**SUPPLEMENTARY MATERIAL**

The evolution of the tetrapod humerus: morphometrics, disparity, and evolutionary rates

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**Contents**

**1. Time-calibrated supertree.** The phylogeny with temporally scaled branches is reproduced as an object of class “phylo”. The file can be opened and manipulated in various phylogenetic R packages. Taxon name abbreviations are reported in Supplementary Table 1.

**2. Literature sources.** The published sources that were consulted for images of humeri are listed in the order in which taxa appear in the time-calibrated supertree. An asterisk next to a taxon name indicates that direct observations of either original specimens or casts were carried out.

**3. Supplementary figure captions.** The captions that refer to Supplementary Figures 1–7 are reported below.

**4. Supplementary table captions.** The captions that refer to Supplementary Tables 1–3 are reported below.

**1. Time-calibrated supertree**

#NEXUS

BEGIN TAXA;

DIMENSIONS NTAX = 135;

TAXLABELS

saur

bara

rhiz

stre

gogo

ster

eust

cabo

mand

pand

tikt

cats

acan

icht

tule

hortone

ossi

pede

what

cras

horttwo

dora

gree

eucr

baph

edop

coch

glau

eryo

scle

chel

glan

arcg

aust

bala

dend

neld

trim

acro

dvin

acat

ache

mrxd

broi

diss

scap

caco

perr

ters

mpho

plat

dole

eoca

celt

kara

sine

chun

irid

beyi

vald

tria

czat

pros

vier

mmel

tung

mele

apko

apca

apdr

silv

eohe

call

prot

arch

chro

geph

disc

seym

west

utah

bracone

bractwo

scin

dipl

sapl

ptyo

uroc

micr

hylo

asap

tudi

saxo

ricn

pant

rhyn

pelo

trih

elfr

leio

eury

card

casi

sole

limn

orob

diad

dias

ophi

oeda

casa

case

coty

ange

aero

vara

wato

edap

hapt

sphe

dime

mros

brba

embr

anth

proc

thur

prus

capt

labi

pale

ptts

spin

petr

arae

;

END;

BEGIN TREES;

TRANSLATE

1 saur,

2 bara,

3 rhiz,

4 stre,

5 gogo,

6 ster,

7 eust,

8 cabo,

9 mand,

10 pand,

11 tikt,

12 cats,

13 acan,

14 icht,

15 tule,

16 hortone,

17 ossi,

18 pede,

19 what,

20 cras,

21 horttwo,

22 dora,

23 gree,

24 eucr,

25 baph,

26 edop,

27 coch,

28 glau,

29 eryo,

30 scle,

31 chel,

32 glan,

33 arcg,

34 aust,

35 bala,

36 dend,

37 neld,

38 trim,

39 acro,

40 dvin,

41 acat,

42 ache,

43 mrxd,

44 broi,

45 diss,

46 scap,

47 caco,

48 perr,

49 ters,

50 mpho,

51 plat,

52 dole,

53 eoca,

54 celt,

55 kara,

56 sine,

57 chun,

58 irid,

59 beyi,

60 vald,

61 tria,

62 czat,

63 pros,

64 vier,

65 mmel,

66 tung,

67 mele,

68 apko,

69 apca,

70 apdr,

71 silv,

72 eohe,

73 call,

74 prot,

75 arch,

76 chro,

77 geph,

78 disc,

79 seym,

80 west,

81 utah,

82 bracone,

83 bractwo,

84 scin,

85 dipl,

86 sapl,

87 ptyo,

88 uroc,

89 micr,

90 hylo,

91 asap,

92 tudi,

93 saxo,

94 ricn,

95 pant,

96 rhyn,

97 pelo,

98 trih,

99 elfr,

100 leio,

101 eury,

102 card,

103 casi,

104 sole,

105 limn,

106 orob,

107 diad,

108 dias,

109 ophi,

110 oeda,

111 casa,

112 case,

113 coty,

114 ange,

115 aero,

116 vara,

117 wato,

118 edap,

119 hapt,

120 sphe,

121 dime,

122 mros,

123 brba,

124 embr,

125 anth,

126 proc,

127 thur,

128 prus,

129 capt,

130 labi,

131 pale,

132 ptts,

133 spin,

134 petr,

135 arae

;

TREE \* UNTITLED = [&R] ((1:24.1,(2:20.1,(3:14.225,4:17.775):14.225):20.1):24.1,((5:1.65,6:24.55):18.15,((7:5.5,(8:7.9,9:7.9):7.9):5.5,(10:5.5,(11:4.4,(12:20.36666667,(13:6.933333333,(14:3.466666667,((15:4.322222222,(16:6.161111111,(17:20.77407407,(18:2.387037037,19:14.83703704):2.387037037):2.387037037):6.161111111):4.322222222,(20:33.48333333,((21:4.161111111,(22:12.58055556,23:15.58055556):12.58055556):4.161111111,((24:2.5,25:21.5):18.2047619,(((26:21.18,27:13.5):17.5,(((28:10,29:17.8):10,(30:13.25,(31:15.33333333,(32:5.416666667,(33:2.708333333,34:33.10833333):2.708333333):5.416666667):5.416666667):13.25):13,((35:1,36:17.8):1,((37:4.55,(38:6.475,(39:3.2375,40:35.2375):3.2375):6.475):28.71666667,(41:28.73333333,(((42:35.83333333,43:4.833333333):4.833333333,((44:6.255555556,45:28.15555556):6.255555556,(46:10.45555556,47:25.85555556):10.45555556):6.255555556):4.833333333,(((48:11.75,(49:9.625,50:35.525):9.625):19,(51:3.625,(52:17.3125,(53:92.984375,((54:42.6,(55:45.68,(56:59.16,((57:8.1,58:3.9):24.94,(59:10.52,60:41.42):10.52):10.52):10.52):10.52):63.65625,(61:10.528125,(62:5.7640625,(63:33.08203125,64:45.48203125):33.08203125):5.7640625):10.528125):10.528125):10.528125):17.3125):3.625):3.625,(65:19.92916667,(66:60.78333333,(67:12.8375,(68:9.891666667,(69:2.945833333,70:4.345833333):2.945833333):2.945833333):2.945833333):2.945833333):2.945833333):3.625):4.833333333):4.833333333):4.833333333):1):1):14.08730159,((71:2.5,(72:4.25,(73:12.63333333,(74:2.416666667,75:37.91666667):2.416666667):2.416666667):4.25):12.96984127,((76:65.53333333,(77:10.66666667,(78:12.43333333,79:10.08333333):10.08333333):10.66666667):18.51904762,((80:2.5,(81:8.15,(((82:21.55,83:21.55):22.35,((84:4.6,85:35.6):5.2,(86:9.6,(87:9.4,88:0.2):0.2):0.2):0.2):8.5625,((89:5.1,90:5.1):10.675,(91:2.7875,(92:12.35625,((93:16.45,94:4.6):7.125,((95:15.65,96:27.45):17.54375,((97:34.3,98:5.9):7.1625,(99:0.63125,(100:0.315625,(101:20.2578125,102:20.2578125):20.2578125):0.315625):0.63125):0.63125):0.63125):0.63125):0.63125):2.7875):2.7875):2.7875):8.15):7.734920635,(103:2.617460317,(104:31.1292517,((105:8.45,(106:22.43333333,(107:5.616666667,108:2.816666667):2.816666667):2.816666667):25.89104308,((109:31.38333333,((110:4.65,((111:9.783333333,112:8.033333333):8.033333333,(113:9.558333333,114:10.85833333):9.558333333):8.033333333):13.71666667,((115:3.25,(116:10.3,117:20.45):10.3):10.05,(118:18.08333333,(119:2.266666667,(120:7.908333333,121:18.20833333):7.908333333):2.266666667):2.266666667):2.266666667):2.266666667):16.21950113,((122:52.76,((123:25.73,(124:10.44,125:19.39):10.44):10.44,126:46.22):10.44):20.90462585,((127:16.75,(128:10.35,(129:5.175,130:11.825):5.175):10.35):23.72641723,(131:3.488208617,(132:1.744104308,(133:13.52940287,(134:5.114701436,135:28.51470144):5.114701436):5.114701436):1.744104308):3.488208617):3.488208617):3.488208617):3.488208617):3.488208617):3.488208617):2.617460317):2.617460317):2.617460317):2.617460317):2.617460317):2.617460317):4.161111111):4.161111111):4.322222222):3.466666667):6.933333333):6.933333333):4.4):5.5):5.5):5.5):1;

END;

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**3. Supplementary figure captions**

**Supplementary Figure 1** Supertree used in this paper with branches scaled in proportion to their durations in millions of years; for taxon name abbreviations, see Supplementary Table 1. Colour codes for the branches are as follows: fish, blue; stem tetrapods, green; stem amphibians, magenta; crown amphibians, red; stem amniotes, grey-blue; crown amniotes, brown; lepospondyls, black.

**Supplementary Figure 2** Plots of Ripley’s *K* function for the distribution of humeri in the three-dimensional space delimited by the first three eigenaxes; in each plot, the solid black line represents Ripley’s *K* for the observed data; the grey area is the 95% confidence envelope obtained via 1000 simulations of complete spatial random distributions for a number of data points equal to that of the observed data; the dashed red line is the median distribution obtained from those random simulations. Abbreviations at the top of the plots are as follows: (A) EALL, total sample; (B) EFISH, fin-bearing tetrapodomorphs (fish); (C) ESTTET, limb-bearing tetrapodomorphs (stem tetrapods); (D) ESTAMP, stem-group amphibians; (E) ECAMP, crown-group amphibians; (F) ESAMN, stem-group amniotes; (G) ECAMN, crown-group amniotes; (H) ELEPOS, lepospondyls.

**Supplementary Figure 3** Distribution of evolutionary rate shifts for the scores on the first eigenaxis, plotted as coloured branches on the supertree (see also Supplementary Table 3).

**Supplementary Figure 4** Distribution of evolutionary rate shifts for the scores on the second eigenaxis, plotted as coloured branches on the supertree (see Supplementary Table 3).

**Supplementary Figure 5** Distribution of evolutionary rate shifts for the scores on the third eigenaxis, plotted as coloured branches on the supertree (see Supplementary Table 3).

**Supplementary Figure 6** Distribution of evolutionary rate shifts for the scores on the first three eigenaxes, plotted as coloured branches on the supertree (see Supplementary Table 3).

**Supplementary Figure 7** Distribution of evolutionary rate shifts for the scores on the first ten eigenaxes, plotted as coloured branches on the supertree (see Supplementary Table 3).

**Supplementary Figure 8** Labelled plot of the distribution of humeri in the two-dimensional space delimited by eigenaxes ES1-2 (x-y).

**Supplementary Figure 9** Labelled plot of the distribution of humeri in the two-dimensional space delimited by eigenaxes ES1-3 (x-z).

**Supplementary Figure 10** Labelled plot of the distribution of humeri in the two-dimensional space delimited by eigenaxes ES2-3 (y-z).

**4. Supplementary table captions**

**Supplementary Table 1** The left part of the table shows the sample of taxa used in this study arranged in the order in which they appear in the time-calibrated supertree, the acronyms for the taxon names, first stratigraphic appearance data in millions of years, and the ln-transformed humerus lengths originally expressed in mm. The right part of the table shows the results of the Coordinate Point Eigenshape analysis, with the first 40 eigenaxes accompanied by the value of the variance they explain (eigenvalue), also expressed as a percentage of the total variance. The cumulative variance column reports, in percentage, the amount of variance of all eigenaxes that precede any given eigenaxis, and including the latter.

**Supplementary Table 2** The table shows the results of two statistical tests of group separation in morphospace based on the first 40 eigenaxes, specifically an analysis of similarity and a permutational multivariate analysis of variance. For each pair-wise comparison, the test statistic values are reported above the diagonal, and the associated p-values are shown below (uncorrected to the left of the forward slash, Bonferroni-corrected to the right).

**Supplementary Table 3** The left part of the table shows the results of evolutionary model fitting for various sets of eigenscores, as well as two analyses of evolutionary rates and shifts. The middle part of the table shows the results of pair-wise comparisons between group-specific posterior evolutionary rates. The right part of the table shows the results of the Phylogenetic Generalized Least Square correlations between humeral size and shape, ith shape represented by scores on each of the first three eigenaxes.