The evolution of the axial skeleton intercentrum system in snakes revealed by new data from the Cretaceous snakes *Dinilysia* and *Najash*

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Supplementary Information

1. List of Institutional abbreviations:

FMNH, The Field Museum of Natural History, Chicago, U.S.A.; **HUJ-Pal,** Hebrew University of Jerusalem, Palaeontology Collections, Jerusalem, Israel; **MACN-RN**, Museo Argentino de Ciencias Naturales "Bernandino Rivadavia", Río Negro Collections, Buenos Aires, Argentina; **MACN-PV-N**, Museo Argentino de Ciencias Naturales "Bernandino Rivadavia", Paleontología de Vertebrados-Neuquén Collections, Buenos Aires, Argentina; **MCZ**, Museum of Comparative Zoology, Massachusetts, U.S.A.; **MPCA-PV**, Museo Provincial Carlos Ameghino, Paleontología de Vertebrados Collections, Río Negro, Argentina; **UAMZ**, University of Alberta Museum of Zoology, Alberta, Canada; **USNM**, National Museum of Natural History, Washington, D.C., U.S.A; **ZFMK**, Zoologisches Forschungsmuseum Alexander Koenig, Bonn, Germany.

2. Supplementary Figures

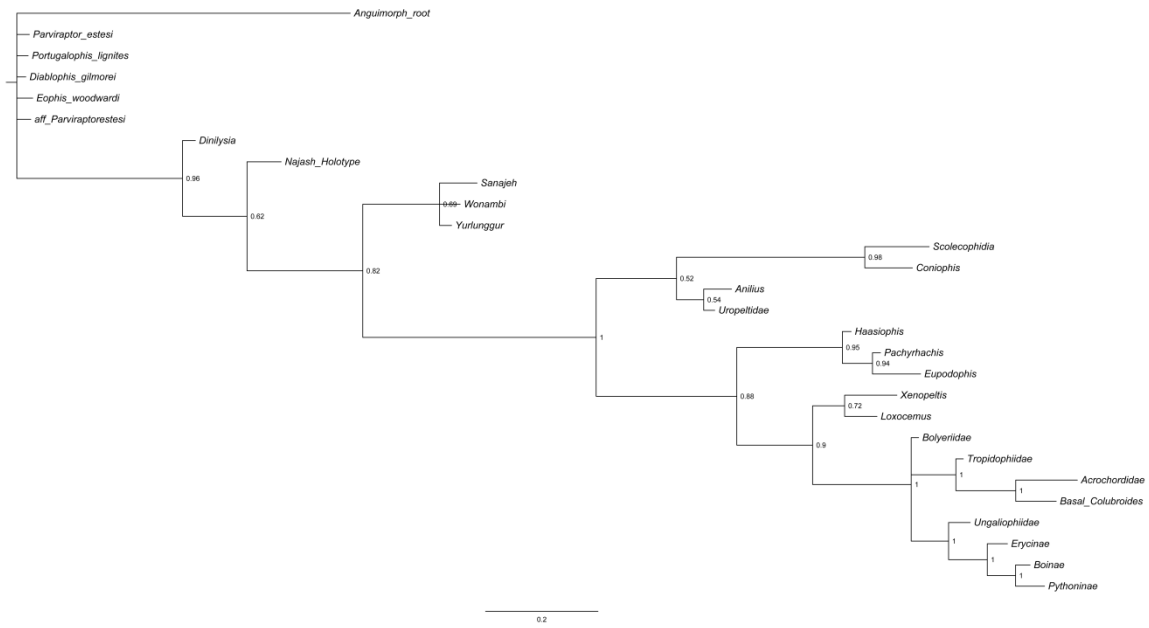

Figure S1. Majority rule consensus of Bayesian Inference analysis. Number indicates posterior probabilities.

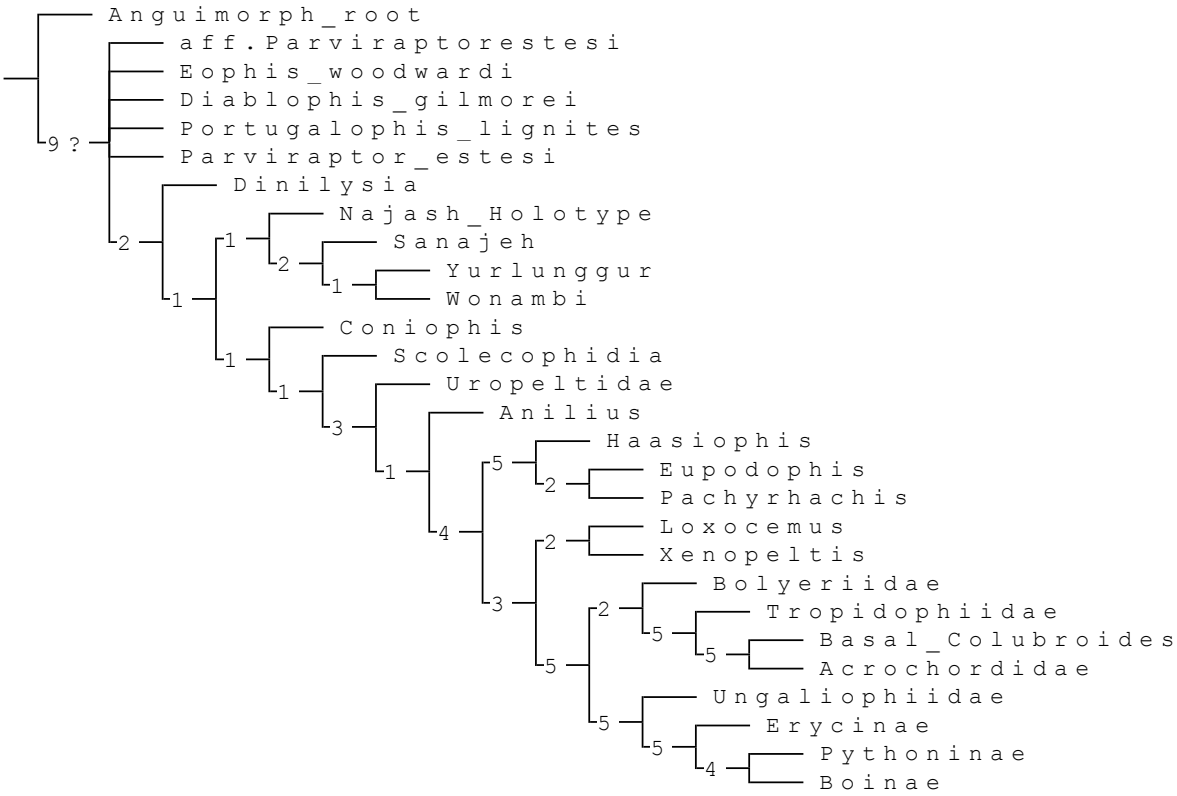

Figure S2. Bremer supports for the MPT from the maximum parsimony analyses (from

675 trees, cut = 0).

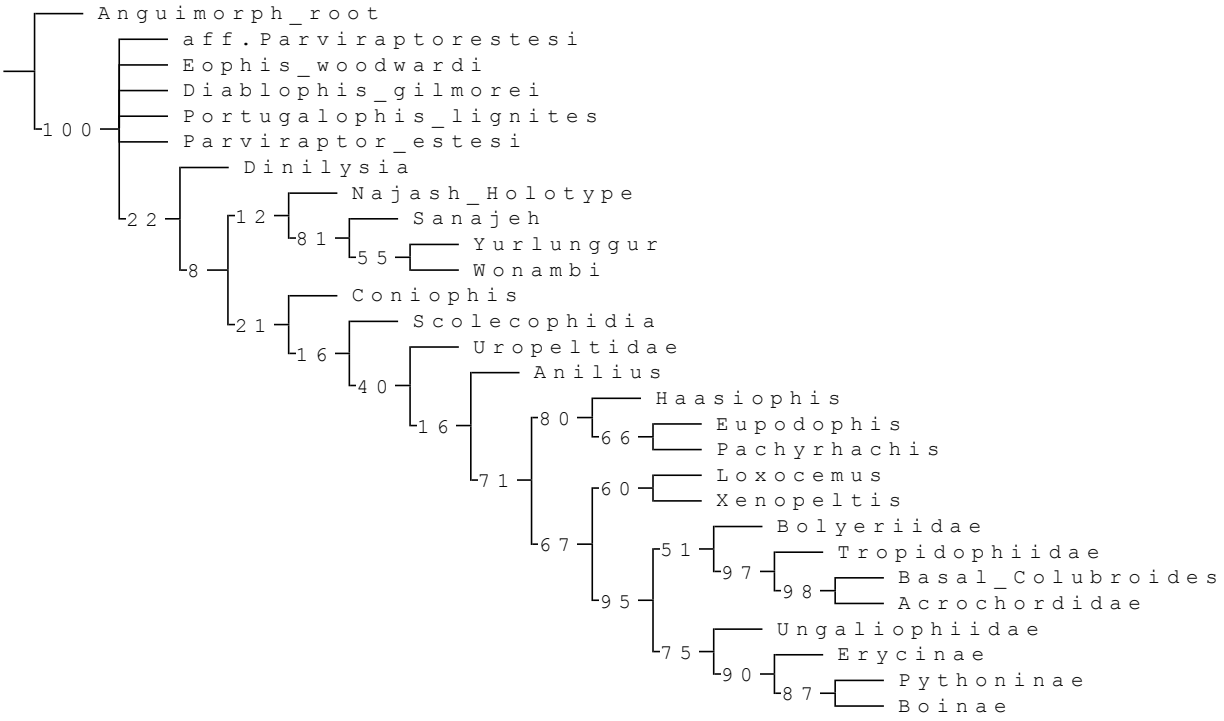

Figure S3. Standard bootstrap support for the MPT from the maximum parsimony analyses (1000 replicates, cut = 50).

Figure S4. Jacknife support for the MPT from the maximum parsimony analyses (1000 replicates, cut = 50).

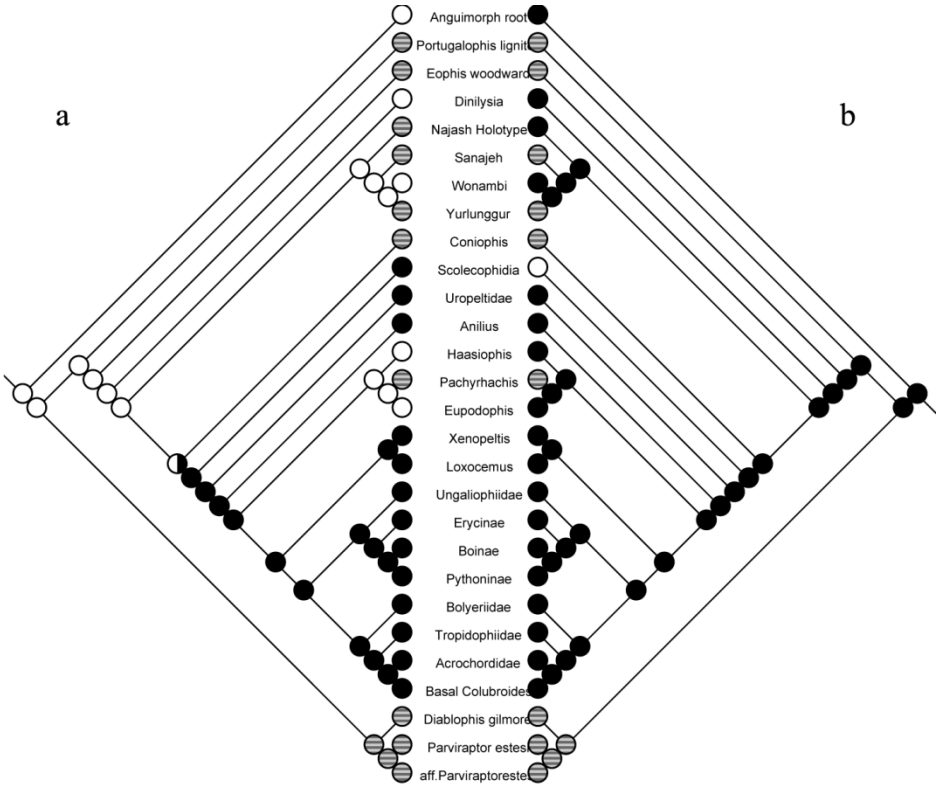

Figure S5. Ancestral character state reconstruction for the CaIS, based on the MPT. a) Presence of intercentra, white circles indicates present, black absent, and striped is unknown. b) Presence of haemapophyses, white circles indicate absent, black present, and striped is unknown.

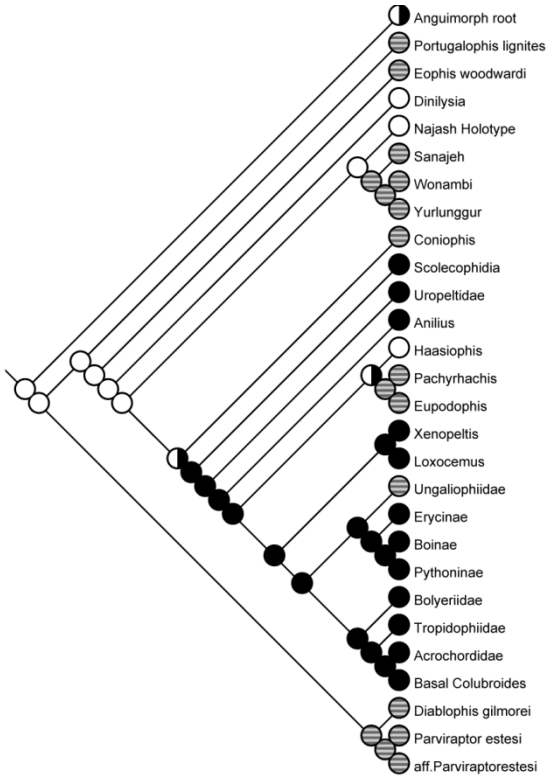

Figure S6. Ancestral character state reconstruction for the CeIS, based on the MPT. Presence of unfused intercentra in precloacal vertebrae posterior to the axis, white circles indicates present, black absent, and striped is unknown.

3. Supplementary Data

Data matrix of Caldwell et al.[1] with the addition of a new character - Character 238: Unfused intercentra in precloacal vertebrae posterior to the axis: present (0); absent (1) - and with character-state scorings corrections for *Dinilysia* and the holotype of *Najash*:

xread

238 28

Anguimorph_root

00001[0 1]0001?00[0 3]0?0000010000000[0 1]0000010000?00010000-000000000?000000001000010100000?100?0000?0000000-0000000000000000001000[0 1][0 1]0000000?00[0 1]0000000000000000[0 1]0000?000000000000000000000000000[0 1]0000000[0 1]0-0000000000000000100000-00000000000000000[0 1]000[0 1]

Najash_Holotype

11??1??0??????101011?100011100001?1?000110??????????1???10???0??20????1?????????01111100

Scolecophidia

11[1 2]1101110?1010??000??00???0000211[0 1]??000?11?11?[0 1]1?000[0 1]0[0 1]020---1[0 1]0?01000000111112100100000?0?02000010111[0 1]010000000110001120[0 1][0 1]10[0 1]01[1 2]11011111[0 1]11101??1110[0 1]0[0 1][0 1]100011000001111101010?0011112111000011--1[0 1]0--1-10000111?0[0 1]0102[0 2]000121110[0 2]10[0 1]111001001

Dinilysia

112?111??1?100??????0?0102100000100100100100110100000000?01?00000000000010001101010110000001[0 1]100000?11100120?00001010101[0 1]01000[0 1]010?101?1???????001000000001???????000112020010011111111110100001-1100010000-011010101011000111001110110111111110

Sanajeh

111??????????????????????2??????1?????0??10?01020?00?0?0??1???1??????1????????01?1111100??0???12?10????1?12?1????1??010???1?0111???001?1??????????11?????????1????????????01?0?????????????????????????0?1??1??0?????1???1??????????1111??1?

Wonambi

112?111?????0?????????0??2?????1?????0101100111200 11?010101?011101?0?1????????0101111000000011121101?111?1201?0??101010?111?01111??001?1????120????11?0???1??01???00?11202011??11101111110100?0?????10?-00110?111011111110011???11101011111111?

Yurlunggur

112111101??103??0?01000001?00?1110010011010??1020001?0101010011101001 1?010???01011?1?000?001112110111 11?12?0????1??010111100111???001[0 1]1???????10?011001??1??011100001120201 10?11101??1110??0001?11010?000110???10??1?1?????1?00??????1111111?

Anilius

111011100001002000010010111000111 11?1001010?110100000010011001111100000001011110100010011000102100001101011101200111101111010101011110111111111011101110111111001101010011212001001111112111111 0111-110001110000111111000201101??10??101111001101

Uropeltidae

11111[0 1][0 1]0[0 1][0 1]010[0 1]100[0 1]0100100110001111[0 1]01001010?110[1 2]00000[0 1][0 1]00110010111000[0 1]00101111[0 1]1000100010001021[0 1][0 1]0[0 1][0 1]111011[1 2]0120011110111101010101111011111111101110111011110111110[0 1]0110[0 1]001121[0 2][0 1]01001[0 1][0 1]1112111[0 1]11[0 1]11--1101011101001111[0 1]00[0 1][0 1]20[0 1]001111[0 1][0 1]2101111001[0 1]01

Pachyrhachis

112??11?1??10??????????00???00???11011??0?11??112???0101??11??????10111?111?20?1??????????1??????????10???120110001??0101111?001?121111?11011110???????0???1????110?001???2??1???1?1???1?1????1-?-1011????????111?0?1???1?111?????1?01111021?1?

Haasiophis

112?111?1??10???????0?00???00???110110?1?11?01121?00101??11?11??11?111?011????1???0????11?????1?0??10???120110001010101111?10??121?11011011110??????01111???11?0?0011??[1 2]101?0??1????1??????10?-1011????????111?0????20???111101?101111?2??10

Eupodophis

112?011?1??10????????????1???????1011????1???1101???1011?11????2?101???1?1????1????????????????1????1????120110001010001111?00??0?1111111011?10???????0???1???11??????1??????????1?1??1??????1????011????????1?1??????1???????1????0?11112??1?

Xenopeltis

1120011011010220010100110310001111 1??001011102020000101101100111111111001000111101010001010101110001100121201201111101111011101101211010111----111111110111110111110111121110111 0?110?2111-11110-01111111000001111010102011112111121111111001101

Loxocemus

1120011011010210010100110210001110001001011102020010101101100111111111001012101 1010100[0 1]1010101110111100121201201111101111011101012110101111 1?201111111011111011111100 1112111011111111?211111101020101111101000111111111201101111111101111011111

Erycinae

1121011111011[0 1]1011011011012[0 1]10111[0 1]0[0 1]1100111[0 1][1 2]211101010[0 1]1011111121111[0 1]10011120012011100[0 1]1011[0 1]?11[1 2]0[0 1]011[0 1]0101211201111101111010011012110101111122011111110111111021110001 1[1 2]11101[0 1]11?111?211111101[0 1]-1101101211001111111 0112111[0 1]121101[1 2]101110011111

Ungaliophiidae

1121011011011020110110 1[0 1]0120101111001100111?021[0 2]1000101101111112[0
1]1110100111200120101000101110110001110 01?1211?1-
2111011110100110121101011111220111111101??11[0
1]0111100011211111111111112111111011-
0101101211001111111111211111211112101111001 10?

Boinae

1121011[0 1]11011[0 1]2011011011[0 1]1211011110111[0 1]0111122121011101[1
2]0111111201111100111200121 11[0 1]00[0 1]1111011120101100121211201111101111[0
1]1001101211010111112201111111011111102111010112121111111111112111111110-
1101101211001111111011211111111012101111011111

Pythoninae

112[0 1]011[0 1]1101002001011011112110111001110011 1?0212101110120111[0
1]1021111110011120012111100[0 1]101[0 1]00112[0
1]1011001212112011111011110100110121101011111220111111101111110211101011212111
1111111211111101021101101211001111111011211111111111101111111111

Tropidophiidae

1121011111011320010100110110111111011100111?0210111010100111011211110100111200 1
2011101110111011100111001?1211201211111111110011011110101111122[0
1]1111111111111101111000112111111111?111?2111111110-
0101101110001111101111221111211012111111001101

Bolyeriidae

1121011011011320010100110110101111011100111?0212001010110111011211110100111201 1
201110001011??1100011100121211201111101111110011012110101 11----
1111111101111110111100011211111111?111?2111110110-0101101110001111111120[0
1]1112110121[0 1]1111001101

Acrochordidae

1121011110111310011211111200111111011110?11?0212111010100111011201111110211200 1
???0101110111011100111001012 01?1-21111111111[0 1]01101211010[0 1]11----
1111111111??1110111100011110111001?111?2111110110-
1101101100000011010?1111210?1211012111111011101

Basal_Colubroides

112101101[0 1][0 1]113110112111[0 1]0[0 2][0 1][0 1]111111[0 1]01100111?021[0 1 2][0
1]1101010011101020111[0 1]1102113001211110111011[0 1][0 1]1[0 1]0001110[0 1]101211-1-

211111110110[0 1]1101211010111----1111111111??11101111000112111111111?111?21110-1110-1101101100001111101110221101211012111011001111

Coniophis

111?1???0???0001201?10[0 1]01??10?????????????????????1??0?????????????????????0?????????????????????????????????11????1?10?????????????0100100?

Parviraptor_estesi

112?1?1???10101???

1. Caldwell, M.W., Nydam, R.L., Palci, A. & Apesteguía, S. The oldest known snakes from the Middle Jurassic-Lower Cretaceous provide insight on snake evolution. *Nat. commun.* **6 (5996)**, 1–11 (2015).