Hyloplesion* (CG78: fig. 5856 87B; Olori, 2015) and *Orobates* (Nyakatura et al., 2015: digital reconstruction).
- 5857 We have scored *Schoenfelderpeton* as unknown due to its pronounced 5858 paedomorphosis.
- 5859 State 1 was scored for *Ossinodus* in RC07, but as preserved (Warren & Turner, 2004) 5860 the incomplete interclavicle shows state 0; because of its broken margins we have scored it as 5861 unknown. 5862
- 5863 197. INTCLA 4: **Caudal part of interclavicle (excluding parasternal process, if present)** 5864 **longer (0) or shorter (1) than cranial part.** The original wording was: "Interclavicle 5865 rhomboidal with posterior part longer (0) or shorter (1) than anterior part", but it is usually 5866 possible to distinguish the parts even when the interclavicle lacks the plesiomorphic deltoid 5867 shape, the boundary being the mediolateral line along which the interclavicle is widest. We 5868 have added the mention of the parasternal process.
- 5869 *Ventastega* (Ahlberg et al., 2008) and *Limnoscelis* (Kennedy, 2010) have state 0, as do 5870 *Tuditanus* and *Pantylus* (CG78) and *Orobates* (Nyakatura et al., 2015: digital reconstruction).
- *Cochleosaurus* shows a mild case of state 1 (Sequeira, 2009), as, surprisingly, *Doleserpeton* (Sigurdsen & Bolt, 2010) seems to. *Eryops* is an unambiguous example of state
 1, with the caudal part only about 2/3 as long as the cranial part (Pawley & Warren, 2006).
 State 1 is further found in *Archeria* (Romer, 1957: fig. 1C), *Kotlassia* (Bystrow, 1944: fig. 15)
 and *Seymouria* (White, 1939: fig. 21).
- 5876 *Sclerocephalus passes from state 0 to state 1 in ontogeny (Meckert, 1993: fig. 1, 4;
 5877 Schoch & Witzmann, 2009a: fig. 6A, D, E).
 5878
- 5879 198. INTCLA 5: Transversely elongate grooves and ridges on central part of interclavicle
 5880 ventral surface: absent (0); present (1).
- *Ventastega* (Ahlberg et al., 2008), *Chenoprosopus* (Hook, 1993; D. M., pers. obs. of
 USNM 437646), *Cochleosaurus* (Sequeira, 2009), *Trimerorhachis* (Pawley, 2007) and *Doleserpeton* (Sigurdsen & Bolt, 2010) have state 0, as do *Solenodonsaurus* (Danto, Witzmann & Müller, 2012) and *Limnoscelis* (Kennedy, 2010).
- 5885 *Whatcheeria* was scored 0 in RC07. We have changed it to unknown, because 5886 ornamentation is entirely absent not only on the skull but also on the shoulder girdle of 5887 *Whatcheeria* (Lombard & Bolt, 1995: 483–484), making state 0 predictable and thus this 5888 character inapplicable.
- 5889
- State 1 is, surprisingly, found in *Eryops* (Pawley & Warren, 2006).
- Panchen (1975) described an interclavicle as belonging to *Pholidogaster even though 5890 5891 it was isolated and not found at the type locality. Clack & Milner (2015: 49) pointed this out 5892 and added that this interclavicle "is unlike undisputed colosteid interclavicles in shape", 5893 casting doubt on its referral. This refers to the fact that it has state INTCLA 4(0) (see above), 5894 the plesiomorphy, while the two other colosteids that preserve interclavicles - Colosteus and 5895 Greererpeton – have state 1. However, the interclavicle of the holotype, which is partially 5896 covered by the clavicles and partially preserved as an impression, does have state 0 of that character (Romer, 1964). This is not surprising for a colosteid that lies outside the smallest 5897 5898 clade formed by Colosteus and Greererpeton. For the moment, we accept Panchen's (1975) 5899 referral and have used the interclavicle he described to score *Pholidogaster where that of the 5900 holotype does not suffice; this concerns only the present character (state 0).
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5902 199. SCACOR 1: Separate scapular ossification: absent (0); present (1). As previously 5903 pointed out (e.g. Marjanović & Laurin, 2008: 185), ontogenetic fusion makes this character 5904 difficult to interpret. Also, the taxon sample is perhaps somewhat unfortunate – the 5905 salamanders in this matrix (*Karaurus, Valdotriton, *Beiyanerpeton, *Pangerpeton* and 5906 **Chelotriton*) all have state 0, but ***Kokartus*, a close relative of *Karaurus*, shows state 1 in 5907 an apparently immature specimen (Averianov et al., 2008: 480, fig. 7B), as do adults of the 5908 extant paedomorphic salamanders ***Amphiuma* and ***Siren* (Goodrich, 1930).

Nonetheless, we have scored *Ventastega* (Ahlberg et al., 2008), *Platyrhinops* (implied
by Carroll, 1964, and Clack & Milner, 2010) and *Micromelerpeton* (implied by Boy, 1995:
444) as possessing state 0.

5912 In contrast, we have not been able to find any mention of the endochondral shoulder 5913 girdle of *Amphibamus* in the literature (Carroll's [1964] "*Amphibamus lyelli*" is *Platyrhinops*) 5914 and have therefore scored it as unknown.

5915 Where known (*Celtedens*: McGowan, 2002), albanerpetids have state 1. So do 5916 *Eocaecilia* (Jenkins, Walsh & Carroll, 2007), *Diplocaulus* (Douthitt, 1917) and *Orobates* 5917 (Nyakatura et al., 2015: digital model).

5918 In *Bruktererpeton* the condition is unknown because the coracoid region is entirely 5919 unossified (Boy & Bandel, 1973).

5920 *Captorhinus* was scored 0 in RC07. Fox & Bowman (1966) insisted several times that 5921 it has state 1, but provided no evidence other than a notch which supposedly marked the 5922 otherwise obliterated suture between the procoracoid and the metacoracoid. It is quite likely 5923 that *Captorhinus* changed from state 1 to state 0 in ontogeny, but in the absence of a reference 5924 for state 1, we have kept state 0.

5925 Unknown in *Trimerorhachis*, where of the entire scapulocoracoid only the central part 5926 of the scapula ever ossifies (Pawley, 2007), and in *Brachydectes* (Wellstead, 1991), where the 5927 same seems to be the case. Also unclear in *Microbrachis*, where a break in an unusually well 5928 ossified specimen may or may not correspond to a suture (Olori, 2015).

5929 Danto, Witzmann & Müller (2012) identified a small bone of *Solenodonsaurus* that, as 5930 far as preserved, does not participate in the glenoid as a coracoid would; despite this 5931 uncertainty, they scored *Solenodonsaurus* as having state 1 of this character. We side with the 5932 uncertainty of the text and fig. 4 and have scored *Solenodonsaurus* as unknown.

5933 Based on the report of a longitudinal groove which may be "a partially co-ossified 5934 suture" (Schoch & Rubidge, 2005: 511), we have assigned state 1 to **Micropholis*. 5935

5936 200. SCACOR 2: **Glenoid subterminal: yes (0); no (1).** This character describes whether the 5937 coracoid part of the scapulocoracoid is at least partly ventral (state 1) or purely medial to the 5938 glenoid (state 0); it is not applicable to taxa with unossified coracoids, unless the clavicles and 5939 the interclavicle allow a 3D reconstruction.

5940State 0 occurs in Ventastega (Ahlberg et al., 2008), Cochleosaurus (Sequeira, 2009),5941Doleserpeton (Sigurdsen & Bolt, 2010), Eoscopus (Daly, 1994: 16) and Diplocaulus5942(Williston, 1909), likely also in Apateon (Werneburg, 1991: fig. 5b).

5943 State 1 is found in *Eryops* (Pawley & Warren, 2006; D. M., pers. obs. of TMM 31227-5944 14), Albanerpetidae (McGowan, 2002), *Eocaecilia* (Jenkins, Walsh & Carroll, 2007), 5945 *Scincosaurus* (Milner & Ruta, 2009), *Orobates* (Nyakatura et al., 2015: digital model) and 5946 *Ossinodus* (Warren & Turner, 2004: fig. 9I; Bishop, 2014: fig. 12).

5947 Glienke (2013: fig. 5K) reconstructed state 1 for *Batropetes niederkirchensis*; Glienke 5948 (2015: fig. 5B) reconstructed state 0 for *B. palatinus*; Glienke (2015: fig. 8G) reconstructed 5949 state 1 for *B. appelensis*. In *B. niederkirchensis* and *B. palatinus*, the coracoid portion is 5950 preserved and shows state 1, which may be due to diagenetic pressure; in *B. appelensis*, the 5951 coracoid portion was unossified, but the clavicles and the interclavicle allow a 3D reconstruction. It is not clear from Glienke (2015: fig. 5) or from MB.Am.1232 (D. M., pers. obs.) whether this is also the case for *B. palatinus*; for the time being, we have scored *Batropetes* as polymorphic.

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5956 201. SCACOR 3: Enlarged glenoid foramen: absent (0); present (1). "Loss of an enlarged 5957 glenoid foramen occurs sporadically and does not show any clear phylogenetic signal" 5958 (RC07: 105, 106) - it only happens at most once on the shortest trees from Analysis R6 (in 5959 Pantylus; unknown in Stegotretus) and at most twice in R4 and R5 (Pantylus and Batropetes 5960 + Lissamphibia; unknown in *Brachydectes* and many other "microsaurs"), for a constant total 5961 of four steps under the LH, the TH and the PH. Presence of the enlarged foramen, however, 5962 may keep several "microsaurs" together with each other (Asaphestera, Pelodosotis, 5963 *Trihecaton; unknown in most others) and with Diplocaulus.

- *Doleserpeton* (Sigurdsen & Bolt, 2010, Sigurdsen & Green, 2011: appendix 2), apparently *Apateon* (Werneburg, 1991: fig. 5b), *Eocaecilia* (Jenkins, Walsh & Carroll, 2007), apparently *Triadobatrachus* (Ascarrunz et al., 2016: 3D model 1), *Valdotriton* (Evans & Milner, 1996: fig. 11a), *Batropetes* (Carroll, 1991; Glienke, 2013, 2015), *Notobatrachus* (Báez & Nicoli, 2004: fig. 3B) and *Orobates* (Nyakatura et al., 2015: digital model) have state 0; the notch cranial of the glenoid of *Notobatrachus* should correspond to the coracoid foramen, not the glenoid foramen, judging from Pawley & Warren (2006: fig. 5).
- 5971 State 1 is present in *Ventastega*, assuming this is what "glenoid canal" means (Ahlberg 5972 et al., 2008). The condition in *Diplocaulus* (Williston, 1909: pl. 4a) may also count.
- 5973 Unknown in *Trimerorhachis* (Pawley, 2007), *Scincosaurus* (Milner & Ruta, 2009) and 5974 *Ossinodus* (Warren & Turner, 2004: 166). 5975
- 5976 202. SCACOR 4: Ventrome[d]ially extended infraglenoid buttress: absent (0); present 5977 (1).
 - State 0 is present in Ventastega (Ahlberg et al., 2008).

5979 Doleserpeton has state 1 (Sigurdsen & Bolt, 2010, Sigurdsen & Green, 2011: appendix
5980 2). State 1 is also known in *Eocaecilia* (most likely: Jenkins, Walsh & Carroll, 2007: fig. 40),
5981 *Triadobatrachus* (Ascarrunz et al., 2016: 3D model 1), *Westlothiana* (Smithson et al., 1994:
5982 392), *Diplocaulus* (Williston, 1909: pl. 4a) and *Orobates* (Nyakatura et al., 2015: digital
5984

- 5985 203. ANOCLE 1: Anocleithrum: present (0); absent (1).
 - State 0 is present in *Ventastega* (Ahlberg et al., 2008).
 - State 1 looks like a safe interpretation of *Cochleosaurus* (Sequeira, 2009: fig. 2, 4, 6).
- 5988 Complete articulated skeletons of *Celtedens*, with even the scales in place, 5989 demonstrate state 1 for Albanerpetidae (McGowan, 2002).
- 5990 The dorsal end of the cleithrum of *Tseajaia* is known and lacks a contact surface for an 5991 anocleithrum (Moss, 1972), so we have taken the absence of a preserved anocleithrum at face 5992 value and scored *Tseajaia* as possessing state 1.
- 5993 Only a small part of the cleithrum has ever been found in any of the many specimens 5994 of *Trimerorhachis* (Pawley, 2007); we therefore cannot (except by phylogenetic bracketing) 5995 feel safe about taking the lack of an anocleithrum at face value and have changed the score to 5996 unknown. 5997

5998 204. HUM 1: Latissimus dorsi process offset anteriorly relative to the ectepicondyle (0) 5999 or aligned with the latter (1).

6000 This character and HUM 4 are inapplicable to *Ichthyostega*, where the attachment 6001 surface for the latissimus dorsi isn't much of a process. Ahlberg (2011) stated that the M. latissimus dorsi probably attached to process 1; however, even if so, process 1 can hardly be
considered homologous with the latissimus dorsi process or ridge in other OTUs in this matrix
(Callier, Clack & Ahlberg, 2009: supp. inf.; Ahlberg, 2011: fig. 1; Clack et al., 2012a). It is
confusing, though, that Ahlberg is a coauthor of Callier, Clack & Ahlberg (2009) as well as of
Clack et al. (2012a), and that his 2011 paper was both submitted and accepted while the
manuscript of Clack et al. (2012a) was in review.

6008 State 0 is now known in *Ossinodus* (Bishop, 2014). It also appears to be present in 6009 *Panderichthys* (Boisvert, Mark-Kurik & Ahlberg, 2008: supplementary movie 4); a possible 6010 process for the M. latissimus dorsi can be seen in a location similar to where the process is in 6011 *Acanthostega* (Coates, 1996: fig. 16d), distal to a foramen – the feature labeled "ldp" by 6012 Coates (1996: fig. 35i) is instead a part of the ectepicondyle ridge. Instead of a process, 6013 Ahlberg (2011) figures several ridges as the attachment area for the M. latissimus dorsi; these 6014 are offset anteriorly (preaxially) from the ectepicondyle as well.

6015 State 1 is documented in all but the smallest specimens of *Trimerorhachis* (Pawley, 6016 2007) and appears to occur in *Isodectes* (D. M., pers. obs. of USNM 4474) and in *Karaurus* 6017 (D. M., pers. obs. of unnumbered MNHN cast of PIN 2585/2).

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6019 205. HUM 2: Distinct "supinator" (brachioradialis) process projecting anteriorly: absent
6020 (0); present (1). See Bishop (2014) for the homology of this feature.

- 6021State 0 occurs in Baphetes (Milner & Lindsay, 1998), Doleserpeton (Sigurdsen &6022Bolt, 2009; D. M., pers. obs. of AMNH 29466) and Eocaecilia (Jenkins, Walsh & Carroll,60232007).
- 6024 Lebedev & Coates (1995: 316) described a not particularly pointed, but large "supinator" process in *Tulerpeton*; it even appears to be visible in distal view (Lebedev & 6025 6026 Coates, 1995: fig. 5D). A pathetic version of this is seen in the most ossified specimen of 6027 Archeria (Romer, 1957: fig. 4B, D, 5E). Chase (1965: 200) reported the presence of a "supinator" process (state 1) in *Neldasaurus*. *Trimerorhachis* shows state 1 in presumably 6028 6029 subadult and adult specimens (Pawley, 2007); similarly, state 1 is seen in the most mature 6030 specimens of Micromelerpeton (Boy, 1995). Notably, it is shared by Ariekanerpeton 6031 (Klembara & Ruta, 2005b: fig. 6A).
- Danto, Witzmann & Müller (2012: 49) stated that the "supinator" process is absent in *Solenodonsaurus*. Even as preserved, the process is clearly present (Danto, Witzmann & Müller, 2012: fig. 1, 4, 5A); it may have been longer, with the rest of the impression being part of the lost counterpart.
 - State 1 is further found in *Captorhinus* (Fox & Bowman, 1966: fig. 28).

6037 CG78 figured a corner in the position where the "supinator" process would be 6038 expected (from comparison to Smithson et al., 1994: fig. 12) in *Tuditanus* (CG78: fig. 5D) 6039 and *Asaphestera* (CG78: fig. 8E). For *Tuditanus*, this appears to be confirmed by the 6040 photograph in Carroll & Baird (1968: fig. 4 right side) – the specimen drawing (fig. 5) 6041 disagrees, but is clearly reconstructed in several places. We have tentatively scored state 1 for 6042 both *Tuditanus* and *Asaphestera*; the specimens of both should clearly be restudied, however.

6043 Like those of Apateon, Leptorophus, Schoenfelderpeton (Boy, 1986, 1987; Werne-6044 burg, 2007a; Schoch, 2014a) and Discosauriscus (Klembara & Bartík, 2000), the humerus of 6045 *Chroniosaurus (Clack & Klembara, 2009: fig. 9) and that of *Micropholis figured by Schoch & Rubidge (2005: fig. 6A) are too poorly ossified to possess a "supinator" process 6046 (Pawley & Warren, 2006); we have scored all OTUs mentioned in this paragraph as unknown. 6047 6048 Similarly, we have scored Amphibamus as unknown: Gregory (1950: 850) described a specimen where the ends of the humeri "are imperfectly ossified"; Daly (1994: fig. 18) 6049 6050 presented a photograph of the largest Amphibamus specimen, which clearly has completely 6051 ossified humeri (with a distal end much wider than in the closely related Doleserpeton), but it

remains impossible to determine from this photograph whether "supinator" processes werepresent.

6054 Preservation and ossification conspire in *Balanerpeton* to make it impossible to 6055 determine the state of this character, at least from the published figures (Milner & Sequeira, 6056 1994); we have scored *Balanerpeton* as unknown.

6057 Carroll (1967) stated that his dendrerpetid material lacked the "supinator" process. 6058 However, a minimally ossified process might even be present in the incompletely ossified 6059 humerus drawn in his fig. 15D, judging from comparison to the less incompletely ossified one 6060 of *Ariekanerpeton* which was labeled by Klembara & Ruta (2005b: fig. 6A) as possessing the 6061 process. A more or less fully ossified humerus is preserved in the specimen described by 6062 Holmes, Carroll & Reisz (1998), but there the area where the process would be has not been 6063 prepared out of the matrix. We have scored Dendrerpetidae as unknown.

About *Broiliellus*, Carroll (1964: 200) stated: "The left humerus is complete except for the ectepicondylar process distal to the middle of the articulating surface for the radius." His fig. 10B, however, suggests that the distal end is quite incompletely ossified. We have scored *Broiliellus* as unknown.

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Probably not visible in *Eoscopus* (Daly, 1994: fig. 11, 14).

6069 *Diplocaulus* was scored in RC07 as having state 0; the only figured humerus 6070 (Williston, 1909; Douthitt, 1917) is not quite well enough ossified to tell, however, and the 6071 ectepicondyle projects so far that state 1 actually seems quite likely. We have changed the 6072 score to unknown.

6073 We have kept state 1 for *Orobates*, although the process is very small indeed 6074 (Nyakatura et al., 2015: digital model).

6075The area where the process would be – indeed the entire proximal, preaxial and ventral6076edge of the humerus – is not ossified in *Pederpes* (Clack & Finney, 2005: fig. 13). We have6077therefore changed the score to unknown.

6078 The area is preserved in **Casineria*, and the humerus is well ossified, but the 6079 specimen is split through the bone so that the "supinator" process, if present, is deeply buried 6080 in matrix (D. M., pers. obs. of NMS G 1993.54.1) and cannot be scored. 6081

6082 206. HUM 3: Sharp-edged ventral humeral ridge: present (0); absent (1). RC07 had a
6083 comma after "sharp-edged", but the ventral humeral ridge is present and blunt in *Edops* (D.
6084 M., pers. obs. of MCZ 1781) and *Eryops* (Pawley & Warren, 2006), whose scores we keep as
6085 1.

6086State 0 is known from Tulerpeton and Eoherpeton (Milner & Lindsay, 1998),6087Whatcheeria and Ossinodus (Bishop, 2014) and Pederpes (Clack & Finney, 2005).

Isodectes (D. M., pers obs. of USNM 4471 and USNM 4474), Trimerorhachis
(Pawley, 2007), Acheloma (Polley & Reisz, 2011), Doleserpeton (Sigurdsen & Bolt, 2009),
Platyrhinops (Clack & Milner, 2010), Albanerpetidae (McGowan, 2002), Eocaecilia (Jenkins,
Walsh & Carroll, 2007), Diplocaulus (Williston, 1909; Douthitt, 1917), Orobates (Nyakatura
et al., 2015: digital model) and Tseajaia (Moss, 1972: fig. 9A) have state 1.

6093 6094

6095 207. HUM 4: Latissimus dorsi process confluent with (0) or distinct from (1) 6096 deltopectoral crest.

Unknown or at least not illustrated or described in Kotlassia (Bystrow, 1944: fig. 16).

6097 State 1 is found in *Panderichthys* (Boisvert, 2009), *Isodectes* (D. M., pers. obs. of USNM 4474) and *Ossinodus* (Bishop, 2014).

6099

6100 208. HUM 5: Entepicondyle foramen: present (0); absent (1).

State 0 is known in Hyloplesion (Olori, 2015) and Ossinodus (Bishop, 2014). 6101 6102 Diplocaulus was scored in RC07 as having state 1, in keeping with the claim that the humerus 6103 of Scincosaurus "is unique among nectrideans in having an entepicondylar foramen" (Bossy & Milner, 1998: 97); it has state 0 instead (Williston, 1909; Douthitt, 1917). We note that 6104 6105 Bossy & Milner (1998) did not mention or illustrate the humerus of Diplocaulus at all.

6106 Orobates was correctly (Nyakatura et al., 2015: digital model) scored as having state 0 6107 in RC07, even though the condition was neither described nor illustrated by Berman et al. (2004) and RC07 (appendix 1) did not claim to have seen specimens. 6108

6109 6110 Unknown in Colosteus (Hook, 1983).

6111 209. HUM 6: Ectepicondyle foramen: present (0); absent (1). See Bishop (2014) for the 6112 homology of this feature; the foramen found in many amniotes happens not to occur in the 6113 present matrix.

The idea that this character might be size-dependent (loss of the foramen at a certain 6114 6115 size: Sequeira, 2009) seems unlikely to us, because very small amphibamids including branchiosaurids lack this foramen as well as the much larger Eryops, Trimerorhachis and 6116 6117 *Sclerocephalus.

6118

State 1 is found in Scincosaurus (Milner & Ruta, 2009) and Ossinodus (Bishop, 2014). Orobates was correctly (Nyakatura et al., 2015: digital model) scored as having state 6119 1, even though the condition was neither described nor illustrated by Berman et al. (2004) and 6120 6121 RC07 (appendix 1) did not claim to have seen specimens.

6122 We keep the score of Cochleosaurus as unknown; the foramen is present in small 6123 humeri, while in the largest one it is absent – if, that is, the quality of the plaster cast that is all which remains of that specimen can be trusted (Sequeira, 2009). 6124

6125

6126 210. HUM 7-8: Ectepicondyle ridge present, not reaching distal humeral end (0); 6127 present, reaching distal end (1); absent (2) (unordered). State 0, originally HUM 8(0), was 6128 originally scored only for Eusthenopteron, Notobatrachus and Vieraella - but the latter two 6129 have state 2 instead, which limited state 0 to Eusthenopteron and thus made character HUM 8 6130 uninformative. However, Panderichthys shares state 0 (Boisvert, 2009).

6131 Platyrhinops has state 1 (Hook & Baird, 1984: fig. 1).

State 2 is known in Eocaecilia (Jenkins, Walsh & Carroll, 2007), Batropetes (Glienke, 6132 6133 2015: fig. 6) and Microbrachis (Olori, 2015).

6134 Unclear in Eoscopus (Daly, 1994).

We have changed the score of *Isodectes* from entirely unknown to state 0 or 1. This 6135 6136 must be based on D. M.'s pers. obs. of the specimens mentioned for other characters here, but 6137 if so, D. M. forgot to document this. The area where the ridge should be is preserved in 6138 several specimens, and the distal end is never ossified (D. M., pers. obs.), so the new score is 6139 most likely correct.

6140 We have tentatively kept the score of 2 for *Micromelerpeton* and all branchiosaurids, because there is no evidence of another state in the literature; however, we wonder if this 6141 6142 could be due to insufficient ossification. Unfortunately, fig. 5b of Werneburg (1991) is not 6143 clear enough to tell if it can be known which state the skeletally most mature individual of 6144 Apateon had.

6145

6146 211. HUM 9: Distal extremity of ectepicondyle ridge: aligned with ulnar articulation (0); 6147 between ulnar articulation and radial condyle (1); aligned with radial condyle (2) 6148 (ordered). This continuous character is inapplicable when the ectepicondyle ridge is absent 6149 (HUM 7-8(2)); RC07 already scored accordingly. We use the term "ulnar articulation" instead 6150 of "ulnar condyle" because the articular surface for the ulna on the humerus is a trochlea

- rather than a condyle in most OTUs of this matrix (see Sigurdsen & Bolt, 2009) to the extent 6151 6152 that it is even ossified.
- 6153 Eucritta (Clack, 2001: fig. 7, in comparison with Baphetes: Milner & Lindsay, 1998: fig. 9), Isodectes (D. M., pers. obs. of USNM 4471 and USNM 4474), Platyrhinops (Hook & 6154
- 6155 Baird, 1984), Diplocaulus (Williston, 1909; Douthitt, 1917) and Silvanerpeton (Ruta & Clack,
- 6156 2006) show state 2. 6157
 - Bishop (2014: 217, fig. 12) reconstructed state 0 in Ossinodus.
- We tentatively score state 1 or 2 for the incompletely ossified *Erpetosaurus (Milner 6158 6159 & Sequeira, 2011: fig. 8).
- 6160

6163

- Unknown in Eoscopus (Daly, 1994: fig. 11, 14). 6161
- 6162 212. HUM 10: Humerus without (0) or with (1) waisted shaft.
 - Ossinodus has state 0 (Bishop, 2014).

6164 Cochleosaurus (Sequeira, 2009) and Isodectes (D. M., pers. obs. of USNM 4471, 6165 USNM 4474, USNM 4555, and CM 81430) have state 1, and so do Cardiocephalus (CG78: fig. 31), Microbrachis (CG78; Olori, 2015) and, somewhat surprisingly, Diplocaulus 6166

(Williston, 1909; Douthitt, 1917). 6167

6168 Sigurdsen & Green (2011: appendix 2) stated, in agreement with Romer (1946), that 6169 Limnoscelis lacks a humeral shaft, and changed the score from 1 to 0. The humerus is still, however, strongly constricted in the middle, where the proximal expansion (the head with the 6170 deltoid and pectoral processes) and the distal expansion (with the epicondyles and the 6171 6172 "supinator" process) meet at a right angle in the widespread tetrahedral shape (Romer, 1946; Berman & Sumida, 1990: 331, fig. 12A; Kennedy, 2010), so we regard Limnoscelis as 6173 combining state 1 with an unusually short humerus (in particular HUM 12-15(0), see below); 6174 6175 humeri with state 0 look quite different. This is also in accordance with the femur, which Berman & Sumida (1990) described as follows: "The proximal and distal ends are widely 6176 expanded and joined by an extremely short and moderately stout shaft, giving the femur a 6177 6178 deeply waisted appearance."

6179 Sigurdsen & Green (2011: appendix 2) went on to state that "Seymouria has a very 6180 porrly [sic] developed shaft", which they scored as polymorphic - they appear not to have 6181 distinguished polymorphism from partial uncertainty, although we still wonder why they would have wanted to score "partial" uncertainty for a binary character -; White (1939: fig. 6182 6183 23) clearly figured a short waisted shaft, so we retain state 1 here as well.

6184

6186

6185 213. HUM 11: Position of radial condyle: terminal (0); ventral (1).

"It seems very likely" that Ossinodus had state 0 (Bishop, 2014: 217).

6187 State 1 is documented in Doleserpeton (Sigurdsen & Bolt, 2009; D. M., pers. obs. of 6188 AMNH 29466), Eocaecilia (Jenkins, Walsh & Carroll, 2007), Archeria (Romer, 1957: fig. 6189 4D), Kotlassia (Bystrow, 1944: fig. 16), Westlothiana (Smithson et al., 1994: fig. 12), 6190 Hyloplesion (Olori, 2015) and Orobates (Nyakatura et al., 2015: digital model). Sigurdsen & 6191 Green (2011: appendix 2) further reported it for Triadobatrachus; this seems at least plausible 6192 from the inclination of the ossification front shown in Sigurdsen, Green & Bishop (2012: fig. 6193 7C) and Ascarrunz et al. (2016: 3D model 1). It also seems to be present in Isodectes (D. M., 6194 pers. obs. of USNM 4555). In Balanerpeton, the quite small attachment area for the condyle 6195 is well visible on the ventral side (Milner & Sequeira, 1994: fig. 12A, B), and the forelimb of 6196 Dendrysekos (Dendrerpetidae) described by Holmes, Carroll & Reisz (1998: fig. 8) is 6197 preserved in such a strongly flexed position that the probably unossified condyle must have 6198 been on the ventral side; we have therefore scored state 1 for both Balanerpeton and 6199 Dendrerpetidae.

6200 The entire area did not ossify in the known specimens of *Neldasaurus* (Chase, 1965), 6201 Trimerorhachis (Pawley, 2007; D. M., pers. obs. of TMM 40031-80 and TMM 40031-81), Discosauriscus (Klembara & Bartík, 2000), Ariekanerpeton (Klembara & Ruta, 2005b) and 6202 apparently Tuditanus (Carroll & Baird 1968, CG78). Even in Eoherpeton, comparison to the 6203 6204 best-ossified specimen of Archeria (Romer, 1957: 118, fig. 4, 5E; Smithson, 1985: fig. 25) 6205 makes it likely that the articular surface for the humerus was incompletely ossified, so we 6206 have scored it as unknown as well. The area is furthermore not exposed in Silvanerpeton (Ruta & Clack, 2006). 6207

6208

6209 214. HUM 12-15: Humerus L-shaped, postaxial margin proximal to entepicondyle 6210 shorter than or subequal to length of proximal margin of entepicondyle (0); 6211 intermediate (1); slender and elongate, total length more than three times maximum 6212 width of distal end (2) (ordered).

6213 HUM 15 was originally called "Width of entepicondyle greater (0) or smaller (1) than 6214 half humerus length". Ruta, Coates & Quicke (2003) did not explain how these measurements should be taken, though the name of the character seems obvious enough. RC07 (p. 106) 6215 provided fairly precise instructions: "The entepicondyle width is measured in the plane of the 6216 6217 entepicondyle flattening, as the distance between its free margin and a line parallel to the humerus greater axis and passing through the point of attachment of the entepicondyle 6218 posterior margin into the general surface of the bone. The humerus length is the maximum 6219 distance between its proximal and distal extremities." If defined this way, state 0 may not 6220 occur in this matrix at all. All OTUs that were scored HUM 15(0) have HUM 15(1) according 6221 to the usual sources, except apparently Tulerpeton (Lebedev & Coates, 1995; but note the 6222 incomplete ossification of the head, while the entepicondyle is fully ossified) and maybe 6223 6224 Keraterpeton (Jaekel, 1903: fig. 3).

Among those previously scored as unknown, HUM 15(0) has not shown up either, while HUM 15(1) is found in *Panderichthys* (Coates, 1996: fig. 35i; Boisvert, Mark-Kurik & Ahlberg, 2008; Boisvert, 2009), *Cochleosaurus* (Sequeira, 2009), *Isodectes* (D. M., pers. obs. of USNM 4471, USNM 4474 and USNM 4555), *Karaurus* (D. M., pers. obs. of unnumbered MNHN cast of PIN 2585/2), *Archeria* (Romer, 1957), *Paleothyris* (D. M., pers obs. of TMM 45955-2, a cast of MCZ 3482), *Ossinodus* (unless the ossification was very unequally incomplete: Bishop, 2014) and *Tseajaia* (Moss, 1972: 32).

6232 Rather than deleting HUM 15 as uninformative, we strongly suspect that the 6233 explanation by RC07 is wrong and Ruta, Coates & Quicke (2003) actually measured 6234 something else, perhaps the length-to-width ratio of the humerus (width including but not limited to the entepicondyle) or the ratio of the lengths of the proximal margin of the 6235 entepicondyle and the adjacent postaxial margin of the humerus proximal to the 6236 6237 entepicondyle. For ease of scoring, we have decided in favor of the latter, drawing the line close to a ratio of 1 : 1. State 0 of the present character thus occurs in Acanthostega and 6238 6239 Ichthyostega (Callier, Clack & Ahlberg, 2009), Tulerpeton (Lebedev & Coates, 1995), Greererpeton (Godfrey, 1989), Crassigyrinus (Panchen, 1985), Whatcheeria (Lombard & 6240 6241 Bolt, 1995), Baphetes (Milner & Lindsay, 1998), Eoherpeton (Smithson, 1985), Proterogyrinus (Holmes, 1984), Limnoscelis (Kennedy, 2010), Keraterpeton (Jaekel, 1903: fig. 3), 6242 6243 Diceratosaurus (D. M., pers. obs. of MB.Am.776; note that the proximal end of the humerus is better preserved than drawn by Jaekel, 1903: pl. IV), Orobates (Nyakatura et al., 2015: 6244 digital model), Ossinodus (Bishop, 2014), Pederpes (Clack & Finney, 2005) and *NSM 994 6245 GF 1.1 (Holmes & Carroll, 2010). "Defined" this way, HUM 15 had to be merged with HUM 6246 6247 12 (which was defined as absence/presence of state 2 of the present potentially continuous 6248 character), because states 0 and 2 of the present character cannot occur in the same humerus. 6249 However, the present character remains independent of HUM 16 both in theory (unlike state 0 6250 of the present character, HUM 16(0) does not require a wide entepicondyle, and unlike state 1 6251 of the present character, HUM 16(1) does not require a narrow one) and in practice.

6252 Of the OTUs that were originally scored as unknown for HUM 12 and are not listed 6253 above as having state 0, state 1 of the present character is found in *Cochleosaurus* (Sequeira, 6254 2009) and *Isodectes* (D. M., pers. obs. of USNM 4471, USNM 4474, USNM 4555, CM 6255 81512 and CM 81430). *Cardiocephalus* has state 1 or 2 (CG78: fig. 31).

6256 Because of incomplete ossification (Clack, 2001), we cannot determine if *Eucritta* has 6257 state 0 or 1.

6258

6295

6259 215. HUM 13: Posterolateral margin of entepicondyle lying distal relative to plane of 6260 radial and ulnar facets: yes (0); no (1).

6261 *Trimerorhachis* shows state 0 in large specimens (Pawley, 2007), highlighting the fact 6262 that this character can only be scored for well ossified humeri.

6263 We have also assigned this state to *Edops*, because MCZ 1781 appears to show a weak case of it (less weak in extensor view) despite being incompletely ossified (D. M., pers. obs.), 6264 and tentatively to Greererpeton based on the incompletely ossified humerus pictured in 6265 6266 Godfrey (1989: fig. 19g, h). It is further found in Acanthostega (Coates, 1996: fig. 15, 16 6267 contra fig. 35i!; Callier, Clack & Ahlberg, 2009: fig. 2B, note that 2C = 4E is reconstructed), at least marginally in Whatcheeria (Lombard & Bolt, 1995: fig. 7B), Ecolsonia (Berman, 6268 Reisz & Eberth, 1985: fig. 11D), Eoherpeton (Smithson, 1985: fig. 25), Proterogyrinus 6269 (Holmes, 1984: fig. 26), Archeria (Romer, 1957), Pholiderpeton scutigerum (borderline, but 6270 incompletely ossified: Clack, 1987b: fig. 30), apparently Solenodonsaurus (Danto, Witzmann 6271 & Müller, 2012: fig. 5A), Kotlassia (Bystrow, 1944: fig. 16), Seymouria (White, 1939: fig. 6272 23), Diadectes (Berman, Sumida & Martens, 1998), Limnoscelis (Berman & Sumida, 1990; 6273 6274 Kennedy, 2010), Captorhinus (just barely: Fox & Bowman, 1966: fig. 28), Sauropleura (Bossy & Milner, 1998: fig. 66C) and Orobates (Nyakatura et al., 2015: digital model). 6275

6276 State 1 is found in *Panderichthys* (Coates, 1996: fig. 35i; Boisvert, Mark-Kurik & 6277 Ahlberg, 2008; Boisvert, 2009) and *Karaurus* (D. M., pers. obs. of unnumbered MNHN cast 6278 of PIN 2585/2). We have kept the score of 1 for *Ichthyostega* because, although the 6279 entepicondyle projects distal to the ulnar facet, the radial facet is so much more proximal – 6280 much like in *Panderichthys* (Ahlberg, 2011) – that the entepicondyle at most reaches the 6281 oblique plane in which the two facets lie (Callier, Clack & Ahlberg, 2009: fig. 1, 4D); this 6282 situation is in fact quite similar to that seen in *Paleothyris* (Carroll, 1969b: fig. 7E).

Unknown due to insufficient ossification (i.e. absence of the posterolateral margin of 6283 6284 the entepicondyle) in Crassigyrinus (Panchen, 1985: fig. 22), Baphetes (Milner & Lindsay, 1998), Eucritta (Clack, 2001), Neldasaurus (Chase, 1965: fig. 12), Balanerpeton (Milner & 6285 6286 Sequeira, 1994), Dendrerpetidae (Carroll, 1967; Holmes, Carroll & Reisz, 1998), Apateon (Werneburg, 1991: fig. 5b), Triadobatrachus (Sigurdsen, Green & Bishop, 2012: fig. 7C; 6287 6288 Ascarrunz et al., 2016: 3D model 1), Discosauriscus (Klembara & Bartík, 2000), Brachydec-6289 tes (Wellstead, 1982), Diplocaulus (Williston, 1909; Douthitt, 1917), Ariekanerpeton 6290 (Klembara & Ruta, 2005b), Pederpes (Clack & Finney, 2005), Silvanerpeton (Ruta & Clack, 6291 2006) and Utegenia (Klembara & Ruta, 2004b).

Unclear (at least from published illustrations) in *Ptyonius* and *Urocordylus* (Bossy &
Milner, 1998: fig. 66A, B) as well as *Tseajaia* (where the text and the illustration of Moss
[1972] appear to contradict each other, and the illustration is at an oblique angle).

6296 216. HUM 14: Posterolateral margin of the entepicondyle markedly concave: yes (0); no
6297 (1). Apparently this describes whether the distal margin is straight or forms a distal hook. If
6298 so, *Panderichthys* has state 0 (Boisvert, 2009).

6299 *Cochleosaurus* (Sequeira, 2009), *Eoscopus* (Daly, 1994: fig. 11, 14) and *Karaurus* (D.
6300 M., pers. obs. of unnumbered MNHN cast of PIN 2585/2) have state 1.

6301 Insufficiently ossified to score in *Triadobatrachus* (Ascarrunz et al., 2016: 3D model
6302 1).
6303

6304 217. HUM 16: Portion of humerus [...] length proximal to entepicondyle smaller (0) or 6305 greater (1) than humerus head width.

- State 0 looks very likely in Ossinodus (Bishop, 2014).
- 6307 State 1 is found in Eusthenopteron (just barely: Coates, 1996: fig. 35h), Panderichthys (Coates, 1996: fig. 35i; Boisvert, Mark-Kurik & Ahlberg, 2008), Baphetes (perhaps just 6308 barely: Milner & Lindsay, 1998), Edops (D. M., pers. obs. of MCZ 1781), Isodectes (D. M., 6309 6310 pers. obs. of USNM 4471, USNM 4474 and USNM 4555), Balanerpeton (Sequeira & Milner, 1994: fig. 12), Dendrerpetidae (Holmes, Carroll & Reisz, 1998: fig. 8), Eryops (Pawley & 6311 6312 Warren, 2006), Karaurus (D. M., pers. obs. of unnumbered MNHN cast of PIN 2585/2), Sole-6313 nodonsaurus (Danto, Witzmann & Müller, 2012), Kotlassia (Bystrow, 1944: 409), Paleothyris (D. M., pers obs. of TMM 45955-2, a cast of MCZ 3482), Cardiocephalus 6314 6315 (CG78: fig. 31), Diplocaulus (Williston, 1909; Douthitt, 1917) and Orobates (Nyakatura et 6316 al., 2015: digital model).
- 6317 We have scored *Eucritta* as unknown because the measurements are about equal 6318 (Clack, 2001) and the proximal end of the humerus seems incompletely ossified.
- The state in the largest specimen of *Cochleosaurus* is unclear; smaller ones are rather borderline (Sequeira, 2009). We have therefore kept its score as unknown. *Proterogyrinus* is likewise borderline (Holmes, 1984: fig. 26), so we have scored it as unknown as well; taking the width in fig. 26(c) at face value, *P*. would just barely have state 1, rather than 0 as originally scored.
- 6324 6325

6306

Unknown in Scincosaurus (Milner & Ruta, 2009).

6326 218. HUM 17: Accessory foramina on humerus: present (0); absent (1).

6327 State 1 occurs in *Tulerpeton* (Lebedev & Coates, 1995), *Cochleosaurus* (Sequeira,
6328 2009), *Paleothyris* (D. M., pers obs. of TMM 45955-2, a cast of MCZ 3482) and *Ossinodus*6329 (Bishop, 2014). Germain (2008a) correctly scored state 1 in *Isodectes* (D. M., pers. obs. of
6330 USNM 4471, USNM 4474, and USNM 4555), but did not mention this in the text; instead he
6331 intended (Germain, 2008a: 185) to change the score of the next character from unknown to 1,
6332 but did not do this in the matrix. Evidently, the right score ended up in the wrong column.

6333

6334 219. HUM 18/DIG 1: Forelimb absent (0); humerus present, length smaller (1) or greater
6335 (2) than combined length of two and a half mid-trunk vertebrae (ordered). State 0
6336 corresponds to part of state DIG 1(0) of RC07; for the other part see state DIG 1-2-3-4(0) in
6337 our ch. 276. States 1 and 2 correspond to states HUM 18(0,1) of RC07 – who had exchanged
6338 the states in the text but not in the matrix, except maybe for the taxa they added.

6339 State 2 is found in Whatcheeria (strongly implied by Lombard & Bolt, 1995), 6340 Baphetes (Milner & Lindsay, 1998 – the longest intercentrum is 22 mm long, the humerus 6341 somewhere around 85; this should ensure state 2 even if the vertebrae were very rhachito-6342 mous), Eucritta (Clack, 2001), Edops (Romer & Witter, 1942), Cochleosaurus (Sequeira, 2009), Isodectes (Sequeira, 1998; Germain, 2008a: 185 - see HUM 17; D. M., pers. obs. of 6343 6344 CM 81512), Acheloma (Polley & Reisz, 2011), Phonerpeton (Dilkes, 1990), Ecolsonia (Berman, Reisz & Eberth, 1985), Doleserpeton (Sigurdsen & Bolt, 2010), Leptorophus (Boy, 6345 6346 1986; Werneburg, 2007a), Triadobatrachus (all literature and pers. obs.), Eoherpeton (Smith-6347 son, 1985: compare fig. 19, 24, 25), Pholiderpeton scutigerum (Clack, 1987b), Diadectes (all 6348 literature), Cardiocephalus (CG78: fig. 31), Notobatrachus and Vieraella (Estes & Reig, 6349 1973; Báez & Basso, 1996), Orobates (Berman et al., 2004: fig. 1), Pederpes (Clack &
6350 Finney, 2005), Silvanerpeton (Ruta & Clack, 2006), and Tseajaia (Moss, 1972: pl. 2; D. M.,
6351 pers. obs. of CM 38033). We have kept state 1 or 2 for the very poorly ossified Schoenfeld6352 erpeton (Boy, 1986).

RC07 scored Acherontiscus and all adelogyrinids as unknown for the presence of 6353 6354 limbs; Ruta, Coates & Quicke (2003: 263) commented on the adelogyrinids (there is no comment specifically on Acherontiscus): "Limb absence may well be a preservational artifact, 6355 especially because of the very few specimens known." However, we find it difficult to 6356 imagine that the forelimbs and, notably, the endochondral shoulder girdle would have just 6357 6358 fallen off the specimen of Adelogyrinus drawn by Andrews & Carroll (1991: fig. 6), where the ribs, the dermal shoulder girdle and even the hypbranchial apparatus are hardly 6359 6360 disarticulated and well preserved. Andrews & Carroll (1991: 252) commented on that specimen: "No unidentified bone is present in the area of the dermal shoulder girdle and none 6361 could possibly be confused with the endochondral girdle or fore limbs. All bone present is 6362 6363 well preserved, although it has suffered surface damage. The specimen is broken through the area of the shoulder girdle so that a cross-section of the bones is visible. If the endochondral 6364 shoulder girdle had been ossified, it is difficult to imagine how it could fail to be preserved 6365 6366 with the rest of the girdle, ribs and vertebrae. One can only assume that these bones were unossified (cartilaginous) or missing in the living animal. The scapulocoracoid is slow to 6367 ossify in small labyrinthodonts and microsaurs, but the remainder of the skeleton suggests that 6368 this specimen is mature. The dermal elements are typical of other early tetrapods in their 6369 6370 proportions and configuration." We have therefore scored Adelogyrinus as limbless (state 0), 6371 although we have kept the question mark for the less well articulated Acherontiscus, the much less well articulated Adelospondylus, and of course Dolichopareias which is exclusively 6372 6373 known from skull bones.

**Utaherpeton* changes from state 2 to state 1 in ontogeny (Carroll & Chorn, 1995:
table 1). We have only considered the adult condition.

6376 **Sclerocephalus* has state 2, but just barely (Schoch & Witzmann, 2009a: fig. 9D), at 6377 least as far as the ossified part of the humerus is concerned.

In spite of having only 13 presacral vertebrae, **Chelotriton* has state 1 (Schoch,
Poschmann & Kupfer, 2015), showing that state 1 does not always correlate with trunk
elongation.

6382 220. HUM 19: Process '2' on humerus: absent (0); present (1). Sigurdsen & Green (2011)
6383 suspected that this process is homologous to the latissimus dorsi process, but they are both
6384 present and lie on different sides of the ectepicondyle ridge in *Acanthostega* (Coates, 1996:
6385 fig. 16) and *Ossinodus* (Bishop, 2014) for example; Pawley (2006: fig. 72.2.1) figured and
6386 labeled them both on a humerus of *Proterogyrinus*.

6387

Isodectes has state 0 (D. M., pers. obs. of USNM 4471 and USNM 4474).

6388Panderichthys and even Eusthenopteron have a candidate process (figures in Boisvert,63892009, and Ahlberg, 2011) which we have scored as state 1.

In *Acanthostega*, process 2 seems to disappear during ontogeny (Callier, Clack &
Ahlberg, 2009: fig. 2), which is not known to happen in any other taxon; we have kept state 1
for the time being because process 2 is not mentioned in the figures, text or supplementary
information of Callier, Clack & Ahlberg (2009) and because the drawing is not completely
unambiguous, but we would like to draw attention to this question.

6395 *Ichthyostega* was scored in RC07 as having state 0; but the term "process 2" was first 6396 invented for *Ichthyostega* (Jarvik, 1996: 62). In *Ichthyostega*, unlike in the other OTUs that 6397 have it, process 2 is only identifiable in postaxial/posterior view (Jarvik, 1996: fig. 45), hiding 6398 between the ectepicondyle ridge ("dorsal ridge" of Jarvik, 1996) and the entepicondyle; in extensor/dorsal view, the large process 1 covers it, while in flexor/ventral view, it lies behind
the oblique ridge that forms the proximal edge of the entepicondyle (compare Jarvik, 1996:
fig. 45F and Callier, Clack & Ahlberg, 2009: fig. 1 left side for two slightly different
interpretations of exactly which angle is "ventral view"). It is not common for the humeri of
early tetrapods to be figured in postaxial/posterior view; Callier, Clack & Ahlberg (2009) and
Ahlberg (2011), for example, did not bother. – In short, *Ichthyostega* has state 1.

Tulerpeton was scored as unknown, and RC07 stated without further comment that the
presence of process 2 was "uncertain". Ruta & Clack (2006), however, claimed that *Tulerpeton* had state 1 and cited Lebedev & Coates (1995). The latter did not mention process
from their fig. 5 it seems that a rather indistinct process is present. We have therefore
changed the score to 1.

- The process of *Crassigyrinus* that Panchen (1985) identified as the insertion point of
 M. subscapularis and Lebedev & Coates (1995: fig. 6F) labeled as the insertion point of M.
 latissimus dorsi appears to be process 2 by comparison to *Acanthostega* (Coates, 1996;
 Callier, Clack & Ahlberg, 2009) and *Ossinodus* (Bishop, 2014).
- 6414 It is unclear from Milner & Lindsay (1998: fig. 9) whether *Baphetes* had a small 6415 process 2; we have changed the score to unknown.
- 6416 Not preserved in *Eucritta*, apart from the early ontogenetic stage of the individual 6417 (Clack, 2001: fig. 7).
- 6418 Fig. 13 of Romer & Witter (1942) is a reconstruction; the area where process 2 would 6419 be is not preserved in any known specimen of *Edops* (D. M., pers. obs.), which we have 6420 therefore scored as unknown.
- 6421State 1 is further known in Ossinodus (Bishop, 2014); Silvanerpeton has a possibly6422slightly less weak version of state 1 than Tulerpeton (Ruta & Clack, 2006).
- About *Pederpes*, Clack & Finney (2005: 330) stated: "There is no equivalent to forcess 2' of *Ichthyostega* (Jarvik, 1996) or *Acanthostega* (Coates, 1996)." We do not think, however, that this can be stated with reasonable certainty when the area where the process would be has not been fully prepared and the humerus was even less well ossified (Clack & Finney, 2005: fig. 13) than that of *Ossinodus* (Bishop, 2014). We have therefore changed the score to unknown.
- 6429

6430 221. RAD 1: Radius or radioulna longer (0) or shorter (1) than humerus.

Baphetes has state 1 (Milner & Lindsay, 1998), as do Edops (D. M., pers. obs. of MCZ
1769), Cochleosaurus (Sequeira, 2009), Isodectes (D. M., pers. obs. of USNM 4471, USNM
4474, USNM 4555 and CM 81430), Doleserpeton (Sigurdsen & Bolt, 2009, 2010),
Cardiocephalus (CG78: fig. 31), Notobatrachus (Báez & Nicoli, 2004) and Vieraella (Báez &
Basso, 1996).

6436

6437 222. RAD 2: Radius longer than (0), as long as (1), or shorter than (2) ulna (ordered). 6438 This is a continuous character.

- 6439 State 1 is found in *Doleserpeton* (Sigurdsen & Green, 2011: appendix 2), 6440 Albanerpetidae (McGowan, 2002), *Eocaecilia* (Jenkins, Walsh & Carroll, 2007) and 6441 apparently *Cardiocephalus* (CG78: fig. 33C).
- *Edops* has state 2 (D. M., pers. obs. of MCZ 1769), as do *Cochleosaurus* (Sequeira,
 2009), *Isodectes* (D. M., pers. obs. of USNM 4471 and CM 81430), *Trimerorhachis* (Pawley,
 2007), *Triadobatrachus* (Ascarrunz et al., 2016: 3D model 1), *Valdotriton* (Evans & Milner,
 1996: fig. 7), *Microbrachis* (Olori, 2015: fig. 20C, D, 27C) and *Diplocaulus* (Williston, 1909;
 Douthitt, 1917). Radius and ulna remain distinguishable in a fused radioulna (RAD 3(1));
 state 2 is shared by *Notobatrachus* (Báez & Nicoli, 2004) and probably *Vieraella* (Báez &
 Basso, 1996: fig. 6).

6449 Olori (2015: 58, table S3) has stated that *Microbrachis* and *Hyloplesion* have state 1. 6450 This must reflect a more generous definition of that state than what we have used. As 6451 mentioned, we consider three photographs of *Microbrachis* in Olori (2015) to show state 2. The most mature forearm of Hyloplesion depicted in that study, Olori (2015: fig. 33C), indeed 6452 6453 shows state 1, but the ulna has almost no olecranon, and the caption states: "Beyond this 6454 [ontogenetic] stage, the olecranon becomes a rounded, distinct process." This strongly implies that state 2 was reached later in ontogeny. For this reason we have kept state 2 for 6455 6456 Hyloplesion, which is unambiguously depicted in the drawings in CG78: fig. 90D, E.

6457 Unknown in *Solenodonsaurus* (Danto, Witzmann & Müller, 2012) and *Euryodus* 6458 (CG78).

6459 As preserved, **Erpetosaurus* has state 1 (Milner & Sequeira, 2011: fig. 8), but scoring 6460 it that way would assume that the olecranon process is fully ossified, which is unlikely in the 6461 light of the clearly incompletely ossified humerus. We have therefore scored state 1 or 2.

From Paton, Smithson & Clack (1999: fig. 3) it may seem that **Casineria* has state 2;
however, radius and ulna are so incompletely ossified and preserved (split lengthwise; D. M.,
pers. obs. of NMS G 1993.54.1p) that we have to keep the score as unknown.

6466 223. RAD 3: Compound radio-ulna: absent (0); present (1).

6465

Baphetes is known to have state 0 (Milner & Lindsay, 1998), as are *Edops* (D. M.,
pers. obs. of MCZ 1769), *Cochleosaurus* (Sequeira, 2009), *Isodectes* (D. M., pers. obs. of
USNM 4471, USNM 4474 and CM 81430) and *Cardiocephalus* (CG78: fig. 31).

6471 224. ULNA 1: Olecranon process: absent (0); present (1).

Incompletely ossified proximal ends of ulnae that do not show a process should of 6472 6473 course not be scored 0, but unknown. This affects Crassigyrinus (Panchen, 1985), 6474 Schoenfelderpeton (Boy, 1986: fig. 10), Pederpes (Clack & Finney, 2005), Silvanerpeton 6475 (Ruta & Clack, 2006: fig. 6), and even the most mature known specimens of Discosauriscus 6476 (Klembara & Bartík, 2000) and Utegenia (Klembara & Ruta, 2004b) that preserve an ulna. In 6477 Leptorophus, a rudimentary process might sometimes be present (Boy, 1986: fig. 10), but 6478 more likely the ulna is again too incompletely ossified to tell (supported for Leptorophus by 6479 Werneburg, 2007a, and Schoch, 2014a). The same holds for Micromelerpeton (Boy, 1972: 37, 6480 fig. 20) and Odonterpeton (CG78: 147, fig. 98, 99). We have scored all OTUs mentioned in 6481 this paragraph as unknown.

Edops (D. M., pers. obs. of MCZ 1769 and MCZ 7143), *Cochleosaurus* (Sequeira,
2009), *Isodectes* (D. M., pers. obs. of USNM 4471 and CM 81430), *Apateon* (metamorphosed *A. gracilis*: Fröbisch & Schoch, 2009b), Albanerpetidae (*Celtedens ibericus*: McGowan,
2002: fig. 6C), *Eocaecilia* (Jenkins, Walsh & Carroll, 2007), *Microbrachis* (Olori, 2015), *Diplocaulus* (Williston, 1909; Douthitt, 1917) and *Ariekanerpeton* (Klembara & Ruta, 2005b)
have state 1. Apparently, so do the incompletely ossified *Valdotriton* (Evans & Milner, 1996:
fig. 7, 8) and the incompletely preserved *Cardiocephalus* (CG78: fig. 31).

6489 "In Acanthostega the ulna lacks an olecranon process" (Coates, 1996: 386), and indeed 6490 Acanthostega was scored as having state 0 in RC07. But on the same page (Coates, 1996: fig. 6491 17g-l), the left ulna of Acanthostega is illustrated as having a quite large process that 6492 continues the large flange proximal to the ossification front of the proximal articular end. Comparison to the right ulna of Greererpeton (Godfrey, 1989: fig. 20g-l) and to skeletal 6493 restorations (Godfrey, 1989: fig. 1c; Coates, 1996: fig. 18) does not show any reason not to 6494 6495 consider this process homologous to an olecranon process. The only clear difference to 6496 Greererpeton (scored 1 in RC07) is that, in Acanthostega, the proximal surface of this process 6497 is entirely unfinished (it looks like a cross-section) and continuous with the equally unfinished 6498 surface of the articulation for the humerus; this is not a sufficient reason to score state 0. We 6499 thus agree with Ahlberg (2011) that the olecranon process is present in *Acanthostega* and 6500 have changed the score to 1.

6501 Somewhat similarly, *Notobatrachus* should be considered to have state 1 (Báez & 6502 Nicoli, 2004: 167, fig. 2, 4, 5).

6503 CG78 stated on p. 32 that there is no "distinct olecranon" in **Llistrofus*. The base of 6504 an olecranon process is, however, shown in their fig. 15, so we have scored state 1. Given the 6505 wide-open skull sutures, the neurocentral sutures, the absence of preserved carpals and the 6506 apparently rather featureless radius, we consider the lack of further ossification of the 6507 olecranon to be most likely a juvenile feature.

6508

6509 225. ILI 3: Dorsal iliac process: absent (0); present (1). Judging from various "microsaurs"
6510 like *Tuditanus* and *Sparodus*, or even dinosaurs like *Bagualosaurus* (Pretto, Langer &
6511 Schultz, 2018), this process is homologous to the preacetabular process of (many) amniotes.

Frogs generally have only one process which is directed cranially. We wonder if the tuber superius of *Triadobatrachus*, *Notobatrachus*, ***Gobiates* and ****some other salientians (Roček & Rage, 2000; Ascarrunz et al., 2016; Báez & Nicoli, 2004; Roček, 2008) – though not all others; **Liaobatrachus* lacks it (Dong et al., 2013) – is homologous to the caudal process, and have therefore scored the two mentioned OTUs as having state 1.

6517 Ventastega shares state 1 (Ahlberg et al., 2008). So do Edops (D. M., pers. obs. of MCZ 6489; also implied by Romer & Witter, 1942), Chenoprosopus (Hook, 1993; D. M., 6518 pers. obs. of USNM 437646), Isodectes (D. M., pers. obs. of USNM 4474), Neldasaurus 6519 (Chase, 1965), Trimerorhachis (well developed: Pawley, 2007), Dendrerpetidae (less distinct, 6520 but still clear: Milner, 1996; Holmes, Carroll & Reisz, 1998; Pawley, 2006: 183, fig. 58), 6521 Acheloma (Olson, 1941), Broiliellus (D. M., pers. obs. of MCZ 3272; also suggested by the 6522 6523 illustration of that specimen in Carroll, 1964: fig. 11), Doleserpeton (Sigurdsen & Bolt, 6524 2010), Eoscopus (Daly, 1994), Platvrhinops (Hook & Baird, 1984; Werneburg, 2012a; D. M., pers. obs. of AMNH 2002), Apateon (Werneburg, 1991: fig. 8d), Leptorophus (Werneburg, 6525 6526 2007a: fig. 3), Batropetes (Glienke, 2013, 2015), Saxonerpeton, Hapsidopareion, Micraroter 6527 and Euryodus (CG78: fig. 126), Pelodosotis (CG78: 85), Hyloplesion (in later ontogeny: 6528 Olori, 2015), Scincosaurus, Diceratosaurus, Ptyonius, Sauropleura and Urocordylus (Bossy 6529 & Milner, 1998: fig. 67), and Ariekanerpeton and Utegenia (Klembara & Ruta, 2004b, 6530 2005b). An extremely short but otherwise well developed dorsal process is found in 6531 *Chroniosaurus (Clack & Klembara, 2009: fig. 8, left side); we have scored this as state 1 as 6532 well.

Eryops was scored as having state 0 in RC07. However, if anything, the caudal
process is absent, not the dorsal one (Romer, 1957: 117; Pawley, 2006: 183, fig. 58; Pawley
& Warren, 2006; D. M., pers. obs. of specimens in USNM, TMM, AMNH and elsewhere),
leading us to score state 1. The caudal process may well be present as the corner called "sacral
flange" by Pawley (2006: fig. 58) and Pawley & Warren (2006).

6538The albanerpetid *Celtedens* appears to have a dorsal process and maybe a small caudal6539one (McGowan, 2002: fig. 9); we have therefore assigned state 1 to Albanerpetidae.

The unusual-looking fig. 8 of Watson (1940), recommended by Daly (1994), suggests that *Amphibamus* may have had state 1 rather than 0 as scored by RC07, especially when compared to *Eoscopus* (Daly, 1994: fig. 13); we have scored it as unknown. "[T]he rear parts of the body are missing" in all known specimens of *Schoenfelderpeton* (Boy, 1986: 155; translated by D. M.), almost the entire ilium is unknown in *Valdotriton* (Evans & Milner, 1996), and the situation is unclear (probably the ilium is too poorly ossified) in *Keraterpeton* (Bossy & Milner, 1998: fig. 67).

The ilium of *Cochleosaurus* (Sequeira, 2009) apparently has an unusual ontogeny which begins at a shape very similar to that of *Eryops* but ends at a long, almost parallel6549 sided, caudodorsally directed rod as seen in *Isodectes* and **Erpetosaurus*. However, as we 6550 count both of those conditions as state 1, we have assigned state 1 to *Cochleosaurus* as well.

In **Gerobatrachus*, "[t]he ilium lacks the posterior process common to temnospondyls but the presence of an anterior process, a salientian character, is obscured by an overlying fragment of the femur" (Anderson et al., 2008a: 516). Because the caudal process is absent, we have tentatively scored state 1.

6555The situation in **Micropholis* is borderline, but we interpret the low dorsal bulge6556(Schoch & Rubidge, 2005: fig. 6G) as the dorsal process and have thus scored state 1.

6558 226. ILI 4: Caudal iliac process tapers to a single point or is rounded (0); ends in two corners (1). The original wording, "Posterior iliac process subhorizontal, stout, abbreviated 6559 posteriorly and tapering rearward in lateral aspect: absent (0); present (1)", is a garbled hash 6560 of four statements on size and shape, using "abbreviated" to indicate that the process is 6561 6562 metaphorically 'shortened' by being metaphorically 'cut off', giving it a more or less caudal 6563 edge (sometimes vertical as in Limnoscelis and Discosauriscus) with two corners instead of one. Notably, caudal processes with state 1 usually do not taper, but have a more or less con-6564 stant width throughout. - Judging from various "microsaurs" like Tuditanus and Sparodus, 6565 6566 this process is homologous to the postacetabular process of (many) amniotes.

6567 State 0 is present in *Chenoprosopus* (Hook, 1993; D. M., pers. obs. of USNM
6568 437646), *Cochleosaurus* (Sequeira, 2009), *Isodectes* (D. M., pers. obs. of USNM 4474),
6569 *Platyrhinops* (Hook & Baird, 1984), *Leptorophus* (Werneburg, 2007a) and *Kotlassia*6570 (Bystrow, 1944: 409).

6571 State 1, at least under our definition, is found in *Petrolacosaurus* (Reisz, 1981), 6572 probably *Westlothiana* (Smithson et al., 1994: fig. 11A, 14A, B, 15B), and, more surprisingly, 6573 *Acheloma* (Olson, 1941: fig. 12A), *Archeria* (Romer, 1957), *Sauropleura* (Bossy & Milner, 6574 1998), **Archegosaurus* (Witzmann & Schoch, 2006), **Mordex* (lectotype: Werneburg, 6575 2012a: fig. 31f) and **Australerpeton* (Eltink & Langer, 2014). By comparison to younger 6576 individuals of **Mordex* (Werneburg, 2012a: fig. 31b–d), we have scored **Branchiosaurus* 6577 (Werneburg, 2012a: fig. 30b, d, f) as unknown.

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6557

Batropetes appears to be polymorphic (Glienke, 2015: fig. 5).

Unknown in *Ecolsonia* (Berman, Reisz & Eberth, 1985: fig. 12A); almost the entire
ilium is unknown in *Valdotriton* (Evans & Milner, 1996). If the tuber superius of *Triadoba- trachus* is homologous to the caudal iliac process, it is nonetheless too small and possibly
incompletely ossified for this character to be applicable (Ascarrunz et al., 2016: 3D model 1).

6584 227. ILI 6: Supr[...]acetabular iliac buttress less (0) or more (1) prominent than 6585 postacetabular buttress.

6586

State 0 is found in Orobates (Nyakatura et al., 2015: digital model).

6587 *Cochleosaurus* has state 1 (Sequeira, 2009), as do *Doleserpeton* (D. M., pers. obs. of 6588 BEG 40882-25), apparently *Platyrhinops* (Hook & Baird, 1984) and (weakly expressed) 6589 *Triadobatrachus* (Ascarrunz et al., 2016: 3D model 1). We have also kept this state for 6590 *Eoscopus*, because Daly (1994: 17, fig. 13) mentioned and possibly drew "projecting rims 6591 dorsally and ventrally" on the acetabulum, with no indication of a caudal one; Daly (1994: 17) 6592 went on to state that "there is no supra-acetabular buttress", but clearly such a buttress and the 6593 projecting dorsal rim are homologous.

Eryops was scored as having state 1 in RC07. Pawley & Warren (2006: figs. 8.2 and 8.4, based entirely on specimens not mentioned below) reconstructed state 0 instead. This is not likely to be ontogenetic, because the large specimens TMM 31225-3 and TMM 31225-9 show state 1 while the likewise large MCZ 1126, MCZ 1536, MCZ 2588 and MCZ 2638 share state 0 with the middle-sized MCZ 2682 and the small TMM 31225-33, though other

6599 differences between the large specimens leave open the possibility of sexual or similar dimor-6600 phism. Such dimorphism is well known for the skulls, which are not preserved in these speci-6601 mens: there is a narrow-headed and a round-headed morph independently of absolute size (Werneburg, 2007b; D. M., pers. obs. of USNM, TMM, AMNH and MCZ specimens; 6602 6603 considered two species by Schoch & Milner, 2014). In any case, we have scored Eryops as 6604 polymorphic.

6605 Diagenetic crushing can further make this character difficult to code; the left side of the Diadectes specimen AMNH 23761 shows (if somewhat borderline) state 1 as scored, 6606 6607 while on the right side the ilium is bent ventromedially, creating state 0. (We have kept state 1 6608 for *Diadectes*.)

The postacetabular buttress is unossified in Chenoprosopus (Hook, 1993: fig. 3B; D. 6609 6610 M., pers. obs. of USNM 437646) and Trimerorhachis (Pawley, 2007). The same appears to be the case in *Sclerocephalus (Schoch & Witzmann, 2009a: fig. 8F), *Archegosaurus (Witz-6611 mann & Schoch, 2006b: fig. 7), *Erpetosaurus (Milner & Sequeira, 2011: fig. 10A), and to a 6612 6613 lesser extent *Australerpeton (Eltink & Langer, 2014).

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228. ILI 7: Transverse pelvic ridge: absent (0); present (1).

6616 State 0 is found in Ventastega (Ahlberg et al., 2008) and Cochleosaurus (Sequeira, 6617 2009).

6618 State 1 is documented in Edops (D. M., pers. obs. of MCZ 6489), in at least some large specimens of Trimerorhachis (Pawley, 2007) and in Acheloma (Polley & Reisz, 2011), 6619 and was apparently also present in Chenoprosopus (Hook, 1993; D. M., pers. obs. of USNM 6620 437646), Kotlassia (Bystrow, 1944: fig. 17) and Tuditanus (D. M., pers. obs. of CM 29592). 6621 We further agree with Romer (1957) that the transverse ridge of *Ichthyostega* (Jarvik, 1996) 6622 6623 constitutes state 1.

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6625 229. ILI 9: Ilium shaped like an elongate rod directed anteriorly/anterodorsally: absent 6626 (0); present (1). We have deliberately kept this character independent of the putative 6627 homology of the rod, in particular the question of whether it is the dorsal or the caudal process 6628 (ILI 3), in order to allow the homology hypotheses to compete.

6629 State 0 is present in Ventastega (Ahlberg et al., 2008), Edops (D. M., pers. obs. of MCZ 6489), Chenoprosopus (Hook, 1993), Cochleosaurus (Sequeira, 2009), Isodectes (D. 6630 6631 M., pers. obs. of USNM 4474), Platyrhinops (Hook & Baird, 1984; Clack & Milner, 2010), 6632 Leptorophus (Werneburg, 2007a) and probably Cardiocephalus (CG78: fig. 31).

"[T]he rear parts of the body are missing" in all known specimens of 6633 Schoenfelderpeton (Boy, 1986: 155; translated by D. M.); almost the entire ilium is unknown 6634 6635 in Valdotriton (Evans & Milner, 1996).

6636 *Tungussogyrinus has an intermediate condition that we count as state 1, following 6637 Werneburg (2009). The same appears to be the case in *Beiyanerpeton (Gao & Shubin, 2012: 6638 fig. 2).

6639

6640 deleted ILI 10: Acetabulum directed posteriorly/posterolaterally (0) or laterally (1). As 6641 RC07 pointed out, this character is parsimony-uninformative, so we have deleted it.

6642 Boisvert (2005) stated three times that Panderichthys, which was scored as unknown in RC07, has state 0, referring twice to her fig. 1d. That, however, is a line drawing which 6643 6644 does not show the acetabulum, but instead shows the whole area as damaged. The photograph 6645 (Boisvert, 2005: fig. 1c) which the drawing interprets appears to show that the entire surface of the pelvis and of the proximal half or so of the femur is damaged; no acetabulum can be 6646 6647 discerned. We therefore keep the score as unknown; state 0 thus remains restricted to Eusthe-6648 nopteron, and this character remains parsimony-uninformative.

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deleted ISC 1: Ischium contributing to pelvic symphysis: no (0); yes (1). As RC07 pointed
 out, this character is parsimony-uninformative, so we have deleted it.

230. PUB 1: Number of pubic obturator foramina: multiple (0), single (1), or absent (2)
(ordered). We have ordered this meristic character.

Eryops (Pawley & Warren, 2006), *Acheloma* (Polley & Reisz, 2011), *Phonerpeton* (D.
M., pers. obs. of MCZ 1548), *Doleserpeton* (Sigurdsen & Bolt, 2010), *Eoscopus* (Daly, 1994)
and *Cardiocephalus* (CG78: fig. 31) display state 1.

The three pubes catalogued as MCZ 7158 have been assigned to *Edops*. Only one of them clearly shows a foramen. Right next to it (craniodorsally), there is another hole of about the same size; however, we interpret it as damage, because it seems to have a solid floor of spongy bone (unlike the more likely foramen, which is filled with matrix to at least a deeper level) and because the bone surface around it, including the area between the two holes, is damaged (D. M., pers. obs.). We have therefore scored state 1 for *Edops*.

6666 *Platyrhinops* has state 1 or 2; we can exclude the possibility of state 0 (D. M., pers. 6667 obs. of AMNH 2002).

6668 *Batropetes palatinus* shows states 1 and 2 in different specimens (Glienke, 2015). 6669 Because only state 1 is documented in the other three species (Glienke, 2013, 2015), we have 6670 kept the score of 1, although this may yet turn out to be an artefact: *B. niederkirchensis* and *B.* 6671 *appelensis* are known from a single specimen each, and the specimens of *B. fritschi* and *B.* 6672 *appelensis* are less well preserved and ossified than those of the other two species (Glienke, 6673 2013, 2015).

6674 Clearly, the absence of pubic bones in the **Lydekkerina* specimens described by 6675 Hewison (2008) is due to immaturity, while the specimen described by Pawley & Warren, 6676 (2005) is more mature and has a short but ossified pubis which bears an obturator foramen on 6677 its ventral surface (Pawley & Warren, 2005: fig. 6F–H). We have scored state 1.

6678

6679 231. FEM 1-2-6: Internal trochanter does not project (0); projects proximally, enclosing
(with the head) an indentation (often rounded) in the "ventral" margin of the femur (1);
projects only "ventrally", so that its proximal edge forms an angle of at least 90° with
the shaft (2) (unordered). It may be further possible to distinguish lack of projection (which
appears to occur e.g. in *Ichthyostega*; Pierce, Clack & Hutchinson, 2012: supplementary
movies) from complete absence, but it appears that absence is only documented in *Eustheno- pteron* in the present taxon samples (Coates, 1996: fig. 36i).

6686 State 2 is our reinterpretation of FEM 6(1), which was scored only for *Eocaecilia* and Valdotriton in RC07. In those two OTUs (Evans & Milner, 1996; Jenkins, Walsh & Carroll, 6687 2007), the internal trochanter is very large in relation to the femoral head, projects "ventrally", 6688 6689 and is not continued distally by an adductor blade, making it even more conspicuous; but the 6690 lack of the adductor blade seems to be the only distinction to the condition found in Eryops 6691 (Pawley & Warren, 2006; D. M., pers. obs. of TMM 31227-11 and TMM 31227-14), 6692 Diadectes (Berman, Sumida & Martens, 1998: fig. 18A) or Ossinodus (Warren & Turner, 2004), to all of which we have therefore also assigned state 2. We note that FEM 6(0) was 6693 redundantly scored instead of FEM 6(?) for all OTUs with FEM 1(0) - "Internal trochanter 6694 raised as a distinct protuberance: absent" - except Notobatrachus. 6695

The original FEM 2 was confusing: its name was "Internal trochanter separated from
the general surface of the femur shaft by a distinct, trough-like space: absent (0); present (1)",
but the explanation (RC07: 107) referred to "a deeply notched web of bone", strongly

6699 implying that the "trough-like space" lies proximodorsal to the trochanter, between it and the 6700 head, rather than "dorsal" or "ventral" from it. Complete absence of this notch is 6701 indistinguishable from FEM 1(0), while conversely the notch can occupy the entire space 6702 where the web would be, which is always the case in taxa with state 2 of the present merged 6703 character – including *Eocaecilia* and *Valdotriton* (see above). Clearly, the three characters had 6704 to be merged. Neither the sequence 0-1-2 nor 0-2-1 represents increasing size as far as we can 6705 tell, so we have not ordered this character.

6706 State 0 is present in *Edops* (D. M., pers. obs. of MCZ 6493) and *Saxonerpeton* (CG78: 38).

6708 State 1 is found in *Cochleosaurus* (Sequeira, 2009: fig. 11), the largest specimen of 6709 *Trimerorhachis* (Pawley, 2007), *Pholiderpeton attheyi* (Panchen, 1972: fig. 14b) and 6710 *Gephyrostegus* (D. M., pers. obs. of MB.Am.641). Following Kennedy (2010: fig. 9D), we 6711 have also scored state 1 for *Limnoscelis*; the internal trochanter is in any case present 6712 (Kennedy, 2010: 217).

6713 Kotlassia (Bystrow, 1944: fig. 19) and Seymouria (D. M., pers. obs. of BEG 30966-176) are probably best scored as showing state 2, which they share with Microphon (Bulanov, 6714 6715 2014). State 2 is further seen in Dendrerpetidae (Carroll, 1967: fig. 18), Acheloma (Olson, 6716 1941: fig. 12; Polley & Reisz, 2011: fig. 14), Ecolsonia (Berman, Reisz & Eberth, 1985: 23, fig. 12D), Doleserpeton (Sigurdsen & Bolt, 2010: fig. 11B), Platyrhinops (Hook & Baird, 6717 1984: fig. 1), Archeria (Romer, 1957), Batropetes (Glienke, 2013: fig. 8Q; D. M., pers. obs. 6718 of MB.Am.1232; unclear if 1 or 2 from Glienke, 2015), Diplocaulus (Williston, 1909; 6719 Douthitt, 1917), Orobates (Berman et al., 2004: fig. 15; Nyakatura et al., 2015: digital model), 6720 Tseajaia (Moss, 1972) and *Beiyanerpeton (Gao & Shubin, 2012), although we caution that 6721 in some of these cases it is not certain whether the trochanter was fully ossified. In contrast, 6722 6723 an unambiguous case of state 2 occurs in *Lydekkerina (Pawley & Warren, 2005: fig. 6).

6724 *Urocordylus* seems to have state 0 or 2 (Bossy, 1976: 228).

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It appears from comparisons that the supposedly left femur of **Platyoposaurus* shown by Gubin (1991: drawing 35) is a right one, and that the supposed fourth trochanter (*tr*) is actually the entire adductor blade. Under this assumption, it is not quite clear whether state 1 or 2 is present, but state 2 appears more likely. The text does not mention the internal trochanter.

6730 Incomplete ossification prevents us from determining whether Neldasaurus (Chase, 6731 1965), Proterogyrinus (Holmes, 1984), Bruktererpeton (Boy & Bandel, 1973), Tuditanus, Micraroter, Pelodosotis, Microbrachis (CG78: 99, 124, fig. 5I, 50F, 83, 127; D. M., pers. obs. 6732 6733 of MB.Am.840.2, the specimen figured in Olori, 2015: fig. 24F) and Brachydectes (Wellstead, 1991) had state 1 or 2; we have scored partial uncertainty. Broiliellus is 6734 6735 apparently not well enough preserved to decide between the same two states (Carroll, 1964). 6736 Amphibamus may be well enough preserved, but Daly's (1994) fig. 18 is unclear, and no better reference appears to exist, so we have scored the same uncertainty; similarly, we have 6737 assigned state 1 or 2 to Petrolacosaurus (Reisz, 1981: fig. 22). Being unaware of a sufficient 6738 6739 illustration of a femur of Euryodus, we have also scored it the same way; the only Scinco-6740 saurus specimen that appears to preserve a femur, MB.Am.29, is damaged in that area (D. M., 6741 pers. obs.), so we have scored it the same way as well.

6742 Wholly inapplicable to the insufficiently ossified femora of *Discosauriscus* (Klembara6743 & Bartík, 2000: fig. 25).

6745 232. FEM 3: Fourth trochanter of femur with distinct rugose area: no (0); yes (1). We 6746 have not investigated whether this character is size-related or how distinct the area can be. 6747 *Phonerpeton* shows state 0 (D. M., pers. obs. of MCZ 1771 and MCZ 2474, several
6748 small and incompletely ossified femora), as do *Doleserpeton* (Sigurdsen & Bolt, 2010),
6749 *Diplocaulus* (Williston, 1909; Douthitt, 1917) and *Microphon* (Bulanov, 2014).

We have scored state 1 for **Nigerpeton* because there is a distinct process; whether it was rugose before erosion is impossible to tell (D. M., pers. obs. of MNN MOR 82).

6753 233. FEM 4: Proximal end of femur adductor crest reaching midshaft length: no (0); yes
6754 (1).

Diplocaulus has state 0 (Williston, 1909; Douthitt, 1917).

State 1 is found in *Edops* (D. M., pers. obs. of MCZ 7264), *Chenoprosopus* (Hook,
1993), *Cochleosaurus* (Sequeira, 2009), *Trimerorhachis* (Pawley, 2007), *Phonerpeton* (D. M.,
pers. obs. of MCZ 1771 and MCZ 2474), *Diadectes* (Case, 1911: fig. 30a; Berman, Sumida &
Martens, 1998: fig. 18A; D. M., pers. obs. of BEG 31222-56), *Microphon* (Bulanov, 2014)
and *Orobates* (Berman et al., 2004).

6762 234. FEM 5: Femur shorter than (0), as long as (1), or longer than humerus (2)
6763 (ordered). This is a continuous character.

6764 State 0 is found in *Panderichthys* (Boisvert, 2005) and *Ichthyostega* (Coates & Clack, 6765 1995, and references therein; Pierce, Clack & Hutchinson, 2012: fig. 1, supplementary text 6766 1.1, supplementary movies), making the distinction between states 0 and 1 parsimony-6767 informative. In RC07, state 0 was restricted to *Eusthenopteron*.

Acanthostega (Coates, 1996: 389: "The femur is about 25% longer than the humerus"!), *Cochleosaurus* (Sequeira, 2009), *Isodectes* (D. M., pers. obs. of CM 81430 and USNM 4474), *Trimerorhachis* (Pawley, 2007), *Doleserpeton* (Sigurdsen & Bolt, 2010: fig. 1; Sigurdsen & Green, 2011: appendix 2) and *Leptorophus* (Werneburg, 2007a) have state 2.

6772 State 1 makes surprise appearances in *Acheloma* (specimen WM 1756: Olson, 1941:
6773 fig. 11D, E, 12B–D) and **Lydekkerina* (Pawley & Warren, 2005: fig. 6).

Batropetes was scored as having states 1 and 2 in RC07. State 2 is limited to the left side of one specimen (Glienke, 2015: appendix 1). On the right side, the same specimen has state 1; state 1 is further found in one or two other specimens of *B. palatinus* and maybe one of *B. fritschi*. All others have state 0 (Glienke, 2013: appendix; 2015: appendix 1). Because state 0 is so common, we have assigned it to *Batropetes* without polymorphism.

6779 6780 235. TIB 6: Outline of tibia medial margin shaped like a distinct, subsemicircular 6781 embayment contributing to interepipodial space and the diameter of which is less than 6782 one-third of bone length: absent (0); present (1).

Since almost any condition is by definition state 0, it is not surprising that state 0 is
known to occur in *Panderichthys* (Boisvert, 2005), *Edops* (D. M., pers. obs. of MCZ 7162), *Cochleosaurus* (Sequeira, 2009: fig. 11), *Isodectes* (D. M., pers. obs. of USNM 4474), *Doleserpeton* (Sigurdsen & Bolt, 2010; D. M., pers. obs. of AMNH 24969), *Platyrhinops*(Clack & Milner, 2010), Albanerpetidae (McGowan, 2002) and *Karaurus* (Ivachnenko, 1978;
M. and M. L., pers. obs. of unnumbered MNHN cast of PIN 2585/2).

6789 Strangely, Warren (2007: fig. 11) did not color the tibia of *Ossinodus* in her skeletal 6790 reconstruction to mark it as known. The shape of the reconstructed tibia, however, agrees with 6791 the better preserved one of the two described by Warren & Turner (2004), so we assume the 6792 lack of color is unintentional and have kept the scores for this and the following character.

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6794 236. TIB 7: Tibia without (0) or with (1) flange along its posterior edge.

Like Panderichthys (Boisvert, 2005), Cochleosaurus (Sequeira, 2009: fig. 11),
Isodectes (D. M., pers. obs. of USNM 4474), Doleserpeton (Sigurdsen & Bolt, 2010; D. M.,

6798 PIN 2585/2), Orobates has state 0 (Nyakatura et al., 2015: digital model). 6799 We count the crest of *Archegosaurus (Witzmann & Schoch, 2006b: fig. 9B), and by 6800 extension Edops (D. M., pers. obs. of MCZ 7162 and MCZ 7259), as state 1. 6801 6802 237. FIB 1: Fibula waisted: no (0); yes (1). 6803 State 0 is found in *Panderichthys* (Boisvert, 2005). Edops possesses state 1 (D. M., pers. obs. of MCZ 1782 and 7258), and so do 6804 Cochleosaurus (Sequeira, 2009: fig. 11), Isodectes (D. M., pers. obs. of CM 81430), 6805 Doleserpeton (Sigurdsen & Bolt, 2010; D. M., pers. obs. of AMNH 29470), Platyrhinops 6806 (Hook & Baird, 1984; Clack & Milner, 2010) and Leptorophus (Werneburg, 2007a). We have 6807 6808 also assigned state 1 to Notobatrachus because its tibiofibula is strongly waisted (Báez & 6809 Nicoli, 2004). 6810 The fibula is entirely unknown in Ossinodus (Warren & Turner, 2004; Warren, 2007: 6811 fig. 11). 6812 All of the bones lying around in fig. 10A of Milner & Sequeira (2011) are waisted; 6813 judging from their sizes and positions, one of them is bound to be the fibula. We have 6814 therefore scored state 1 for **Erpetosaurus*. 6815 6816 238. FIB 3: Ridge near posterior edge of fibula flexor surface: absent (0); present (1). Orobates has state 0 (Berman et al., 2004; Nyakatura et al., 2015: digital model). 6817 6818 Trimerorhachis (Pawley, 2007: fig. 15.2.3; D. M., pers. obs. of TMM 40998-39) and Doleserpeton (Sigurdsen & Bolt, 2010) show state 1. (The Doleserpeton specimen AMNH 6819 29470 has state 0 [D. M., pers. obs.], but this could be ontogenetic.) State 1 further shows up 6820 in *Australerpeton (Eltink & Langer, 2014). 6821 6822 Sigurdsen & Green (2011: appendix 2) recommended to score Valdotriton as un-6823 known; we have followed this. 6824 The fibula is entirely unknown in Ossinodus (Warren & Turner, 2004; Warren, 2007: 6825 fig. 11). 6826 6827 239. FIB 4: Rows of tubercles near posterior edge of fibula flexor surface: absent (0); 6828 present (1). 6829 Doleserpeton (Sigurdsen & Bolt, 2010) and Orobates (Berman et al., 2004; Nyakatura 6830 et al., 2015: digital model) have state 0. State 1 is found in Eryops (Pawley & Warren, 2006). 6831 6832 The fibula is entirely unknown in Ossinodus (Warren & Turner, 2004; Warren, 2007: 6833 fig. 11). 6834 6835 240. TAR 2: Separate tibiale, intermedium and/or centrale 4 (0); astragalus (1). The original wording counted the "[p]roximal tarsal ossifications: absent (0); presence of single 6836 ossification (1); presence of more than two ossifications (2)". This did not distinguish incom-6837 6838 plete ossification of the tarsus from fusion of individual tarsals. The degree of ossification 6839 depends both on ontogeny and on lifestyle (with aquatic taxa ossifying the proximal tarsus 6840 later and/or to a lesser degree than terrestrial ones). Furthermore, incomplete ossification and incomplete preservation can only be distinguished in articulated skeletons. Finally, the astra-6841 galus usually comes with a calcaneum (= fibulare), so there are two "[p]roximal tarsal ossifi-6842

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pers. obs. of AMNH 24969) and Karaurus (D. M., pers. obs. of unnumbered MNHN cast of

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6843 cations" – yet no state was available between "single" and "more than two"! Of the OTUs 6844 with an astragalus, *Captorhinus*, *Paleothyris* and *Petrolacosaurus* were scored as having state

6845 2 in RC07, while *Diadectes*, *Tuditanus* and *Pantylus* were scored as having state 1 or 2! We do not consider this tenable and have redefined the character to consider fusion only.
6847 Of the OTUs previously scored as unknown or partially uncertain, Albanerpetidae has 6848 state 0 (McGowan, 2002), as do Eocaecilia (Jenkins, Walsh & Carroll, 2007), Triadobatra-6849 chus (Roček & Rage, 2000; Ascarrunz et al., 2016), Kotlassia (Bystrow, 1944: 406), most likely Limnoscelis (Kennedy, 2010), Batropetes (Glienke, 2013), Microbrachis (CG78: 124; 6850 6851 Olori, 2015) and Scincosaurus (Milner & Ruta, 2009). Apparently, so does Platyrhinops 6852 (Hook & Baird, 1984; Clack & Milner, 2010: fig. 1a). We have also scored state 0 for Ossinodus, where Warren (2007: fig. 11) figured a tibiale in a skeletal restoration without mention-6853 ing it in the text (the possible fibulare of Warren & Turner [2004], which has a quite different 6854 shape, is not shown), and **Pholidogaster*, where the largest preserved tarsal (on both sides), 6855 6856 which is clearly proximal, is much smaller than expected for an astragalus (Romer, 1964: fig. 6857 1B).

6858 We count *Gephyrostegus* as possessing state 1: the tibiale and the intermedium are 6859 (although incompletely) fused, and the lateralmost centrale in fig. 9 of Carroll (1970) should 6860 be the centrale 3, not 4.

6861 6862 In *Euryodus* the condition is unknown (CG78: 65).

6863 241. TAR 3: L-shaped proximal tarsal element: absent (0), present (1).

Albanerpetidae and *Eocaecilia* have state 0 (McGowan, 2002; Jenkins, Walsh &
Carroll, 2007), as do *Limnoscelis* (Kennedy, 2010), *Microbrachis* (Olori, 2015) and *Tseajaia*,
assuming that Moss (1972) has interpreted the tarsus correctly (the shapes of the tibiale and
the intermedium are rather unusual).

6868 6869 *Tuditanus* shows state 1 (Carroll & Baird, 1968: fig. 10B).

6870 242. TAR 4: Distal tarsal ossifications between fibulare and digits: absent (0); present
6871 (1). RC07 (p. 108) stated that this character and TAR 5 have the same distribution. We would
6872 have merged the characters in that case; however, *Scincosaurus* and *Orobates* break the
6873 pattern (see below).

6874 *Platyrhinops* (D. M., pers. obs. of AMNH 2002) and Albanerpetidae (McGowan, 6875 2002) have state 1.

Remarkably, Scincosaurus shows state 0 (Milner & Ruta, 2009).

6876 6877

6878 243. TAR 5: Distal tarsal ossifications between tibiale and digits: absent (0); present (1).

6879 State 1 is known in *Platyrhinops* (D. M., pers. obs. of AMNH 2002), Albanerpetidae 6880 (McGowan, 2002), *Batropetes* (Glienke, 2015) and *Scincosaurus* (Milner & Ruta, 2009).

6881 Orobates has state 0; of all distal tarsals only the fourth is ossified (Berman et al.,
6882 2004).
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6884 244. RIB 1: Anterior and posterior process of ribs: both absent (0); anterior process present, posterior process absent (1); both present, ribs k-shaped in at least part of the 6885 trunk (2) (ordered). RC07 compared the shape to a capital K, but the ventrolateral ramus is 6886 distinctly longer than the others, so we follow the comparison by Anderson (2002, 2003a, b) 6887 6888 and Anderson, Carroll & Rowe (2003). While RC07 only contrasted state 2 with the others in 6889 a binary character, we prefer to code the fact that *Lethiscus* has half of the k-shape (Anderson, 6890 Carroll & Rowe, 2003). State 1 is not known elsewhere (the anterior process may be homologous with the capitulum, but differs in not articulating with a vertebra); ribs with a 6891 6892 posterior but no anterior process appear to be entirely unknown, justifying ordering of this 6893 character.

6894 *Cochleosaurus* (Sequeira, 2009), *Isodectes* (D. M., pers. obs. of USNM 4555, CM 6895 81430 and CM 81512), *Archeria* (D. M., pers. obs. of MCZ 2049 and others) and 6896 *Cardiocephalus* (CG78: fig. 31) have state 0.

6897 6898 245. RIB 2: "Cervical" ("pectoral") ribs with (0) or without (1) flattened distal ends. 6899 Unknown in Ossinodus (Warren & Turner, 2004; Warren, 2007). 6900 Cochleosaurus has state 0 (Sequeira, 2009), and so do Isodectes (D. M., pers. obs. of 6901 USNM 4474 and CM 81430), Doleserpeton (Sigurdsen & Bolt, 2010), Cardiocephalus 6902 (CG78: fig. 31) and Ptyonius (D. M., pers. obs. of MCZ 3721, a cast of "AMNH 6871 6903 (85466)"). 6904 Trimerorhachis has state 1 where known (Milner & Schoch, 2013). So do 6905 Oestocephalus (Anderson, 2003a: fig. 4B) and Phlegethontia (Anderson, 2002). We further 6906 follow Pardo et al. (2017: matrix) in scoring state 1 for Lethiscus and *Coloraderpeton. 6907 6908 246. RIB 3: Ribs mostly straight (0) or ventrally curved in at least part of the trunk (1). 6909 The "first dorsal rib" of *Tseajaia* has "cervical rib" morphology (Moss, 1972); this 6910 may be why it (and it alone) was scored as polymorphic by RC07. The definition refers to "at 6911 least part of the trunk", however, meaning that *Tseajaia* has state 1. 6912 So do Isodectes (D. M., pers. obs. of USNM 4474, CM 81430 and CM 81512) and 6913 Cardiocephalus (CG78). 6914 State 0 is found in Cochleosaurus (Sequeira, 2009). We follow Pardo et al. (2017: 6915 matrix) in scoring state 0 for *Coloraderpeton. 6916 Schoch & Rubidge (2005: figs. 5B, 7A) showed curvature in *Micropholis, but did not 6917 explain if it is ventral or only caudal in direction. We have scored *Micropholis as unknown. 6918 6919 247. RIB 4: Broad rectangular flanges in at least some trunk ribs: absent (0); present (1). 6920 Like Cochleosaurus (Sequeira, 2009), Archeria (D. M., pers. obs. of MCZ 2049 and others), Kotlassia (Bystrow, 1944) and Cardiocephalus (CG78: fig. 31), Lethiscus has state 0 6921 6922 (Anderson, Carroll & Rowe, 2003). 6923 *Nigerpeton has state 1 (D. M., pers. obs. of MNN MOR 83). In *Platyoposaurus, the 6924 flanges are somewhat narrow, but clearly present as well (Konzhukova, 1955; Gubin, 1991). 6925 6926 248. RIB 5: Triangular spur-like posterodorsal process in at least some trunk ribs: 6927 absent (0); present (1). 6928 Baphetes shows state 1 (Milner & Lindsay, 1998), as do Gephyrostegus (Godfrey & 6929 Reisz, 1991) and Kotlassia (Bystrow, 1944). 6930 Like Cochleosaurus (Sequeira, 2009), Archeria (D. M., pers. obs. of MCZ 2049 and 6931 others) and Cardiocephalus (CG78: fig. 31), Lethiscus has state 0 (Anderson, Carroll & Rowe, 2003), and so does *Nigerpeton (D. M., pers. obs. of MNN MOR 83). 6932 6933 6934 249. RIB 6: Elongate posterodorsal triangular flange in the midtrunk ribs: absent (0); 6935 present (1). 6936 Like Cochleosaurus (Sequeira, 2009), Archeria (D. M., pers. obs. of MCZ 2049 and 6937 others) and Cardiocephalus (CG78: fig. 31), Lethiscus has state 0 (Anderson, Carroll & 6938 Rowe, 2003), and so does *Nigerpeton (D. M., pers. obs. of MNN MOR 83). 6939 6940 250. RIB 7: Trunk ribs longer (0) or shorter (1) than three successive articulated 6941 vertebrae in adults. The measured vertebrae should be from the same region of the trunk as the vertebrae. 6942 6943 RC07 added the unquantified terms "poorly ossified" and "slender" to the definition of 6944 state 1 and did not test if all three traits are correlated. We have reduced the character to 6945 length alone, making it identical to McGowan's (2002) ch. 1 as modified by Marjanović & 6946 Laurin (2008: 177f.). Thus, we have scored Micromelerpeton as possessing state 0 which,

according to R. Schoch (pers. comm. to Marjanović & Laurin, 2008: 178), is observed in the
metamorphosed specimens announced by Lillich & Schoch (2007) and Schoch (2009b), and
we have scored *Balanerpeton* (Milner & Sequeira, 1994), Dendrerpetidae (Holmes, Carroll &
Reisz, 1998), *Acheloma* (Case, 1911: fig. 46), *Cardiocephalus* (borderline; CG78: fig. 31), *Odonterpeton* (CG78), *Lethiscus* (the longest preserved rib seems not to reach state 0,
although it comes close: Wellstead, 1982: fig. 8B), *Oestocephalus* (Carroll, 1998a; Anderson,
2003a) and *Phlegethontia* (both species; Anderson, 2002: fig. 10) as having state 1.

Importantly, *Acheloma* (Case, 1911: fig. 46) demonstrates that this character is not
correlated to absolute body size, even though **Utaherpeton* adds to the already known sample
of taxa which change from state 1 to (barely) state 0 in their ontogeny (Carroll, Bybee &
Tidwell, 1991; Carroll & Chorn, 1995).

State 0 is further found in *Baphetes* (Milner & Lindsay, 1998), *Cochleosaurus*(Sequeira, 2009) and *Isodectes* (D. M., pers. obs. of CM 81512) as well as **Nigerpeton* (D.
M., pers. obs. of MNN MOR 83). It furthermore occurs (just barely) in *Adelospondylus* and *Adelogyrinus* (Andrews & Carroll, 1991; contra Marjanović & Laurin, 2009), while *Acherontiscus*, in which the ribs are as long as 2¹/₂ vertebrae, has state 1 (Carroll, 1969a).

6963 Unknown in *Phonerpeton* (Dilkes, 1990) and in *Westlothiana* where it is too 6964 borderline to tell (Smithson et al., 1994).

6966 251. CER VER 1: Halves of atlas neural arch unfused (0) or fused (1).

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Edops has state 0 (D. M., pers. obs. of MCZ 7197), as do *Cochleosaurus* (Sequeira,
2009), *Trimerorhachis* (Pawley, 2007; Milner & Schoch, 2013), *Acheloma* (Polley & Reisz,
2011), *Triadobatrachus* (Ascarrunz et al., 2016) and *Batropetes* (Glienke, 2013: 81; 2015).

6970 *Euryodus* is polymorphic, with *E. dalyae* having state 0 as scored, but *E. primus* 6971 showing state 1 (CG78: fig. 115).

6972 State 1 is found in *Diplocaulus* (Williston, 1909: pl. 3; Douthitt, 1917: fig. 4). We 6973 have scored **Gerobatrachus* as possessing state 1, following the matrix by Anderson et al. 6974 (2008a), surprising though this is (*Doleserpeton* has state 0, as was correctly scored: Bolt, 6975 1991: fig. 5; Sigurdsen & Bolt, 2010).

6976 The situation in *Microbrachis* is unclear; in the other vertebrae the halves seem to 6977 have fused in later ontogeny (Olori, 2015). We have scored it as unknown.

6978 We follow Pardo et al. (2017: matrix) in scoring state 1 for *Lethiscus* and
6979 **Coloraderpeton*.

6981 252. CER VER 3: Axis arch not fused (0) or fused (1) to axis (pleuro)centrum.

6982 *Trimerorhachis* (Pawley, 2007) shows state 0, as does *Acheloma* (Polley & Reisz, 6983 2011).

Eocaecilia has state 1 (Jenkins, Walsh & Carroll, 2007), as do *Triadobatrachus*(Ascarrunz et al., 2016: fig. 7), *Kotlassia* (Bystrow, 1944: 394, fig. 8), apparently *Batropetes*(Glienke, 2013) and *Cardiocephalus* (there is only "a trace of suture": CG78: 58). We have
also scored it for *Hyloplesion*, following Olori (2015: table S3), coherent with a statement on
p. 57 of that paper but apparently contradicting another on p. 46.

We also ascribe state 1 to Albanerpetidae because we strongly suspect that the entirely
arch-less "axis", which often fuses to the "third cervical", is in fact the axis intercentrum, and
the "third cervical" is the axis pleurocentrum + neural arch (Material and methods:
Modifications to individual cells: The albanerpetid neck).

6993 In *Brachydectes*, however, we have scored state 0: while we have not been able to find 6994 a statement concerning specifically the axis, neurocentral sutures are ubiquitous in both the 6995 atlas and other vertebrae (Wellstead, 1991; Pardo & Anderson, 2016: fig. 15), so state 1 6996 would be rather surprising. 6997 State 0 is documented in subadult specimens of *Doleserpeton*, but the condition in 6998 adult individuals is apparently unknown; given state TRU VER 11(1), it is possible that they 6999 had state 1 of this character (Sigurdsen & Bolt, 2010), so we follow Sigurdsen & Green 7000 (2011) in keeping *Doleserpeton* scored as unknown.

7001State 0 is also seen in the only known axis of *Microphon* (Bulanov, 2014); given the7002immature or paedomorphic (Bulanov, 2003) status of that specimen, we retain the original7003score of unknown.

Given that the arch is fused to the centrum both in the atlas and in the trunk (Pardo et al., 2017: ch. 111 and 132 in their matrix), state 1 seems likely enough in *Lethiscus* and **Coloraderpeton* for us to score it.

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253. CER VER 4: Odontoid process, or tuberculum interglenoideum, on anterior surface
of atlas body: absent (0); present (1). It is a good question if this process – also called
"intercotylar tubercle"; not homologous to the odontoid process of mammals, which consists
of the entire atlas pleurocentra that are fused to the axis – should be considered homologous
regardless of whether the "atlas body" consists of pleuro- or intercentra. Unfortunately,
whether the atlantes of, say, lissamphibians consist of pleuro- or intercentra is itself a difficult
question, so we have followed RC07 in considering all such processes primarily homologous.

7015 We have scored this character as unknown for OTUs which are known to have any 7016 state of EXOCC 2-3-4-5/BASOCC 1-5 (ch. 134) other than 4 or 5, because the process does 7017 not (as far as known) and probably cannot occur together with states 0, 1 or 2 of EXOCC 2-3-7018 4-5/BASOCC 1-5-6 and by definition occurs with state 3 (where the cotyle of the 7019 basioccipital articulates with it). The great exception to this rule is *Phlegethontia*, which has state 1 of that character, but nonetheless displays a long odontoid process; this is made 7020 7021 possible by the surprising gap between the skull and the atlas that is bridged by the long 7022 proatlas dorsally and, at least in part, by the odontoid process ventrally (Anderson, 2002; D. 7023 M., pers. obs. of USNM 17097, where the proatlas is not preserved). Although the process is 7024 an extension of the ventral surface in Phlegethontia, it has a more dorsal, more 7025 lissamphibian-like location in the closely related *Pseudophlegethontia (Anderson, 2003b), 7026 so we see no reason not to consider it primarily homologous and have scored state 1.

Furthermore, this character is inapplicable to *Doleserpeton*, in which the area where a tubercle could lie is occupied by the huge notochordal canal (Bolt, 1991: fig. 5; Sigurdsen & Bolt, 2010). Similarly, the presacral centra of **Sclerocephalus* are very incompletely ossified (Schoch & Witzmann, 2009a); **Platyoposaurus* (Gubin, 1991: drawing 27) shows a welldefined but huge notochordal notch similar to that of *Doleserpeton* despite being a much larger animal.

The illustrations of *Acheloma* supplied by Polley & Reisz (2011) are, unfortunately, not three-dimensional enough to tell; however, because Polley & Reisz (2011) did not mention the presence of a process, we have scored *Acheloma* as possessing state 0.

We cannot find a description or illustration of the atlantes of *Amphibamus* or *Eoscopus*; the most likely source, Daly (1994), did not describe any atlas centra, except for mentioning the very existence of one in *Platyrhinops* (which RC07 already scored as unknown). We have therefore scored both as unknown.

The condition is further unknown in *Hyloplesion* (CG78: 131).

7041Odonterpeton was scored as unknown in RC07. CG78: 167 implied state 0, but this7042refers to a large process as commonly found in "microsaurs"; the process can be very small in7043lissamphibians, and indeed CG78: fig. 99C (repeated as fig. 116L) depicted state 1. Personal7044observation by D. M. of USNM 4465+4467 (the holotype and probably only known7045specimen) shows that this is correct – although only as an outline drawing; the process is not

- part of the ventral surface of the atlas, but has a considerably more dorsal position, making theatlas much less unusual than implied by CG78.
- 7048State 1 is found in *Diplocaulus* (Williston, 1909: pl. 3), as well as in *Triadobatrachus*7049(very weakly ossified: Ascarrunz et al., 2016: 3D model 1), *Notobatrachus* (Báez & Basso,70501996; Báez & Nicoli, 2004), **Liaobatrachus* (figures in Dong et al., 2013) and other frogs7051like ***Gobiates* (Roček, 2000: fig. 16; 2008: fig. 2E). We further follow Pardo et al. (2017:7052matrix) in scoring it for *Lethiscus* and **Coloraderpeton*.
- 7054 254. TRU VER 1: Extra articulations above zygapophyses in at least some trunk and 7055 caudal vertebrae: absent (0); present (1).

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- 7056 *Cochleosaurus* (Sequeira, 2009), *Isodectes* (D. M., pers. obs. of CM 81512) and 7057 *Cardiocephalus* (CG78: fig. 31) have state 0.
- 7059 255. TRU VER 2: Neural and haemal spines rectangular to fan-shaped in lateral view:
 7060 no (0); yes (1).
- 7061Chenoprosopus shows state 0 (D. M., pers. obs. of USNM 437646), as do7062Cardiocephalus (CG78: fig. 31), Phlegethontia (Anderson, 2002), Ossinodus (Warren, 2007)7063and *Nigerpeton (D. M., pers. obs. of MNN MOR 83).
- Pardo et al. (2017: supp. inf.) scored **Coloraderpeton* as having state 0 of their ch.
 115: "Neural spine shape in lateral view (HPSA 153): (0) anterior and posterior sides parallel,
 forming a rectangular surface; (1) non-parallel, triangular". We interpret this as our state 1.
- 7068 256. TRU VER 3: Neural and haemal spines aligned dorsoventrally: absent (0); present
 7069 (1).
 - Hyloplesion (Olori, 2015) and Ossinodus (Warren, 2007) have state 0.
- The entire tail is unknown in *Colosteus* (Hook, 1983), *Crassigyrinus* (Panchen, 1985), *Neldasaurus* (Chase, 1965), *Broiliellus* (Carroll, 1964), *Eoherpeton* (Smithson, 1985), *Pholid- erpeton scutigerum* (Clack, 1987b), *Gephyrostegus* (Carroll, 1970; Godfrey & Reisz, 1991), *Solenodonsaurus* (Laurin & Reisz, 1999; Danto, Witzmann & Müller, 2012), *Stegotretus*(Berman, Eberth & Brinkman, 1988), and *Ariekanerpeton* (Klembara & Ruta, 2005b).
 Similarly, no hemal arches are preserved in *Triadobatrachus* (Roček & Rage, 2000), and none
 were ossified in described specimens of *Apateon* or *Leptorophus*.
- Doleserpeton has state 0 as scored, but one wonders how this was done before
 Sigurdsen & Bolt (2010) described (any part of) the tail for the first time in a publication;
 Ruta, Coates & Quicke (2003) did not claim to have seen specimens and did not cite Bolt's
 unpublished thesis (which dates to 1964).
- 7083 257. TRU VER 4: Haemal spines not fused (0) or fused (1) to caudal centra. According to
 7084 RC07, state 1 is "observed almost exclusively in nectrideans", but this statement does not
 7085 seem defensible to us.
- 7086 Importantly, hemal arches are not homologous to intercentra or parts thereof (contra, 7087 e.g., Williston, 1912: 466; Carroll, 1968: 1177, 1188-1189, 1969a: 545; Carroll & Chorn, 1995: 49; Palci, Caldwell & Nydam, 2013: 1339; Olori, 2015: 57). This is demonstrated by 7088 the separate hemal arches and intercentra of animals like the temnospondyls *Acanthostoma-7089 7090 tops (Witzmann & Schoch, 2006a), *Lydekkerina (Pawley & Warren, 2005) and 7091 **Trematolestes (Schoch, 2006: fig. 6H) or the anthracosaurs **RM 206859 (Holmes & Carroll, 2010) and apparently **CM 34638 (Clack, 2011a). Therefore, this character cannot 7092 7093 be interpreted as "hemal spines not/fused to caudal pleurocentra". It is also, unfortunately, not 7094 a cheap way of determining whether an animal has intercentra (see TRU VER 7, 8, 9, 13-14).

7095 State 1 is thus present at a minimum in Eusthenopteron and Acanthostega (Coates, 7096 1996), probably Ichthyostega (Jarvik, 1996: pl. 38), Greererpeton (Godfrey, 1989), Edops (D. 7097 M., pers. obs. of MCZ 7128), Trimerorhachis (Pawley, 2007), Dendrerpetidae (Holmes, 7098 Carroll & Reisz, 1998: fig. 1), Eryops (Moulton, 1974: fig. 6-8), Acheloma (Case, 1911: 135), 7099 Phonerpeton (Dilkes, 1990: fig. 10), Ecolsonia (Berman, Reisz & Eberth, 1985), Amphiba-7100 mus and Eoscopus (Daly, 1994), Platyrhinops (Hook & Baird, 1984), Karaurus (Ivachnenko, 7101 1978: 366; D. M., pers. obs. of unnumbered MNHN cast of PIN 2585/2), Caerorhachis (Ruta, Milner & Coates, 2002), Proterogyrinus (Holmes, 1984), Archeria (Holmes, 1989), Pholider-7102 7103 peton attheyi (Panchen, 1972), Bruktererpeton (Boy & Bandel, 1973: fig. 8), Kotlassia (Bystrow, 1944), Discosauriscus (Klembara & Bartík, 2000), Seymouria (White, 1939: 356), 7104 7105 Diadectes (Berman, Sumida & Martens, 1998: 78), Limnoscelis (Williston, 1912: 466, fig. 25; 7106 Berman & Sumida, 1990: 326), Captorhinus (Dilkes & Reisz, 1986: 1294), Petrolacosaurus (Reisz, 1981: 36), Westlothiana (Smithson et al., 1994), Micraroter (CG78: 97, fig. 58), Oro-7107 7108 bates (Nyakatura et al., 2015: digital model), Ossinodus (Warren, 2007), Silvanerpeton (Ruta 7109 & Clack, 2006) and Utegenia (Klembara & Bartík, 2000: fig. 30). It is also suggested for Balanerpeton by fig. 10C of Milner & Sequeira (1994); we have accepted this at face value. 7110

7111 Hyloplesion has state 0 (Olori, 2015).

7112 A large number of taxa where the tail is poorly or not known were scored as having 7113 state 0 by RC07. This includes Colosteus (Hook, 1983), Crassigyrinus (Panchen, 1985), Neldasaurus (Chase, 1965), Broiliellus (Carroll, 1964), Eoherpeton (Smithson, 1985), Pholid-7114 7115 erpeton scutigerum (Clack, 1987b), Gephyrostegus (Carroll, 1970; Godfrey & Reisz, 1991), Solenodonsaurus (Laurin & Reisz, 1999; Danto, Witzmann & Müller, 2012), Stegotretus 7116 7117 (Berman, Eberth & Brinkman, 1988) and Ariekanerpeton (Klembara & Ruta, 2005b).

7118 Further unknown in Baphetes (Milner & Lindsay, 1998: fig. 8), Albanerpetidae 7119 (McGowan, 2002) and Paleothyris (Carroll, 1969b); inapplicable to Triadobatrachus which 7120 does not preserve any hemal arches (Roček & Rage, 2000; Ascarrunz et al., 2016).

7121 Doleserpeton has a truly remarkable tail in which all elements of each vertebra -7122 neural arch, pleurocentrum, intercentrum, and hemal arch - are fused into a single bone 7123 (Sigurdsen & Bolt, 2010). This constitutes state 1; it is probably not even possible to distin-7124 guish if the hemal arches are fused to the intercentra alone or to both inter- and pleurocentra, 7125 though Sigurdsen & Bolt (2010) suggested that the latter has happened.

7126 We interpret *Archaeovenator (Reisz & Dilkes, 2003: fig. 1) as having fused hemal 7127 arches and intercentra, thus state 1. 7128

7129 258. TRU VER 5: Extra articulations on haemal spines: absent (0); present (1).

State 0 is now known in Hyloplesion (Olori, 2015), Orobates (Nyakatura et al., 2015: 7130 7131 digital model) and Ossinodus (Warren, 2007). 7132

State 1 is found in Scincosaurus (Milner & Ruta, 2009).

7133 The entire tail is unknown in Colosteus (Hook, 1983), Crassigyrinus (Panchen, 1985), 7134 Neldasaurus (Chase, 1965), Broiliellus (Carroll, 1964), Eoherpeton (Smithson, 1985), 7135 Pholiderpeton scutigerum (Clack, 1987b), Gephyrostegus (Carroll, 1970; Godfrey & Reisz, 7136 1991), Solenodonsaurus (Laurin & Reisz, 1999), Stegotretus (Berman, Eberth & Brinkman, 1988) and Ariekanerpeton (Klembara & Ruta, 2005b). Similarly, no hemal arches are pre-7137 7138 served in Triadobatrachus (Roček & Rage, 2000; Ascarrunz et al., 2016).

7139 Doleserpeton has state 0 as scored, but one wonders how this was done before 7140 Sigurdsen & Bolt (2010) described (any part of) the tail for the first time in a publication; 7141 Ruta, Coates & Quicke (2003) did not claim to have seen specimens and did not cite Bolt's 7142 unpublished thesis (which dates to 1964).

7144 259. TRU VER 7: Ossified pleurocentra: absent (0); present (1). Under the assumption that
7145 loss of ossification does not equal loss of the element, we have not treated this character or
7146 TRU VER 13-14 (see below) as irreversible in Analyses R7–R12.

7147 Like RC07, we have scored this and the next two characters as unknown in all taxa 7148 where the vertebrae are monospondylous, because in them there is no way - other than phylo-7149 genetic reconstruction – to tell whether the single centrum is the inter- or the pleurocentrum 7150 (i.e. the fused pair of left and right inter- or pleurocentra); see TRU VER 4 (above) on the 7151 homology of hemal arches. We have correspondingly scored TRU VER 13-14 as state 0 7152 (intercentrum forms complete ring) or 2 (trunk intercentra absent), an option that was not 7153 available before we merged those two characters. The only cases RC07 overlooked are Batropetes (Carroll, 1991; Glienke, 2013, 2015), Microbrachis (CG78; Olori, 2015) and Scincosau-7154 7155 rus (Bossy & Milner 1998; Milner & Ruta 2009) and, in the case of TRU VER 13 but not 7156 TRU VER 7, 8 and 9, Triadobatrachus (Ascarrunz et al., 2016). The only exceptions, for 7157 which we have scored state 1, are Albanerpetidae (already so scored by RC07 for unclear 7158 reasons), which may have axis intercentra (Material and methods: Modifications to individual cells: The albanerpetid neck), and *Utaherpeton: the tail of the immature specimen of 7159 7160 *Utaherpeton of demonstrates that the only ossified centra are pleurocentra because the last 7161 few are broad dorsally but narrow to a point ventrally (Carroll & Chorn, 1995) – the opposite 7162 would be expected for intercentra.

There is evidence from **extant frogs that their centra are pleurocentra: the tadpoles of certain megophryids ossify caudal centra that begin as paired ossifications dorsolateral to the notochord, with the distalmost centra not progressing beyond this stage before they are osteoclastically destroyed during metamorphosis (Handrigan & Wassersug, 2007). However, there are no megophryids, indeed no clear crown-group frogs at all, in this matrix; we have kept *Notobatrachus*, *Vieraella* and **Liaobatrachus* as unknown.

7169 In the adelogyrinids, it is likewise difficult or impossible to determine the homology of 7170 the monospondylous, fully ossified centra; the fact that the neural arches are positioned dorsal 7171 to the cranial halves of the centra and even articulate with two successive centra in part of the 7172 trunk of **Palaeomolgophis (Andrews & Carroll, 1991: 243) rather strongly suggests that the 7173 centra are intercentra and all adelogyrinids are fully stereospondylous, but in order to avoid 7174 potential bias against the traditional hypothesis that the adelogyrinids are "lepospondyls", we have scored them as unknown like the abovementioned other taxa with monospondylous 7175 7176 centra.

State 1 is found in *Cochleosaurus* (Sequeira, 2009), *Cardiocephalus* (CG78: fig. 31)
and *Utegenia* (Klembara & Ruta, 2004b). Pierce et al. (2013) have confirmed it in *Ichthyostega* (contra Ahlberg, Clack & Blom, 2005; though note that Jarvik, 1996, was right
for the wrong reasons).

7181 Clear occurrences of state 0 are thus limited to *Panderichthys* and *Crassigyrinus*, and 7182 certainly not homologous between the two. State 0 in *Crassigyrinus*, at least, may be 7183 correlated to its generally very low degree of ossification in the endochondral skeleton; 7184 scoring *Crassigyrinus* as unknown would render this character parsimony-uninformative.

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7186 260. TRU VER 8: Trunk pleurocentra fused midventrally: no (0); yes (1).

Cochleosaurus apparently has state 0 (Sequeira, 2009).

7188 *Cardiocephalus* (CG78: fig. 31) and *Orobates* (Berman et al., 2004: fig. 11; Nyakatura 7189 et al., 2015: digital model) have state 1.

The vertebrae of **Casineria* are preserved in strict lateral view. We have scored state 1 because the pleurocentra reach the ventral side of the vertebral column and have a flat surface rather than a point there (Fig. 5). The following character remains unknown for **Casineria*. 7194

7195 261. TRU VER 9: Trunk pleurocentra fused middorsally: no (0); yes (1).

7196 *Cochleosaurus* apparently has state 0 (Sequeira, 2009), as does *Trimerorhachis* 7197 (Pawley, 2007).

7198 *Cardiocephalus* (CG78: fig. 31) and *Orobates* (Berman et al., 2004: fig. 10B; 7199 Nyakatura et al., 2015: digital model) have state 1.

In *Proterogyrinus*, the pleurocentra "are tightly appressed dorsally" (Sigurdsen &
Green, 2011: 18), but not fused or apparently even sutured; we have therefore kept state 0.

State 0 is observed in the tail and possibly the last presacral vertebra of the immature specimen of **Utaherpeton*, but the condition is unknown in the other vertebrae (which should be more advanced ontogenetically) of that specimen and entirely unknown in the adult specimen (Carroll & Chorn, 1995). We have therefore scored **Utaherpeton* as unknown for this character.

Ariekanerpeton and Utegenia were scored as polymorphic. Given the ontogenetic
progression from 0 to 1 in better-known seymouriamorphs, we have scored Ariekanerpeton as
unknown following Klembara & Ruta (2005b: 80) and have kept only state 1 for Utegenia,
for which state 1 was mentioned to exist by Klembara & Ruta (2004b: 79), but not illustrated
in their fig. 3C which is cited there.

7213 262. TRU VER 10: Neural arches without (0) or with (1) distinct convex lateral surfaces.

7214 *Chenoprosopus* (D. M., pers. obs. of USNM 437646), *Cochleosaurus* (Sequeira, 2009)
7215 and *Isodectes* (D. M., pers. obs. of CM 81512) have state 0; apparently, so do *Batropetes*7216 (Glienke, 2013) and *Cardiocephalus* (CG78: fig. 31, 33).

7217 Petrolacosaurus was scored as polymorphic in RC07, presumably because "[t]he 7218 neural arches are slightly swollen above the postzygapophyses, but only in the dorsal 7219 vertebrae" (Reisz, 1981: 34). We think, however, that this character should be considered 7220 inapplicable to the greatly elongate cervical vertebrae and have therefore scored state 1 alone. 7221 Similarly, we have kept state 1 for Limnoscelis and Orobates, which have swollen neural 7222 arches in the trunk but not the tail vertebrae (Kennedy, 2010; Nyakatura et al., 2015: digital 7223 model). - In principle, presence of different states in different parts of the vertebral column 7224 should be considered an intermediate state; polymorphism implies that different individuals or indeed subclades have different states, or that the left and right sides of the same individual 7225 7226 do.

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State 1 makes a surprise appearance in *Diplocaulus* (Williston, 1909: pl. 3).

We have scored *Utegenia* as unknown because the observed state 0 is also found in larvae but not "postmetamorphic" individuals of *Discosauriscus*, in which the appearance of state 1 is interpreted as part of the transition to terrestrial life (Klembara & Bartík, 2000; Klembara, 2009).

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7233 263. TRU VER 11: Neural arches of trunk vertebrae fused to centra: no (0); yes (1).
7234 According to RC07, this character "does not appear to be simply related to [...] inferred
7235 degree of specimen maturity", yet there is evidence that *Batropetes* and *Microbrachis* (see
7236 below) changed from state 0 to state 1 in ontogeny, and in amniotes this is a very widely used
7237 marker for skeletal maturity (Irmis, 2007); among OTUs with more or less holospondylous
7238 vertebrae, it seems to us that only the most paedomorphic ones keep state 0 throughout life,
7239 and the same may hold for seymouriamorphs (Laurin, 2000).

Centra are altogether unknown in *Leptorophus* (Boy, 1987; Werneburg, 2007a); they probably only ossified during metamorphosis (if metamorphosis ever occurred in *Leptorophus*). We have accordingly scored it as unknown.

State 1 is documented in Albanerpetidae (Estes & Hoffstetter, 1976; Fox & Naylor,
1982; McGowan, 1996), *Eocaecilia* (Jenkins, Walsh & Carroll, 2007), *Cardiocephalus* (there
is only "a trace of suture"; CG78: p. 60) and *Batrachiderpeton* (Bossy & Milner, 1998: fig.
63A–D).

- 7250 *Discosauriscus, Ariekanerpeton* and *Utegenia* were scored as having state 0. This is 7251 probably ontogenetic (Laurin, 2000); we have changed their scores to unknown.
- Following the skeletally most mature specimens (Carroll, 1991; Glienke, 2013; Olori, 2015), we have scored *Batropetes* and *Microbrachis* as possessing state 1.
- 7255 264. TRU VER 12: Bicipital rib-bearers on trunk centra: absent (0); present (1).

Chenoprosopus (Hook, 1993; D. M., pers. obs. of USNM 437646), *Cochleosaurus*(Sequeira, 2009), *Isodectes* (D. M., pers. obs. of CM 81512), *Broiliellus* (Carroll, 1964: 198), *Cardiocephalus* (CG78) and apparently *Batrachiderpeton* (Bossy & Milner, 1998: fig. 63A)
have state 0.

- Centra are altogether unknown in *Leptorophus* (Boy, 1987; Werneburg, 2007a); they probably only ossified during metamorphosis (if metamorphosis ever occurred in *Leptorophus*). We have accordingly scored it as unknown.
- The rib-bearers of **Pangerpeton* are not bicipital, because the ribs are single-headed (an autapomorphy of Cryptobranchoidea: Gao & Shubin, 2012), but because they are still ribbearers as seen in salamanders and almost nowhere else, we have scored state 1 for **Pangerpeton*.
- We have kept state 0 for all diadectomorphs for the time being, but should point out that the condition of at least *Orobates* (Nyakatura et al., 2015: digital model) is remarkably similar to state 1 and should likely be counted as such.
- 7271 265. TRU VER 13-14: Trunk intercentra: fused middorsally (0), separate middorsally
 7272 (1), absent (2) (ordered). Intercentra in state 1 have a wide range of sizes; usually they are
 7273 crescent-shaped, and their dorsal tips do not touch. Evidently, this is a single continuous
 7274 character, with the degree of intercentrum ossification gradually decreasing from state 0 to
 7275 state 2 (though something in the middle of state 1 is the plesiomorphy). We assign state 0 or 2
 7276 to taxa with single-piece centra throughout the column that cannot (without phylogenetic
 7277 bracketing) be identified as pleuro- or intercentra (see TRU VER 7).
- 7278 *Chenoprosopus* (Hook, 1993; D. M., pers. obs. of USNM 437646) and *Cochleosaurus* 7279 (Sequeira, 2009) have state 1, as does *Cardiocephalus* (CG78: fig. 31).
- 7280

- Isodectes has state 0 or 1 (D. M., pers. obs. of CM 81430).
- 7281Albanerpetidae seems to have axis intercentra (Material and methods: Modifications to7282individual cells: The albanerpetid neck), but lacks trunk intercentra, giving it state 2.
- *Solenodonsaurus* is known (Carroll, 1970: 294–295; Danto, Witzmann & Müller, 2012) to have very small intercentra that are very far from reaching the dorsal edge of the pleurocentra (or rather the notochord) and thus cannot possibly have been fused middorsally; this means state 1.
- 7287 *Orobates* was scored as unknown by RC07. A photo of a specimen containing the first 7288 six vertebrae shows that only the first four, counted as "neck" rather than "trunk", have 7289 intercentra (Berman et al., 2004: fig. 11); this suggests state 2. In the digital model of 7290 Nyakatura et al. (2015), all vertebrae behind the sixth have intercentra (state 1); they are, 7291 however, modeled after an isolated neural arch + pleurocentrum because the vertebrae in the 7292 articulated specimens were apparently too crushed to reconstruct. Given the presence of state

1 in *Diadectes* (as already scored) and the presence of intercentra in caudal, but not cranial or middle, trunk vertebrae in *Eocasea* (*Caseasauria), which we have also counted as state 1, we have tentatively assigned state 1 to *Orobates*. This is probably not the best score; John Nyakatura (pers. comm. March 2018) thinks this character is most likely unknown in *Orobates*.

7298 7299 Unexpectedly, *Nigerpeton has state 0 (D. M., pers. obs. of MNN MOR 69).

7300 266. TRU VER 15: Anteroposteriorly elongate, lateral and ventral carinae on trunk
7301 centra: absent (0); present (1). We have assigned state 0 in cases where ventral carinae
7302 occur but lateral ones do not (e.g. *Westlothiana*: Smithson et al., 1994: fig. 9B, C;
7303 *Archegosaurus: Witzmann & Schoch, 2006; *Lydekkerina: Pawley & Warren, 2005 –
7304 though see Hewison, 2008).

Chenoprosopus (Hook, 1993; D. M., pers. obs. of USNM 437646) and *Cochleosaurus*have state 0 (Sequeira, 2009), and so do *Cardiocephalus* (CG78: fig. 31) and *Orobates*(Berman et al., 2004: fig. 11).

7308 RC07 scored only *Brachydectes* and the adelogyrinids as having state 1, and all other 7309 OTUs with preserved centra except the above as having state 0. It is possible that they meant 7310 to restrict this character to taxa with monospondylous centra; but neither would that make sense, nor did they score diplospondylous OTUs as unknown. We have ascribed state 1 to any 7311 7312 inter- or pleurocentra that have the described carinae. Thus, weak but clear cases of state 1 -7313 where the ventral carinae are not fully distinct from each other but more or less form a very 7314 wide median carina - are found in Colosteus (Hook, 1983), Greererpeton (only in caudal dorsals: Godfrey, 1989: 85, fig. 6d, f), Neldasaurus (Chase, 1965) and Trimerorhachis 7315 (Chase, 1965; Pawley, 2007). State 1 is also found in Eoherpeton (Smithson, 1985: fig. 16; 7316 7317 "horizontal grooves" on p. 349), Proterogyrinus (Holmes, 1984), Archeria (Holmes, 1989), Pholiderpeton attheyi (Panchen, 1966), apparently Ph. scutigerum (Clack, 1987b: especially 7318 7319 fig. 21f), and - a particularly striking case - Acherontiscus (Carroll, 1969a). Given the addi-7320 tional occurrence in *Pholidogaster (Romer, 1964), we strongly suspect that state 1 is univer-7321 sal in anguilliform swimmers; its strong phylogenetic signal (all colosteids, all anthracosaurs, 7322 all adelospondyls, *Brachvdectes*, both dvinosaurs - scored as unknown for *Isodectes*, which 7323 D. M. forgot to check during his collection visits, and for *Erpetosaurus [Milner & Sequeira, 2011]; five steps, no reversals) may well be entirely ecological. All aïstopods seem to have 7324 7325 state 0 as already scored for the three in the original sample, which may be additional 7326 evidence that some of them were terrestrial (Anderson, 2002, 2003a; Germain, 2008a, b); 7327 notably, we could not score *Coloraderpeton.

7328 Unclear in *Bruktererpeton* (Boy & Bandel, 1973).

Centra are altogether unknown in *Leptorophus* (Boy, 1987; Werneburg, 2007a); they
probably only ossified during metamorphosis (if metamorphosis ever occurred in *Leptoro- phus*). We have accordingly scored it as unknown.

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7333 267. TRU VER 16: Strong proximal emargination along anterior and posterior margins
7334 of haemal spines: absent (0); present (1). RC07 added "of tail vertebrae" at the end; that is

redundant.

The entire tail is unknown in *Colosteus* (Hook, 1983), *Crassigyrinus* (Panchen, 1985), *Neldasaurus* (Chase, 1965), *Broiliellus* (Carroll, 1964), *Eoherpeton* (Smithson, 1985), *Pholid- erpeton scutigerum* (Clack, 1987b), *Gephyrostegus* (Carroll, 1970; Godfrey & Reisz, 1991), *Solenodonsaurus* (Laurin & Reisz, 1999; Danto, Witzmann & Müller, 2012), *Stegotretus*(Berman, Eberth & Brinkman, 1988) and *Ariekanerpeton* (Klembara & Ruta, 2005b).
Similarly, no hemal arches are preserved in *Triadobatrachus* (Roček & Rage, 2000;
Ascarrunz et al., 2016), and none have been described in *Leptorophus*.

Doleserpeton has state 0 as scored, but one wonders how this was done before
Sigurdsen & Bolt (2010) described (any part of) the tail for the first time in a publication;
Ruta, Coates & Quicke (2003) did not claim to have seen specimens and did not cite Bolt's
unpublished thesis (which dates to 1964).

Platyrhinops has state 0 (Hook & Baird, 1984; Werneburg, 2012a: fig. 9a); so do *Hyloplesion* (Olori, 2015), *Orobates* (Nyakatura et al., 2015: digital model) and *Ossinodus*(Warren, 2007).

7351 268. TRU VER 18: Striated ornament on vertebral centra: absent (0); present (1). State 1
7352 does in fact exist and occurs where it was scored in RC07 (Williston, 1909; Bossy & Milner,
7353 1998). For this reason we have ignored the original description of this character (RC07: 109)
7354 which contradicts its name: "A 'pleated' or unevenly striated surface sculpture characterises
7355 the neural spines [!] of some of the more derived keraterpetontid [= diplocaulid]
7356 nectrideans."

State 0 is found in *Edops* (D. M., pers. obs. of MCZ specimens), *Chenoprosopus*(Hook, 1993; D. M., pers. obs. of USNM 437646), *Cochleosaurus* (Sequeira, 2009), *Isodectes*(D. M., pers. obs. of CM 81430), *Cardiocephalus* (CG78: fig. 31), *Euryodus* (CG78), *Hyloplesion* (Olori, 2015) and *Ossinodus* (Warren, 2007).

Centra are altogether unknown in *Leptorophus* (Boy, 1987; Werneburg, 2007a); they
probably only ossified during metamorphosis (if metamorphosis ever occurred in *Leptorophus*). We have accordingly scored it as unknown.

7365 269. TRU VER 19: Tallest ossified part of neural arch in posterior trunk vertebrae
railest above (aligned vertically with) posterior half of vertebral centrum: no (0); yes
(1). State 1 is much more widespread than RC07 scored it, at least if we assume that the
neural spine counts as part of the neural arch, and if "entirely behind the centrum" still counts
as "above [...] posterior half" as opposed to the middle or the anterior half. In the absence of
evidence for variation among the dorsal vertebrae, we have resorted to middle or anterior ones
if no posterior ones are preserved.

7372 Specifically, state 1 is present in Eusthenopteron and Acanthostega (Coates, 1996; 7373 Pierce et al., 2013), Greererpeton (Godfrey, 1989), Whatcheeria (Lombard & Bolt, 1995), Cochleosaurus (Sequeira, 2009), Isodectes (D. M., pers. obs. of CM 81430), Neldasaurus 7374 7375 (Chase, 1965), Trimerorhachis (Pawley, 2007), Balanerpeton (Milner & Sequeira, 1994: fig. 9), Dendrerpetidae (Holmes, Carroll & Reisz, 1998), Eryops (Moulton, 1974), Ecolsonia 7376 7377 (Berman, Reisz & Eberth, 1985), Amphibamus (Daly, 1994: fig. 22), Eoscopus (Daly, 1994: fig. 6, 7), Platyrhinops (Hook & Baird, 1984), Micromelerpeton (Boy, 1995), Albanerpetidae 7378 (Estes & Hoffstetter, 1976), Eocaecilia (Jenkins, Walsh & Carroll, 2007: fig. 37A). Karaurus 7379 7380 (Ivachnenko, 1978), Triadobatrachus (Roček & Rage, 2000; Ascarrunz et al., 2016: fig. 9, 3D 7381 model 1), Valdotriton (Evans & Milner, 1996), Caerorhachis (Ruta, Milner & Coates, 2002), 7382 Proterogyrinus (Holmes, 1984), Archeria (somewhat borderline: Holmes, 1989), Brukter-7383 erpeton (Boy & Bandel, 1973), Gephyrostegus (Godfrey & Reisz, 1991), Solenodonsaurus 7384 (Danto, Witzmann & Müller, 2012), Discosauriscus (Klembara & Bartík, 2000: fig. 4h), 7385 Diadectes (Berman, Sumida & Martens, 1998: fig. 13C), Cardiocephalus (CG78: fig. 31, 33), 7386 Scincosaurus (Bossy & Milner, 1998: fig. 63L), Lethiscus (Wellstead, 1982), Ariekanerpeton (Klembara & Ruta, 2005b), apparently Vieraella (Báez & Basso, 1996: fig. 6), Ossinodus 7387 7388 (Warren & Turner, 2004) and Pederpes (Clack & Finney, 2008; Pierce et al., 2013). In 7389 *Australerpeton, Dias & Schultz (2003: fig. 8) reconstructed state 0, but their photo and drawing of an articulated specimen (fig. 2, 3) clearly show state 1, which we have therefore 7390 7391 scored.

7392 We have retained state 0 for the unusual lumbar vertebrae of *Ichthyostega* (Pierce et 7393 al., 2013: fig. 1d); for Batrachiderpeton and Diploceraspis (Bossy & Milner, 1998: fig. 63) as 7394 well as, somewhat tentatively, *Diplocaulus* (Williston, 1909: pl. 3); for *Eoherpeton*, where the 7395 highest point of the neural spine is between the inter- and the pleurocentrum, in the middle of 7396 the centrum as a whole (Smithson, 1985: fig. 19); for Pholiderpeton attheyi, where the highest 7397 point is at least that far cranial in middle trunk vertebrae (more caudal trunk vertebrae are 7398 insufficiently preserved; Panchen, 1966); very tentatively for Ph. scutigerum, where at least 7399 some neural arches show state 0 even though it is less clear where in the column they come 7400 from (Clack, 1987b); and for neural spines with a horizontal flat top where the entire dorsal 7401 edge is the tallest "point" and covers at least part of the cranial half of the centrum 7402 (Keraterpeton, Diceratosaurus, Ptyonius, Sauropleura, Urocordylus: Bossy & Milner, 1998: 7403 fig. 61, 63, 76; *Karpinskiosaurus: Bystrow, 1944: fig. 22). State 0 further occurs in 7404 *Nigerpeton (D. M., pers. obs. of MNN MOR 83) and *NSM 994 GF 1.1 (Holmes & Carroll, 7405 2010).

Unknown in *Colosteus* (Hook, 1983), *Kotlassia* (Bystrow, 1944: 409) and *Utegenia*(Klembara & Ruta, 2004b). **Llistrofus* has state 1 in cranial to midtrunk vertebrae, but the
preservation makes the condition of caudal trunk vertebrae unclear (CG78).

7410 270. TRU VER 20-21-22-23-24-25: Zygapophyses absent throughout, or nearly so (0),
7411 present only on trunk and proximal tail vertebrae (1), or present throughout (2)
7412 (ordered). These originally six characters concerned the presence of prezygapophyses (TRU
7413 VER 20, 22 and 24) and postzygaphopyses (TRU VER 21, 23 and 25) in the trunk (TRU
7414 VER 20 and 21) and the proximal (TRU VER 22 and 23) and distal tail (TRU VER 24 and
7415 25).

7416 One would at first think (as Pawley [2006: 205] did) that pre- and postzygapophyses 7417 only occur together because they articulate with each other. The reason given by RC07 for 7418 keeping them as separate characters was that *Crassigyrinus* and *Trimerorhachis* had been 7419 reported to possess pre- but lack postzygapophyses.

In *Trimerorhachis*, however, the postzygapophyses merely happen not to be visible in
lateral view in tail and caudal trunk vertebrae because the neural spine is continuous with
them (much like in **Acanthostomatops*: Witzmann & Schoch, 2006a); they are
unambiguously present throughout the trunk and tail, like the prezygapophyses (Pawley,
2007), so we have assigned state 2 to *Trimerorhachis*.

7425 In Crassigvrinus, the situation is less clear. Panchen (1985: 534) described two neural 7426 arch pairs as showing "no sign" of a postzygapophysis and then stated: "Postzygapophyses, formerly thought of (with prezygapophyses) as an autapomorphous feature of tetrapods, 7427 7428 appear to be absent." Two pages earlier, however, we find the statement: "The neural arches 7429 of Crassigvrinus are remarkable for their primitive or degenerate condition. All those visible 7430 occur as separate bilateral halves with no sign of suture or fusion in the middle. They lack 7431 clear zygapophyses of tetrapod type and they are very small for the size of the animal. None 7432 has been found in natural articulation with a centrum and in the absence of clearly defined 7433 matching articular facets on each it is not clear precisely what their mutual orientation was." 7434 This implies quite strongly that prezygapophyses are also absent – yet, prezygapophyses (though unusually small ones) are illustrated and described as present. In the light of this, it 7435 7436 must be wondered if postzygapophyses were likewise present - not necessarily as processes 7437 visible in lateral view, but at least as articular facets. Indeed, fig. 17(e), which shows the 7438 presumed left atlas arch in left lateral and cranial views, shows a convex surface that would fit 7439 into the concave craniodorsal margin of the prezygapophysis of the same arch. This convex 7440 surface is overhung by the craniocaudally very broad neural spine. We consider it likely that 7441 *Crassigvrinus* simply has a less well ossified version of the condition seen in *Trimerorhachis*.

7442 (The vertebrae of *Crassigyrinus* are indeed as poorly ossified as the quote above implies; fig. 7443 17(a)–(c) shows three pairs of incompletely fused left and right intercentra, the broadest pair 7444 measuring more than 2 cm from side to side.) At least, this interpretation is more probable 7445 than the occurrence of prezygapophyses that have nothing to articulate with. The tail of 7446 *Crassigyrinus* being unknown, we have scored *Crassigyrinus* as showing state 1 or 2.

7447 The reason given for keeping the zygapophyses of the trunk, the proximal tail and the 7448 distal tail as three separate pairs of characters was "to account for the possibility that 7449 acquisition of fully developed and ossified zygapophyses occurred in a 'stepwise' fashion 7450 along the backbone (e.g. tail of certain Devonian taxa, notably Acanthostega and 7451 Ichthyostega; trunk of Crassigyrinus and Trimerorhachis)" (RC07: 110). First, to the best of our knowledge, it is never observed, and would be unexpected from functional considerations, 7452 7453 that prezygapophyses occur in the distal but not the proximal part of the tail. This confirms 7454 the suspicion of the "stepwise' fashion" by RC07. Second, stepwise evolution can only be 7455 represented by an ordered multistate character (a meristic character, more precisely). Thus, 7456 TRU VER 22/23 and 24/25 should have been merged already by Ruta, Coates & Quicke 7457 (2003). Third, to the best of our knowledge, no animal is known that has zygapophyses in the 7458 trunk but nowhere in the tail (the urostyle of frogs perhaps excepted); the distinction between 7459 TRU VER 20/21 and 22/23 is therefore useless in this matrix. For these reasons we feel 7460 obliged to perform this megamerger of six characters into one.

- *Chenoprosopus* (Hook, 1993; D. M., pers. obs. of USNM 437646), *Cochleosaurus*(Sequeira, 2009), *Isodectes* (D. M., pers. obs. of CM 81512 and CM 81430) and *Cardiocephalus* (CG78) have state 1 or 2.
- 7464 *Doleserpeton* has state 2 as already scored for TRU VER 22 through 25, but one 7465 wonders how this was done before Sigurdsen & Bolt (2010) described (any part of) the tail for 7466 the first time in a publication; Ruta, Coates & Quicke (2003) did not claim to have seen 7467 specimens and did not cite Bolt's unpublished thesis (which dates to 1964).
- 7468 *Triadobatrachus* has state 1 or 2: the distalmost tail vertebrae are poorly preserved and 7469 poorly ossified (Ascarrunz et al., 2016).
- We have scored *Bruktererpeton* (Boy & Bandel, 1973) as possessing state 1 or 2 because the distal tail is not described and only visible in one illustration (the plate), the resolution of which is insufficient to determine whether zygapophyses are present. About the same holds for *Leptorophus* (Werneburg, 2007a: fig. 2, 3).
- We have assigned the same score to *Westlothiana*, the distal part of whose tail is
 entirely unknown (Smithson et al., 1994). Similar things hold for Albanerpetidae (McGowan,
 2002) and for *Microphon* (only an axis is known: Bulanov, 2014), so we have scored them the
 same way.
- 7479 271. TRU VER 26: Capitular facets situated on posterior rim of vertebral midtrunk
 7480 centra: absent (0); present (1). State 0 will need to be divided; the capitular facet often sits
 7481 on the intercentrum when inter- and pleurocentra are both present, but it can sit in the center
 7482 of a pleurocentrum in gastrocentral vertebrae. State 1 includes cases where the facet straddles
 7483 two successive centra.
- 7484 *Gephyrostegus* has state 0 (Godfrey & Reisz, 1991), as do *Cardiocephalus* (CG78) 7485 and *Orobates* (Nyakatura et al., 2015: digital model).
- State 1 is found in *Scincosaurus* (Milner & Ruta, 2009). We have also assigned it to *Eocaecilia*, where the facets commonly straddle two neighboring centra (Jenkins, Walsh &
 Carroll, 2007).

7489State 1 was scored for *Batropetes* in RC07; however, capitular facets are altogether7490absent in *Batropetes* (Glienke, 2015), so we have changed the score to unknown.

7492 272. TRU VER 27: Height of the ossified portion of the neural arch in midtrunk
7493 vertebrae greater (0) or smaller (1) than the distance between pre- and
7494 postzygapophyses.

7495 *Chenoprosopus* has state 0 (D. M., pers. obs. of USNM 437646). So does **Nigerpeton*7496 (D. M., pers. obs. of MNN MOR 83).

7497 State 1 is found, at least, in Cochleosaurus (Sequeira, 2009: fig. 12), Trimerorhachis 7498 (Pawley, 2007: fig. 5.1), Amphibamus (Daly, 1994: fig. 22), Doleserpeton (Sigurdsen & Bolt, 7499 2010), Eoscopus (Daly, 1994: fig. 6, 7), Albanerpetidae (Estes & Hoffstetter, 1976), 7500 Eocaecilia (Jenkins, Walsh & Carroll, 2007), Karaurus (M. L., pers. obs. of unnumbered 7501 MNHN cast of PIN 2585/2), Valdotriton (judging from cranial dorsals and proximal caudals: 7502 Evans & Milner, 1996: fig. 9a, 10), Cardiocephalus (CG78: fig. 31, 33), Scincosaurus (Bossy 7503 & Milner, 1998: fig. 63; Milner & Ruta, 2009), Diplocaulus, Diploceraspis and Ptyonius (Williston, 1909: pl. 3; Bossy & Milner, 1998: fig. 61, 63), Urocordylus (borderline: Bossy, 7504 7505 1976), all aïstopods (Wellstead, 1982; Anderson, 2002, 2003a) and Orobates (Nyakatura et 7506 al., 2015: digital model).

7507 *Tseajaia* is given state 0 because that state is found in the vertebrae with the dorsoventrally longest neural spines (Moss, 1972).

Unknown in *Kotlassia* (Bystrow, 1944: 409); borderline and probably not completely
prepared in the photo of **Chroniosaurus* (Clack & Klembara, 2009: fig. 8).

We have scored state 0 for **Coloraderpeton* because the neural spines are described as "tall" or "high" in two of the three accessible sources (Carroll, 1998b; Anderson, 2003a). The third, however, scored them as "low" as opposed to "high" without quantifying these states (Anderson, Carroll & Rowe, 2003: table A1).

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7516 273. TRU VER 28: Crenulations or fimbriate sculpture along dorsal margin of ossified
7517 portion of neural spines: absent (0); present (1).

Edops (D. M., pers. obs. of MCZ 7136) has state 0, as do *Cochleosaurus* (Sequeira,
2009), *Isodectes* (D. M., pers. obs. of CM 81430), *Triadobatrachus* (Roček & Rage, 2000), *Cardiocephalus* and *Euryodus* (CG78), *Hyloplesion* (pers. obs. of NHMW specimens; Olori,
2015) and *Ossinodus* (Warren & Turner, 2004).

Inapplicable to *Diplocaulus*, the neural spines of which are too small to be ornamented
(Williston, 1909; Douthitt, 1917).

7525 274. TRU VER 29: Intravertebral foramina for spinal nerves in at least some trunk 7526 vertebrae: absent (0); present (1).

7527 *Cardiocephalus* has state 0 (CG78: fig. 31).

Sauropleura is polymorphic (Bossy & Milner, 1998; Milner & Ruta, 2009: matrix).

7529 We have scored state 1 for **Pseudophlegethontia* following the matrix of Anderson, 7530 Carroll & Rowe (2003).

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7532 275. TRU VER 30: Transverse processes stout and abbreviated, the length of which is 7533 less than 30% of neural arch height: absent (0); present (1). State 0, which D. M. has 7534 observed in Isodectes (CM 81512), probably hides some phylogenetically informative 7535 diversity. For instance, Carroll & Chorn (1995: 49f.) mentioned that adelogyrinids (scored 1 in RC07) "are unique among lepospondyls in having very *long* transverse processes [...] as in 7536 primitive labyrinthodonts" (emphasis ours), implying that the other "lepospondyls" have an 7537 7538 intermediate condition (in terms of length) between those seen in "primitive labyrinthodonts" 7539 and adelogyrinids on the one hand and seymouriamorphs and diadectomorphs (which were 7540 scored as having state 0) on the other hand.

Anyway, *Adelospondylus* and *Adelogyrinus* have state 0 (Andrews & Carroll, 1991), and the condition in *Acherontiscus* is unknown (Carroll, 1969a). State 0 further seems to be known in *Cardiocephalus* (CG78: fig. 31). This leaves state 1 exclusively to *Colosteus* and *Greererpeton*.

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7546 276. DIG 1-2-3-4: "Independent radials" (0); polydactyly (1); pentadactyly (2); tetradactyl forelimb (3); tridactyl forelimb (4) (ordered). RC07 treated the 7547 7548 presence/absence of digits (DIG 1), the presence/absence of four or fewer fingers per hand 7549 (DIG 2), the presence/absence of five or fewer fingers per hand (DIG 3), and the presence/ 7550 absence of three or fewer fingers per hand (DIG 4) as completely independent characters. It goes without saving that, if a taxon has three or fewer fingers per hand, it also has fewer than 7551 7552 four and fewer than five, yet RC07 did not even provide for these cases by scoring inapplicability. We have therefore merged all these characters, except for splitting DIG 1 to 7553 7554 differentiate the mere absence of digits (state 0 of the present character) from the wholesale 7555 absence of limbs (state HUM 18/DIG 1(0), see ch. 219).

The present character differs from DIG 5 of Germain (2008a) by being ordered, 7556 7557 containing partial uncertainty, and defining state 0 of this character and of ch. 219 (his states 7558 DIG 5(0) and DIG 5(5)) morphologically where Germain (2008a) had called them "primary absence of digits" and "secondary absence of digits", which should be an inference from the 7559 results of the analysis and not an assumption of coding. It differs from DIG 1 of Ruta & Bolt 7560 (2006) in not splitting polydactyly into two states (eight and six fingers per hand, each only 7561 7562 present in a single OTU), in providing for OTUs with three fingers per hand (which do not occur in the matrix of Ruta & Bolt, 2006), and again in being ordered. 7563

We have not counted the prepollex/-hallux, where identifiable as such, as a digit, because it is not homologous to an "independent radial" (Johanson et al., 2007) and because it is so common in otherwise four-fingered lissamphibians (if only, in most cases, as something like a distal carpal). The postminimus of *Tulerpeton* does count, but the possibly homologous pisiform bone does not, because its homology is unclear, because it is only a carpal without a digit, and because it is common in less-than-pentadactyl hands.

In relation to a pentadactyl limb, a tetradactyl one can have digits I–IV or II–V. We
have ignored this issue, treating all tetradactyl hands as primarily homologous, but see
Marjanović & Laurin (2013a) for discussion.

7573 Greererpeton has often been thought to have tetradactyl hands, but Coates (1996: 415) 7574 mentioned and illustrated a well preserved hand with five fingers and mentioned another that preserves four, one of which is the distinctively small fifth. Accordingly, we have scored 7575 7576 Greererpeton as having state 2, even though the closely related Colosteus really does seem to 7577 have only four fingers per hand as scored by RC07 (the third is the longest, as common in 7578 tetradactyl limbs, not the fourth as would usually be expected in a pentadactyl one; Hook, 7579 1983). - D. M. has not been able to find the fourth finger in the articulated hand of AMNH 7580 6917 (pers. obs.), but there is sufficient space for it.

Only state 0 can be ruled out for Crassigyrinus (Panchen, 1985; Panchen & Smithson, 7581 7582 1990), Baphetes (Milner & Lindsay, 1998), Edops (D. M., pers. obs. of MCZ 7126 and MCZ 7274), Ecolsonia (Berman, Reisz & Eberth, 1985 - inferred from the hindlimb), Eocaecilia 7583 7584 (Jenkins, Walsh & Carroll, 2007), Pholiderpeton scutigerum (Clack, 1987b), Kotlassia (Bystrow, 1944 - inferred from the hindlimb), Stegotretus (Berman, Eberth & Brinkman, 7585 7586 1988), Saxonerpeton (CG78: 38), Asaphestera, Pelodosotis, Cardiocephalus, Euryodus (CG78), Ossinodus (Warren, 2007) and Pederpes (Clack & Finney, 2005); we have thus 7587 7588 scored them all, and several OTUs which we added, as having state 1, 2, 3, or 4.

7589The same appears to hold for *Whatcheeria* (Lombard & Bolt, 1995: 483; Bolt &7590Lombard, 2000: 1049), even though the latter source makes state 4 appear unlikely.

7591 In *Eucritta*, the same holds. The hindlimb does appear to be pentadactyl, which would 7592 strongly suggest five or fewer fingers in the forelimb, but we do not think polydactyly -7593 especially a small postminimus like in the hand of *Tulerpeton* – can be ruled out.

7594 Cochleosaurus has state 3 (Sequeira, 2009). So does Isodectes (D. M., pers. obs. of 7595 USNM 4471, USNM 4555, and CM 81430).

7596 Trimerorhachis has state 2 or 3 (Case, 1935; Pawley, 2007).

Dendrysekos (Dendrerpetidae) preserves four distal carpals (Holmes, Carroll & Reisz, 7597 7598 1998). That most likely means four or five fingers (state 2 or 3).

7599 No metacarpals or fingers are preserved in Acheloma cumminsi, but there appear to 7600 have been five distal carpals (Olson, 1941), of which the tiny preaxialmost one could belong 7601 to a prepollex; this means four or five fingers and thus state 2 or 3. Dilkes (2015a) described 7602 only four distal carpals (all set in a plaster sculpture), but did not explicitly exclude (or mention) the possibility of a fifth beyond the absence of an articulation facet for one on distal 7603 7604 carpal 4. – A. dunni only preserves two fragments of pedal phalanges (Polley & Reisz, 2011).

7605 Doleserpeton has state 3 (Sigurdsen & Bolt, 2009, 2010), as do Platyrhinops (Carroll, 7606 1964) and Leptorophus (judging from the drawings in Werneburg, 2007a).

Bruktererpeton can safely be given state 2 (Boy & Bandel, 1973: 63 and fig. 14).

7608 Solenodonsaurus has at least four metacarpals (Carroll, 1970; Danto, Witzmann & 7609 Müller, 2012), giving it state 1, 2, or 3.

Westlothiana preserves parts of four fingers (Smithson et al., 1994) and may have had 7610 7611 more, meaning state 1, 2, or 3.

7612 Keraterpeton has state 3 (A. C. Milner, pers. comm., September 2009) as scored by RC07. This agrees with Bossy & Milner (1998), contradicting Bossy (1976) and possibly 7613 Jaekel (1903: fig. 2), probably agreeing with pl. XIX of Huxley & Wright (1867), and 7614 7615 contradicting the text of Huxley & Wright (1867) which mentions five metacarpals and 7616 fingers.

Diceratosaurus, however, has state 2 (A. C. Milner, pers. comm., September 2009; D. 7617 7618 M., pers. obs. of MB.Am.776, "Dicey 2-hands" = CM 34617, CM 81504, CM 81508, CM 7619 25468, and AMNH 6933, the type specimen), agreeing with Jaekel (1903: three times 7620 explicitly, and pl. IV-6, which shows MB.Am.776) and with Bossy (1976) but contradicting 7621 Bossy & Milner (1998).

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Diplocaulus has state 2 or 3 (Douthitt, 1917). In *Erpetosaurus, four incomplete fingers are preserved next to a break (Milner &

7624 Sequeira, 2011: fig. 8). We have scored state 1, 2 or 3. 7625

7626 deleted DOR FIN 1: Ossified lepidotrichia in dorsal fin: present (0); absent (1). As RC07 7627 pointed out, this character is parsimony-uninformative, so we have deleted it. 7628

7629 277. CAU FIN 1: Ossified lepidotrichia in caudal fin: present (0); absent (1).

7630 State 0 is probably present in *Ventastega* (Ahlberg et al., 2008); we have tentatively 7631 scored it accordingly.

7632 State 1 is found in *Isodectes* (D. M., pers. obs. of MCZ 6044, a cast of USNM 4481) 7633 and seems to be a safe inference for *Platyrhinops* (Clack & Milner, 2010; Werneburg, 2012a: 7634 fig. 9a).

7635 Although there is no evidence for lepidotrichia or endoskeletal radials around the 34 7636 preserved tail vertebrae of Bruktererpeton, in all but the first few very little is known beyond 7637 the centra, and what is known does not seem to preclude a tail fin skeleton (Boy & Bandel, 7638 1973); we have kept the score as unknown.

7639 Complete tails of *Hyloplesion*, preserving state 1, are known (CG78). We have scored both *Proterogyrinus* and *Archeria* as unknown, because at least the 20
distalmost tail vertebrae in the latter (Holmes, 1989) and more in the former (Holmes, 1984)
are unknown. Some discussion is provided by Clack (2011a).

Further unknown in Broiliellus (the entire tail is unknown; Carroll, 1964), 7643 7644 Doleserpeton (as already scored; although Sigurdsen & Green [2011: appendix 2] reported 7645 state 1, and although a tail fin is of course unexpected in this terrestrial or at most amphibious 7646 animal, the middle and distal parts of the tail are unknown: Sigurdsen & Bolt, 2010), 7647 Gephyrostegus (the entire tail is unknown: Carroll, 1970), Acherontiscus (the tail tip, and 7648 possibly the entire tail, is unknown: Carroll, 1969a), apparently Silvanerpeton (the known 7649 tails are very poorly preserved: Clack, 1994b: 375, fig. 1, 2; Ruta & Clack, 2006: fig. 9C) and 7650 Tseajaia (almost the entire tail is unknown; Moss, 1972).

We have also scored *Caerorhachis* as unknown: only the first 16 or so caudal vertebrae are preserved (Holmes & Carroll, 1977; Ruta, Milner & Coates, 2002), and the first caudal with a supraneural radial in **CM 34638 appears to be around number 17 (Clack, 2011b).

7656 **deleted** BAS SCU 1: **Basal scutes: present (0); absent (1).** As RC07 pointed out, this 7657 character is parsimony-uninformative, so we have deleted it.

7659 Additional references

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References not listed here are cited in the main text. In some cases, "a" cited here is absent
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