Ontogeny and evolution of the elasmosaurid neck highlight a greater diversity of Antarctic plesiosaurians

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SUPPLEMENTARY MATERIAL

This supplementary material contains:

SUPPLEMENTARY MATERIAL AND METHODS

Phylogenetic analysis. The codification of the specimen in the matrix of O'Gorman (2020) with codification of *Jucha* by Fischer *et al*. (2021) is available in the files "OG(20120) & Fischeretal(2021).nex" and "OG(2020) & Fischeretal(2021).tnt".

Statistical analyses. The whole dataset employed in our statistical analyses to cervical and dorsal vertebrae are compiled in the file "Dataset.xlsx". All the compiled cervical vertebrae specimens are listed in **Supplementary Table 1**. The whole dataset of PAST files to cervical vertebrae are available in the files: "Supp cervical adult morphotypes.dat"; "Supp cervical adult genus level.dat" and "Supp cervical juvenile genus level.dat".

All the analyzed dorsal vertebrae specimens are listed in **Supplementary Table 2**. The whole dataset of PAST files to cervical vertebrae are available in the files: "Supp dorsal adult genus level.dat".

We plotted the VLI values in histograms and performed the normality test Shapiro-Wilk (*W*) to determine whether we could perform non-parametric analyses.

SUPPLEMENTARY RESULTS

Locality and horizon. The photographed sites shown in Figure 1 of the article are available in **Supplementary Figure 1**.

Phylogenetic analysis. The complete collapsed tree from dataset of O'Gorman (2020) with *Jucha* codifications—without MN 7820-V and excluding the wildcard OTUs *Alexandronectes* and *Lagenectes*—is in **Supplementary Figure 2**. This first analysis considered all characters unordered. Following, the list of the common synapomorphies recovered from this first analysis:

Node 102 (the node number follows the present in **Supplementary Figure 2**):
  All trees:
    No synapomorphies
 Node 103 :
  All trees:
    Char. 102: 2 --> 0
    Char. 164: 0 --> 2
    Char. 176: 0 --> 1
 Node 104 :
  All trees:
    Char. 159: 0 --> 1
    Char. 163: 0 --> 1
    Char. 170: 1 --> 0
    Char. 180: 0 --> 1
 Node 105 :
  All trees:
    Char. 0: 0 --> 1
    Char. 18: 2 --> 1
    Char. 32: 0 --> 1
    Char. 113: 0 --> 1
    Char. 119: 1 --> 2
    Char. 151: 3 --> 2

Char. 238: 0 --> 1
Char. 251: 0 --> 1
Node 106 :
All trees:
Char. 2: 1 --> 0
Char. 3: 0 --> 1
Char. 6: 0 --> 1
Char. 8: 1 --> 2
Char. 12: 0 --> 1
Char. 66: 1 --> 0
Char. 69: 0 --> 1
Char. 172: 1 --> 0
Node 107 :
All trees:
Char. 16: 0 --> 1
Char. 76: 0 --> 1
Char. 94: 0 --> 1
Char. 137: 0 --> 1
Node 108 :
All trees:
Char. 30: 0 --> 1
Char. 68: 1 --> 0
Char. 105: 1 --> 0
Char. 157: 1 --> 0
Node 109 :
All trees:
Char. 1: 1 --> 0
Char. 48: 1 --> 0
Char. 49: 2 --> 1
Char. 64: 2 --> 1
Node 110 :
All trees:
Char. 135: 0 --> 1
Char. 136: 2 --> 1

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    Char. 166: 0 --> 1
    Char. 171: 0 --> 3
Node 111 :
  All trees:
    Char. 171: 3 --> 1
    Char. 182: 0 --> 1
    Char. 183: 0 --> 2
Node 112 :
  All trees:
    Char. 56: 0 --> 1
  Some trees:
    Char. 163: 1 --> 0
    Char. 174: 0 --> 1
    Char. 248: 0 --> 1
Node 113 :
  All trees:
    Char. 3: 1 --> 0
    Char. 17: 1 --> 0
    Char. 136: 1 --> 0
Node 114 :
  All trees:
    Char. 152: 1 --> 0
  Some trees:
    Char. 1: 0 --> 1
    Char. 115: 1 --> 0
    Char. 244: 0 --> 1
Node 115 :
  All trees:
    Char. 45: 1 --> 0
    Char. 95: 1 --> 0
    Char. 159: 1 --> 2
    Char. 171: 1 --> 3
Node 116 :
  All trees:
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    Char. 137: 1 --> 2
  Some trees:
    Char. 18: 1 --> 0
    Char. 58: 0 --> 1
    Char. 231: 0 --> 1
Node 117 :
  All trees:
    Char. 120: 1 --> 2
Node 118 :
  All trees:
    Char. 24: 1 --> 0
    Char. 52: 1 --> 0
    Char. 81: 0 --> 1
    Char. 82: 2 --> 1
    Char. 83: 2 --> 0
    Char. 112: 1 --> 0
    Char. 129: 0 --> 2
    Char. 215: 0 --> 1
    Char. 256: 0 --> 1
Node 119 :
  All trees:
    Char. 3: 1 --> 2
    Char. 15: 0 --> 1
    Char. 33: 0 --> 1
    Char. 65: 0 --> 1
    Char. 111: 1 --> 0
Node 120 :
  All trees:
    Char. 157: 0 --> 1
    Char. 208: 0 --> 2
Node 121 :
  All trees:
    Char. 116: 0 --> 1
    Char. 119: 1 --> 0
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Char. 120: 1 --> 0
Char. 136: 1 --> 0
Char. 152: 1 --> 0
Char. 160: 1 --> 2
Char. 175: 0 --> 1
Char. 176: 1 --> 0
Char. 185: 0 --> 1
Char. 188: 1 --> 0
Char. 221: 1 --> 0
Char. 222: 0 --> 2
Char. 230: 1 --> 2
Char. 239: 0 --> 1
Char. 240: 1 --> 0
Char. 241: 1 --> 0
Char. 265: 0 --> 1

Node 122 :

All trees:

Char. 53: 0 --> 1
Char. 113: 0 --> 1
Char. 131: 0 --> 1
Char. 141: 0 --> 1
Char. 223: 2 --> 3
Char. 231: 0 --> 2
Char. 237: 0 --> 1
Char. 243: 1 --> 2
Char. 244: 0 --> 1
Char. 250: 1 --> 2

Node 123 :

All trees:

Char. 3: 2 --> 1
Char. 9: 1 --> 2
Char. 103: 0 --> 1

Node 124 :

All trees:

Char. 1: 0 --> 1
Char. 111: 0 --> 1
Char. 137: 2 --> 1
Char. 166: 1 --> 0
Char. 246: 0 --> 1

Node 125 :

All trees:

Char. 23: 0 --> 1
Char. 138: 0 --> 1

Some trees:

Char. 64: 1 --> 2
Char. 119: 0 --> 2
Char. 126: 1 --> 3

Node 126 :

All trees:

Char. 29: 0 --> 1
Char. 65: 1 --> 0
Char. 82: 2 --> 1
Char. 131: 1 --> 0
Char. 175: 1 --> 2

Node 127 :

All trees:

Char. 32: 0 --> 1
Char. 187: 0 --> 2
Char. 201: 1 --> 0
Char. 230: 2 --> 3

Node 128 :

All trees:

Char. 83: 2 --> 1
Char. 85: 1 --> 0
Char. 122: 0 --> 1
Char. 159: 1 --> 3
Char. 161: 0 --> 1
Char. 162: 0 --> 1

Some trees:
Char. 0: 1 --> 0
Char. 3: 1 --> 2
Char. 12: 1 --> 0
Char. 30: 1 --> 0
Char. 34: 0 --> 1
Char. 53: 1 --> 0
Char. 155: 1 --> 2
Char. 180: 1 --> 0

Node 129 :
All trees:
Char. 158: 1 --> 2
Char. 204: 2 --> 1
Char. 226: 1 --> 2
Char. 243: 1 --> 2
Char. 250: 1 --> 2
Node 130 :
All trees:
Char. 140: 01 --> 2
Char. 188: 1 --> 0
Node 131 :
All trees:
Char. 156: 0 --> 1
Char. 227: 1 --> 0
Char. 234: 2 --> 0
Node 132 :
All trees:
Char. 248: 0 --> 1
Char. 249: 0 --> 1
Char. 263: 0 --> 1
Node 133 :
All trees:
Char. 2: 1 --> 0

Char. 13: 0 --> 2
Char. 38: 0 --> 1
Char. 60: 0 --> 1
Char. 153: 0 --> 1
Char. 177: 1 --> 2
Char. 178: 1 --> 0
Char. 187: 0 --> 1
Char. 192: 0 --> 1
Char. 209: 0 --> 3
Char. 222: 0 --> 2
Char. 264: 1 --> 2
Node 134 :
All trees:
Char. 171: 3 --> 0
Char. 206: 0 --> 2
Char. 218: 0 --> 3
Char. 262: 0 --> 1
Node 135 :
All trees:
Char. 36: 0 --> 1
Char. 37: 0 --> 1
Char. 49: 1 --> 2
Char. 152: 1 --> 2
Char. 248: 1 --> 0
Node 136 :
All trees:
Char. 32: 0 --> 1
Char. 47: 0 --> 1
Char. 230: 1 --> 0
Char. 244: 0 --> 1
Node 137 :
All trees:
Char. 45: 1 --> 0
Char. 74: 0 --> 1

Char. 150: 1 --> 2
Char. 162: 0 --> 1
Char. 256: 1 --> 0
Char. 268: 0 --> 1
Node 138 :
All trees:
Char. 72: 1 --> 0
Char. 113: 1 --> 0
Char. 150: 2 --> 1
Node 139 :
All trees:
Char. 64: 0 --> 1
Char. 132: 1 --> 0
Char. 137: 0 --> 1
Char. 143: 0 --> 1
Char. 226: 2 --> 1
Char. 233: 0 --> 1
Node 140 :
All trees:
Char. 219: 0 --> 1
Node 141 :
All trees:
Char. 223: 2 --> 1
Char. 260: 0 --> 2
Node 142 :
All trees:
Char. 13: 0 --> 1
Char. 44: 0 --> 1
Char. 73: 0 --> 1
Char. 127: 0 --> 1
Char. 201: 1 --> 0
Char. 209: 0 --> 2
Char. 236: 0 --> 1
Char. 241: 1 --> 3

Char. 244: 0 --> 1
Char. 261: 0 --> 1
Node 143 :
All trees:
Char. 64: 1 --> 0
Char. 72: 0 --> 1
Char. 113: 0 --> 1
Char. 132: 0 --> 1
Char. 159: 1 --> 3
Char. 186: 3 --> 0
Char. 187: 0 --> 2
Char. 220: 0 --> 1
Char. 221: 1 --> 0
Char. 222: 0 --> 1
Char. 225: 1 --> 0
Char. 229: 0 --> 1
Char. 258: 0 --> 1
Char. 259: 1 --> 0
Char. 267: 1 --> 2
Node 144 :
All trees:
Char. 232: 0 --> 1
Node 145 :
All trees:
Char. 153: 0 --> 1
Char. 157: 1 --> 2
Char. 245: 0 --> 1
Node 146 :
All trees:
Char. 196: 1 --> 0
Char. 208: 1 --> 2
Node 147 :
All trees:
Char. 147: 1 --> 0

Node 148 :
All trees:
Char. 146: 0 --> 1
Node 149 :
All trees:
Char. 151: 4 --> 5
Node 150 :
All trees:
Char. 133: 0 --> 1
Char. 264: 1 --> 0
Node 151 :
All trees:
Char. 10: 0 --> 2
Char. 64: 0 --> 2
Char. 86: 0 --> 1
Char. 103: 0 --> 1
Char. 104: 0 --> 1
Char. 105: 1 --> 0
Some trees:
Char. 178: 0 --> 1
Node 152 :
All trees:
Char. 157: 1 --> 0
Char. 158: 2 --> 1
Char. 163: 2 --> 1
Some trees:
Char. 5: 0 --> 1
Char. 60: 0 --> 1
Char. 122: 0 --> 1
Char. 151: 4 --> 2
Char. 167: 1 --> 0
Char. 169: 1 --> 0
Char. 220: 1 --> 2
Node 153 :

All trees:
Char. 172: 1 --> 0
Char. 183: 0 --> 2
Char. 187: 2 --> 1
Some trees:
Char. 47: 0 --> 2
Char. 48: 0 --> 2
Char. 120: 0 --> 1
Char. 129: 0 --> 1
Char. 131: 0 --> 1
Char. 137: 0 --> 1
Char. 178: 1 --> 0
Char. 218: 3 --> 2
Node 154 :
All trees:
Char. 11: 1 --> 0
Char. 16: 0 --> 1
Char. 21: 1 --> 2
Char. 49: 1 --> 2
Char. 50: 0 --> 2
Char. 54: 0 --> 1
Char. 65: 0 --> 1
Char. 75: 1 --> 0
Char. 80: 1 --> 0
Char. 83: 1 --> 2
Char. 99: 0 --> 2
Char. 101: 0 --> 1
Char. 108: 0 --> 1
Char. 118: 0 --> 1
Char. 125: 0 --> 1
Char. 156: 1 --> 0
Char. 189: 0 --> 1
Char. 190: 0 --> 1
Char. 202: 2 --> 1

Char. 204: 1 --> 2
Char. 224: 0 --> 1
Some trees:
Char. 214: 0 --> 1
Char. 248: 1 --> 2
Node 155 :
All trees:
Char. 27: 0 --> 2
Char. 43: 0 --> 1
Char. 111: 1 --> 0
Char. 131: 1 --> 0
Char. 132: 1 --> 0
Node 156 :
Some trees:
Char. 3: 0 --> 1
Char. 14: 1 --> 2
Char. 17: 0 --> 1
Char. 116: 0 --> 1
Char. 134: 0 --> 1
Char. 147: 2 --> 0
Char. 164: 0 --> 2
Char. 168: 1 --> 0
Char. 173: 1 --> 0
Node 157 :
All trees:
Char. 248: 2 --> 1
Some trees:
Char. 60: 0 --> 1
Char. 114: 0 --> 1
Char. 189: 0 --> 1
Char. 244: 2 --> 1
Char. 269: 1 --> 0
Node 158 :
All trees:

Char. 52: 1 --> 2
Char. 158: 1 --> 2
Char. 178: 1 --> 0
Char. 192: 0 --> 1
Some trees:
Char. 156: 0 --> 2
Char. 260: 0 --> 1
Char. 269: 0 --> 1
Node 159 :
All trees:
Char. 43: 0 --> 1
Char. 203: 1 --> 0
Some trees:
Char. 113: 1 --> 0
Node 160 :
All trees:
Char. 196: 1 --> 0
Node 161 :
All trees:
Char. 158: 2 --> 1
Node 162 (Euelasmosaurida):
All trees:
Char. 4: 0 --> 1
Char. 49: 2 --> 3
Char. 154: 0 --> 2
Char. 201: 1 --> 0
Char. 254: 1 --> 2
Node 163 :
All trees:
Char. 55: 0 --> 1
Char. 62: 1 --> 0
Char. 66: 1 --> 0
Char. 114: 1 --> 0
Char. 138: 0 --> 2

Char. 139: 1 --> 0
Char. 157: 1 --> 2
Char. 204: 0 --> 1
Char. 244: 1 --> 2

Node 164 :

All trees:

Char. 208: 1 --> 2
Char. 218: 3 --> 1

Node 165 :

All trees:

Char. 204: 2 --> 0
Char. 244: 0 --> 1

Node 166 (Elasmosauridae):

All trees:

Char. 152: 1 --> 2
Char. 153: 0 --> 1
Char. 164: 0 --> 1
Char. 207: 0 --> 13
Char. 243: 2 --> 3

Node 167 :

All trees:

Char. 60: 0 --> 1
Char. 132: 1 --> 0
Char. 196: 1 --> 0
Char. 250: 2 --> 3
Char. 253: 2 --> 1

Node 168 (Weddellonectia):

Some trees:

Char. 30: 0 --> 1
Char. 71: 0 --> 1
Char. 98: 2 --> 0
Char. 132: 1 --> 0
Char. 218: 1 --> 3
Char. 232: 0 --> 1

Char. 244: 2 --> 1
Char. 247: 0 --> 1
Char. 270: 0 --> 1
Char. 275: 1 --> 0
Char. 282: 0 --> 1

Node 169 :

All trees:

Char. 17: 0 --> 2
Char. 18: 2 --> 1

Node 170 (Aristonectinae):

All trees:

Char. 121: 1 --> 0
Char. 122: 0 --> 1
Char. 137: 0 --> 2
Char. 152: 2 --> 1
Char. 172: 1 --> 2
Char. 254: 2 --> 1

Some trees:

Char. 113: 2 --> 3
Char. 144: 1 --> 0
Char. 153: 1 --> 0
Char. 188: 0 --> 2
Char. 190: 1 --> 2
Char. 271: 0 --> 1
Char. 273: 0 --> 1

Node 171 :

All trees:

Char. 111: 1 --> 2

Some trees:

Char. 220: 12 --> 2
Char. 231: 0 --> 2
Char. 243: 3 --> 4
Char. 250: 2 --> 3
Char. 252: 0 --> 1

Char. 276: 1 --> 0
Char. 278: 0 --> 2
Node 172 :
All trees:
Char. 158: 1 --> 2
Node 173 :
All trees:
Char. 281: 0 --> 1
Node 174 :
All trees:
Char. 178: 1 --> 0
Char. 203: 0 --> 2

The strict consensus tree of the inclusion of MN 7820-V in the phylogenetic analysis is in **Supplementary Figure 3**. In both ordered and unordered character (chr. 155) the topology was the same.

Normality tests. The VLI values of the cervical vertebrae in the dataset are not normally distributed (**Supplementary Figure 4**). Although the osteologically juvenile '*Cimoliasaurus*'-grade, adult early elasmosaurids, juvenile *Styxosaurus* and juvenile *Aristonectes* + *Morturneria* complex showed a normal distribution isolated, these groups are marked by small sample sizes and the histograms corroborate the non-normal distribution. The distribution of the dataset of dorsal vertebrae show that only elasmosaurines is significantly normal (**Supplementary Figure 5**). However, as in the cervical vertebral samples, the dorsal vertebrae dataset histograms suggests a non-normal distribution. Therefore, we employed non-parametric methods.

Statistical analyses of cervical vertebrae. The regressions with BI vs HI and VLI vs both BI and HI to adult elasmosaurid morphotypes are in **Supplementary Figures 6-8**.

The multivariate analyses of the adult elasmosaurid morphotypes are in **Supplementary Figure 9** and **10**.

All the LBR to cervical vertebrae at genus-level are in **Supplementary Figure 11-14**.

Statistical analyses of dorsal vertebrae. The regression with HI vs BI is available in **Supplementary Figure 15**.

The regression with BI vs VLI available in **Supplementary Figure 16**.

The regression with HI vs VLI available in **Supplementary Figure 17**.

The LDA evaluating the adult morphotypes of elasmosaurines and early weddellonectians are available in **Supplementary Figure 18**. The preliminary LDA analysis at generic level revealed a wide overlap between them and it failed in segregate them. The PCA shows this overlap in **Supplementary Figure 19**.

SUPPLEMENTARY FIGURES

Supplementary Figure 1. Photographed sites where crops out the Snow Hill Island Formation in Santa Marta Cove. Outcrops of AF-6P2C in (**A**-**C**), with stratigraphic profile in (**C**). View of the sites Site AF-6P1and AF-6P2 in (**D**). Site AF-6P2b (**E**), in which the elasmosaurine vertebrae were collected. The elasmosaurine silhouettes marks where they were recovered in the outcrop. View of the Shark Stream (**F**). Site AF-2 (**G-H**). Elasmosaurine silhouettes in (**A** and **F**) indicates the direction of the site in which the specimen was recovered. Silhouette from PhiloPic, drawn by Frank Denota (CC0 1.0; https://creativecommons.org/publicdomain/zero/1.0/).

Supplementary Figure 2. Strict consensus tree from 30 MTPs of 1518 steps using the dataset of O'Gorman (2019a) with the codification of *Jucha* from Fischer *et al.* (2020), without the wildcard OTUs *Alxandronectes* and *Lagenectes*, and MN 7080-V.

Supplementary Figure 3. Strict consensus tree obtained from the phylogenetic analyses with the inclusion of MN 7820-V.

Supplementary Figure 4. Distribution of the VLI of cervical vertebrae dataset. The *p* values in **bold** are significant.

Supplementary Figure 5. Distribution of the VLI of dorsal vertebrae dataset. The *p* values in **bold** are significant.

Supplementary Figure 6. LBR between BI and HI of adult elasmosaurid cervical vertebral morphotypes. The silhouette of the cervicals indicates the deformation along the axes.

Supplementary Figure 7. LBR between BI and VLI of adult elasmosaurid cervical vertebral morphotypes. The silhouette of the cervicals indicates the deformation along the axes.

Supplementary Figure 8. LBR between HI and VLI of adult elasmosaurid cervical vertebral morphotypes. The silhouette of the cervicals indicates the deformation along the axes.

Supplementary Figure 9. PCA of adult elasmosaurid cervical vertebral morphotypes. The silhouette of the cervicals indicates the deformation along the axes.

Supplementary Figure 10. LDA of adult elasmosaurid cervical vertebral morphotypes. The silhouette of the cervicals indicates the deformation along the axes.

Supplementary Figure 11. LBR of juvenile and adult cervical vertebrae of the early elasmosaurid '*Cimoliasaurus*'-grade. The silhouette of the cervicals indicates the deformation along the axes.

Supplementary Figure 12. LBR of juvenile and adult cervical vertebrae of the elasmosaurine *Styxosaurus*. The silhouette of the cervicals indicates the deformation along the axes.

Supplementary Figure 13. LBR of juvenile and adult cervical vertebrae of the early weddellonectian *Tuarangisaurus*. The silhouette of the cervicals indicates the deformation along the axes.

Supplementary Figure 14. LBR of juvenile and adult cervical vertebrae of the aristonectine genus complex *Aristonectes* + *Morturneria*. The silhouette of the cervicals indicates the deformation along the axes.

Supplementary Figure 15. LBR of BI x HI of adult vertebrae focused on elasmosaurines and early weddellonectians only. The silhouette of the cervicals indicates the deformation along the axes.

Supplementary Figure 16. LBR of BI x VLI of adult dorsal vertebrae focused on elasmosaurines and early weddellonectians only. The silhouette of the cervicals indicates the deformation along the axes.

Supplementary Figure 17. LBR of HI x VLI of adult dorsal vertebrae focused on elasmosaurines and early weddellonectians only. The silhouette of the cervicals indicates the deformation along the axes.

Supplementary Figure 18. LDA of elasmosaurines (*Elasmosaurus* and *Fluvionectes*) and early weddellonectians (*Futabasaurus*, *Kawanectes* and *Vegasaurus*).

Supplementary Figure 19. PCA of elasmosaurines (*Elasmosaurus* and *Fluvionectes*) and early weddellonectians (*Futabasaurus*, *Kawanectes* and *Vegasaurus*). The silhouette of the cervical in graphs indicates the deformation along the axes.

SUPPLEMENTARY TABLES

Supplementary Table 1. Specimens used in the statistical analysis to the cervical vertebrae.

Morphotype	Taxon	Specimen	N	Ontogenetic stage	Reference
?	Indet.	MLP 11-II-20-4	1	Adult	(O'Gorman 2012)
Early elasmosaurid	*Callawayasaurus colombiensis*	UCMP 38349	11	Adult	(O'Keefe and Hiller 2006)
Early elasmosaurid	*'Cimoliasaurus magnus'*	AMNH 2554	10	Adult	(Otero 2016)
Early elasmosaurid	*'Cimoliasaurus maccoyi'*	AM F9630-9928	19	Juvenile	(O'Gorman *et al.* 2013)
Early elasmosaurid	*Thalassomedon haningtoni*	CMNH 1588	57	Adult	(O'Keefe and Hiller 2006)
Early elasmosaurid	*Jucha squalea*	UPM 2756/1-53	21	Adult	(Fischer *et al.* 2020)
Early elasmosaurid	*Jucha* cf.	UPM NV 15	18	Adult	(Fischer *et al.* 2020)
Early elasmosaurid	*Libonectes morgana*	SMUMP 69120	38	Adult	(Welles 1949)
Elasmosaurine	*Albertonectes vanderveldei*	TMP 2007.011.0001	7	Adult	(Kubo *et al.* 2012)

Elasmosaurine	*Elasmosaurus platyurus*	ANSP 1801	47	Adult	(O'Keefe and Hiller 2006)
Elasmosaurine	*Fluvionectes sloanae*	TMP 2009.037.0068/1990.046.0001/.0002	2	Adult	(Campbell *et al.* 2021)
Elasmosaurine	*Hydrotherosaurus alexandrae*	UCMP 33912	36	Adult	(O'Keefe and Hiller 2006)
Elasmosaurine	*Nakonanectes bradti*	MOR 3072	21	Adult	(Serratos *et al.* 2017)
Elasmosaurine	*Styxosaurus* sp.	AMNH 1495	53	Adult	(Otero 2016)
Elasmosaurine	*Styxosaurus* sp.	SDSM 451	42	Adult	(O'Keefe and Hiller 2006)
Elasmosaurine	*Styxosaurus browni*	AMNH 5385	55	Adult	(Otero 2016)
Elasmosaurine	*Styxosaurus glendowerensis*	QMF 3567	24	Juvenile	(Sachs 2004)
Elasmosaurine	*Terminonatator ponteixensis*	RSM P214	3	Adult	(Sato 2003)
Early weddellonectian	*Futabasaurus suzukii*	NSM PV 15025	13	Adult	(Sato *et al.* 2006)
Early weddellonectian	*Kawanectes lafquenianum*	MCS Pv 4	12	Adult	(O'Gorman 2016*a*)
Early weddellonectian	*Kawanectes lafquenianum*	MLP 71-II 13-1	6	Adult	(O'Gorman 2016*a*)
Early weddellonectian	*Kawanectes lafquenianum*	MUC Pv 92	1	Adult	(O'Gorman 2016*a*)
Early weddellonectian	*Kawanectes lafquenianum*	MPEF 1155	7	Adult	(O'Gorman 2019)
Early weddellonectian	*Tuarangisaurus keyesi*	NZGS CD 426	8	Adult	(Wiffen and Moisley 1986)
Early weddellonectian	*Tuarangisaurus keyesi* cf.	CM Zfr 115	39	Juvenile	(O'Keefe and Hiller 2006)
Early weddellonectian	*Vegasaurus molyi*	MLP 93-I-5-1	42	Adult	(O'Gorman *et al.* 2015)
Aristonectine	*Aristonectes* cf.	MLP 89-III-3-1	11	Adult	(O'Gorman *et al.* 2019)
Aristonectine	*Aristonectes* sp.	MLP 14-I-20-16	2	Adult	(O'Gorman *et al.* 2018)
Aristonectine	*Aristonectes parvidens*	MLP 40-XI-14-6	17	Adult	(O'Gorman 2016*b*)
Aristonectine	*Aristonectes quiriquinensis*	SGO.PV.957	17	Adult	(Otero *et al.* 2014)

Aristonectine	*Aristonectes* cf. *parvidens*	MLP 89-III-3-2	1	Juvenile	(O'Gorman *et al.* 2013)
Aristonectine	*Aristonectes* cf. *parvidens*	MML PV 192	3	Juvenile	(O'Gorman *et al.* 2013)
Aristonectine	*Aristonectes* cf. *parvidens*	MUCPv 131	3	Juvenile	(O'Gorman *et al.* 2013)
Aristonectine	*Morturneria seymourensis*	TTU P 9219	6	Juvenile	(O'Gorman *et al.* 2013)
Aristonectine	*Wunyelfia maulensis*	SGO.PV.6507	8	Adult	Otero and Soto-Acuña (2021)

Abbreviations: N, number of analyzed vertebrae.

Supplementary Table 2. Specimens used in the statistical analysis to the adult dorsal vertebrae.

Group	Taxon	Specimen	N	Reference
Early elasmosaurid	*Jucha squalea*	UPM 2756/1-53	5	(Fischer *et al.* 2020)
Elasmosaurine	*Albertonectes vanderveldei*	TMP 2007.011.0001	1	(Kubo *et al.* 2012)
Elasmosaurine	*Elasmosaurus platyurus*	ANSP 18001	7	
Elasmosaurine	*Fluvionectes sloanae*	TMP 2009.037.0068/1990.046.0001/.0002	22	(Campbell *et al.* 2021)
Weddellonectian	*Futabasaurus suzukii*	NSM PV 15025	17	(Sato *et al.* 2006)
Weddellonectian	*Kawanectes lafquenianum*	MCS Pv 4	14	(O'Gorman 2016*a*)
Weddellonectian	*Kawanectes lafquenianum*	MLP 71-II-13-1	3	(O'Gorman 2016*a*)
Weddellonectian	*Kawanectes lafquenianum*	MUC Pv 92	3	(O'Gorman 2016*a*)
Weddellonectian	*Kawanectes lafquenianum*	MPEF 1155	8	(O'Gorman 2019)
Weddellonectian	*Vegasaurus molyi*	MLP 93-I-5-1	9	(O'Gorman *et al.* 2015)

Abbreviations: N, number of analyzed vertebrae.

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