Contents

S1. Scan parameter metadata of auditory structures in birds

This file contains the scan parameters and details for each scan ID and its corresponding digital specimen on Morphosource. The file has the following columns: taxonomic order, species scientific names, common name, specimen code, scan date, Morphosource specimen number, Morphosource file ark identifier, specimen type (either head, head in fluid fixative, or scan from digital repository), scan facility, scanner model, resolution (x), resolution (y), resolution (z), tube voltage (kV), tube current (uA), number of images acquired, acquisition time for each image, averaging (number of images taken at each step position during rotation, then averaged to reduce noise), filters used, rotation (in degrees), bit depth, and specimen source.

S2. Behavioural audiogram data

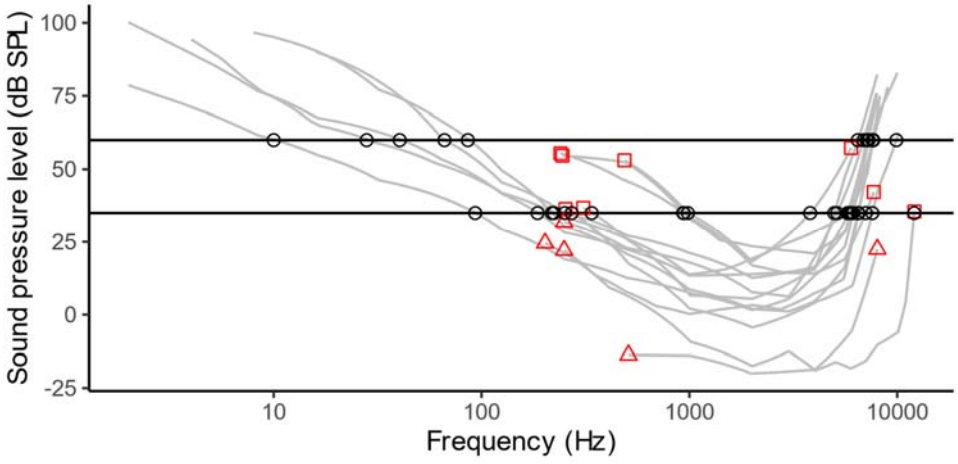

Fig S1. (A) Audiograms of 14 species with conspecifics or congeners with scan data showing cut-offs at 35 dB and 60 dB (horizontal lines) and audiograms failing to reach cut-off criteria. Red symbols indicate the limits of audiograms that did not reach the 35 dB (triangles) or 60 dB (squares) cut-off levels and were omitted from analysis.

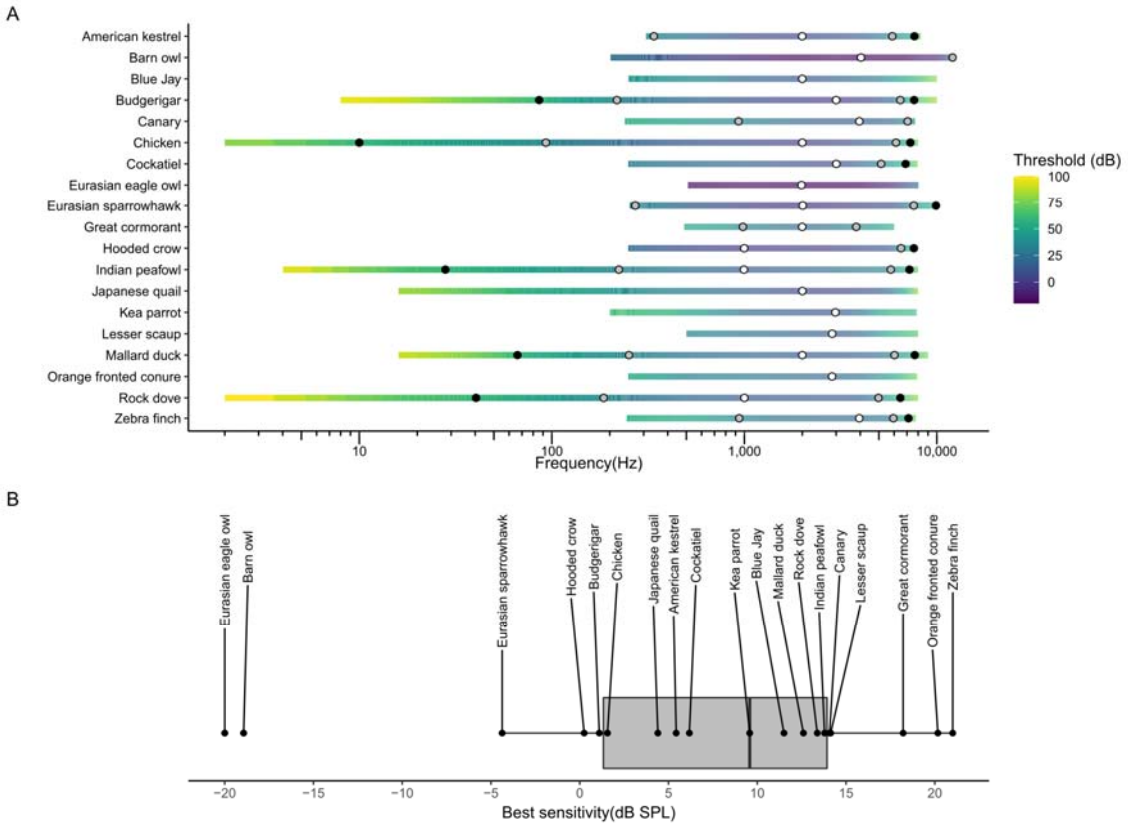

Fig. S2 (A) Audiogram values for individual species included in the study, highlighting their hearing ranges and best frequencies. The colours highlight threshold levels (dB SPL) with the left and right end of each bar representing the entire range of frequencies measured (Hz), low and high frequency limits determined at a cutoff level of 60 dB (black dots) and 35 dB (grey dots), and best frequency as white dots. (B) Boxplot of best sensitivity data with species represented by dots.

S3. Scatterplots: scaling between auditory structures and scaling of auditory structures with head mass

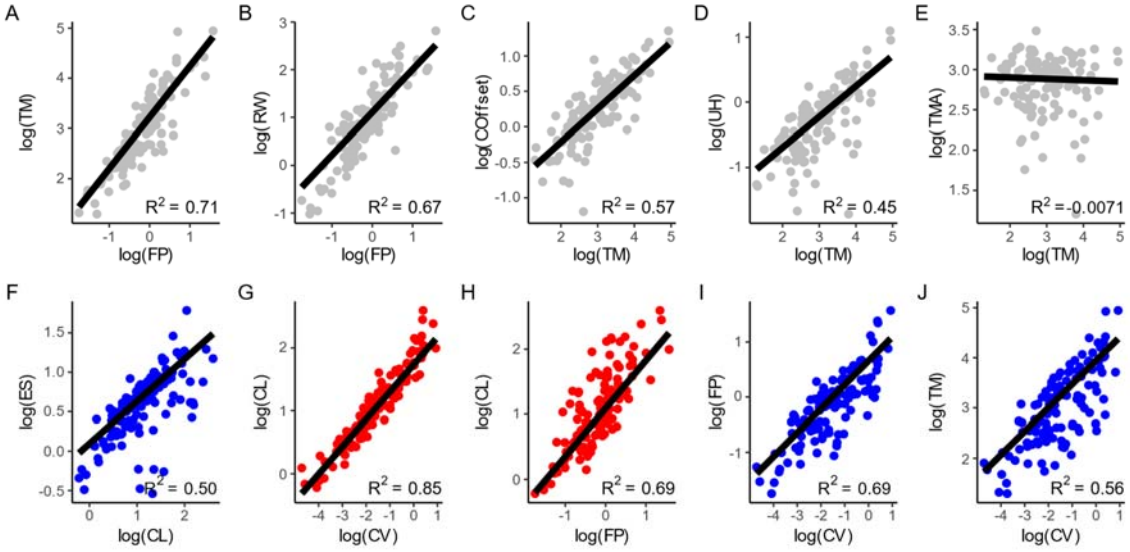

Fig. S3. Scaling relationships between auditory structures. Order follows that of Table 2 (main paper) and are grouped as traits related to impedance matching (A-E), stiffness (F), and columella morphology (G-J). Data points are coloured grey if the relationship is isometric, blue if hypoallometric (negative allometry) and red if hyperallometric (positive allometry). Black line shows the linear fit of the PGLS model. Abbreviations: CL is columella length (mm), COffset is columella offset from centroid of perimeter of tympanic membrane (mm), CV is columella volume (mm^3), ECD is endosseous cochlear duct length (mm), ES is extrastapedius length (mm), FP is columella footplate area (mm^2), RW is round window area (mm^2), TM is tympanic membrane area (mm^2), TMA is tympanic membrane angle (degrees), UH is umbo height (mm).

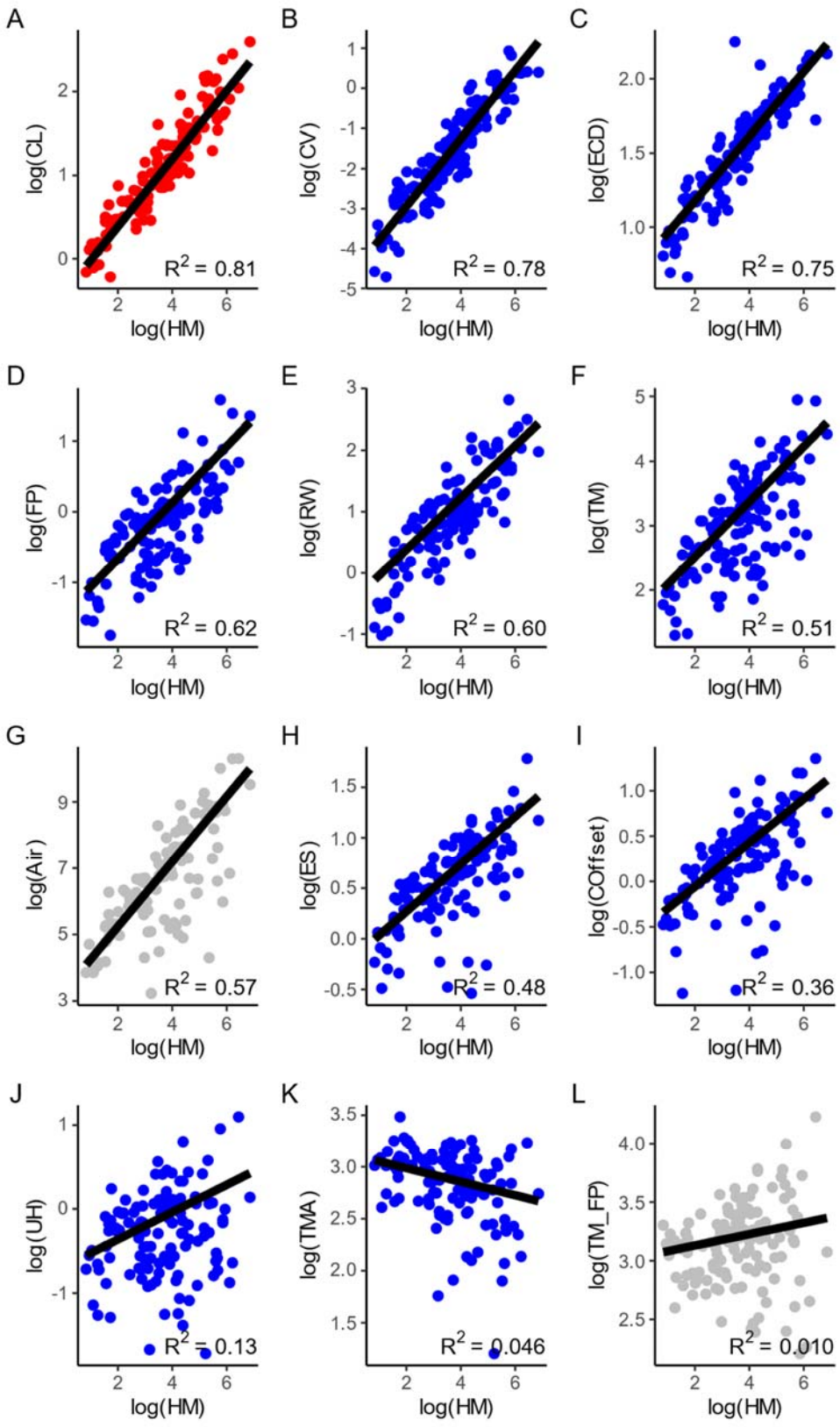
A
log(CL)
log(HM)
R2 = 0.81
B
log(CV)
log(HM)
R2 = 0.78
C
log(ECD)
log(HM)
R2 = 0.75
D
log(FP)
log(HM)
R2 = 0.62
E
log(RW)
log(HM)
R2 = 0.60
F
log(TM)
log(HM)
R2 = 0.51
G
log(Air)
log(HM)
R2 = 0.57
H
log(ES)
log(HM)
R2 = 0.48
I
log(COffset)
log(HM)
R2 = 0.36
J
log(UH)
log(HM)
R2 = 0.13
K
log(TMA)
log(HM)
R2 = 0.046
L
log(TM_FP)
log(HM)
R2 = 0.010

Fig. S4. Scaling of auditory structures with head mass. Order follows that of Table 3 (main paper) and are grouped by columella morphology (A-B), auditory endorgan length (C), input/output areas (D-F), stiffness (G-H), and impedance matching (I-L). Data points are coloured grey if the relationship is isometric, blue if hypoallometric (negative allometry) and red if hyperallometric (positive allometry). Black line shows the linear fit of the PGLS model. Trait abbreviations follow Fig. 1 (main paper). Abbreviations: Air is cranial air volume (mm^3), CL is columella length (mm) and CV is columella volume (mm^3), FP is columella footplate area (mm^2), COffset is columella offset from centroid of perimeter of tympanic membrane (mm), ECD is endosseous cochlear duct length (mm), ES is extrastapedius length (mm), RW is round window area (mm^2), TM is tympanic membrane area (mm^2), TM_FP is tympanic membrane-to-columella footplate area ratio, TMA is tympanic membrane angle (degrees), UH is umbo height (mm).

S4. Scatterplots: auditory structures versus audiogram metrics

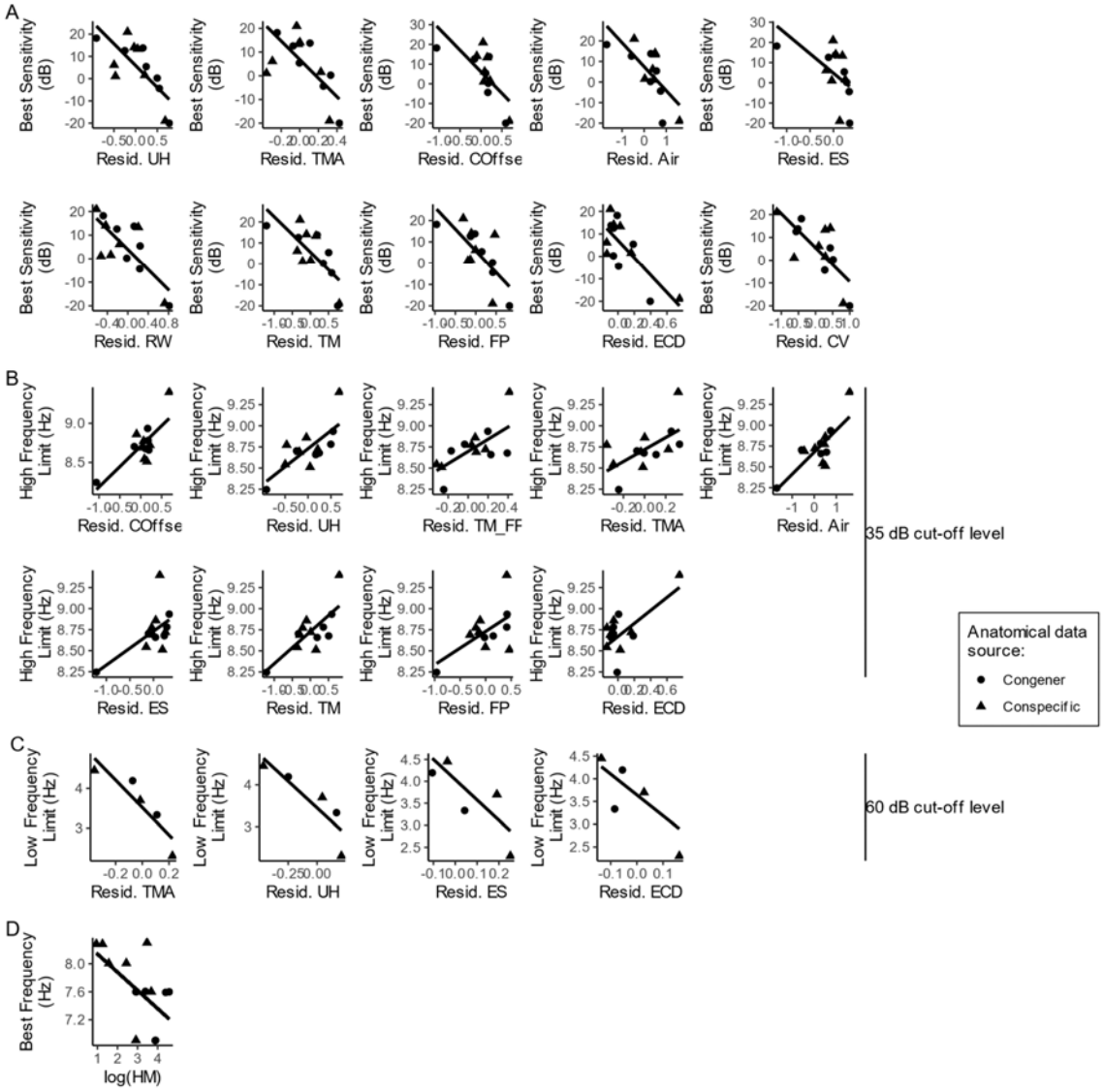

Fig. S5 Scatterplots showing significant relationships between size-adjusted auditory structures (residuals from regressions with head mass), or head mass (HM) alone, and (A) best sensitivity (dB), (B) high frequency hearing limit (Hz) (35 dB cut-off), (C) low frequency hearing limit (Hz) (60 dB cut-off), and (D) best frequency (Hz) obtained from published audiograms. Triangles indicate that the morphological data were drawn from the same species as the audiogram, whereas circles indicate that the data were drawn from congeners. Abbreviations: Air is cranial air volume (mm^3), CL is columella length (mm), COffset is columella offset from centroid of perimeter of tympanic membrane (mm), CV is columella volume (mm^3), FP is columella footplate area (mm^2), ECD is endosseous cochlear duct length(mm), ES is extrastapedius length

(mm), RW is round window area (mm^2), TM is tympanic membrane area (mm^2), TMA is tympanic membrane angle (degrees), TM_FP is tympanic membrane-to-columella footplate area ratio, UH is umbo height (mm). Black line shows the linear fit of the PGLS model.

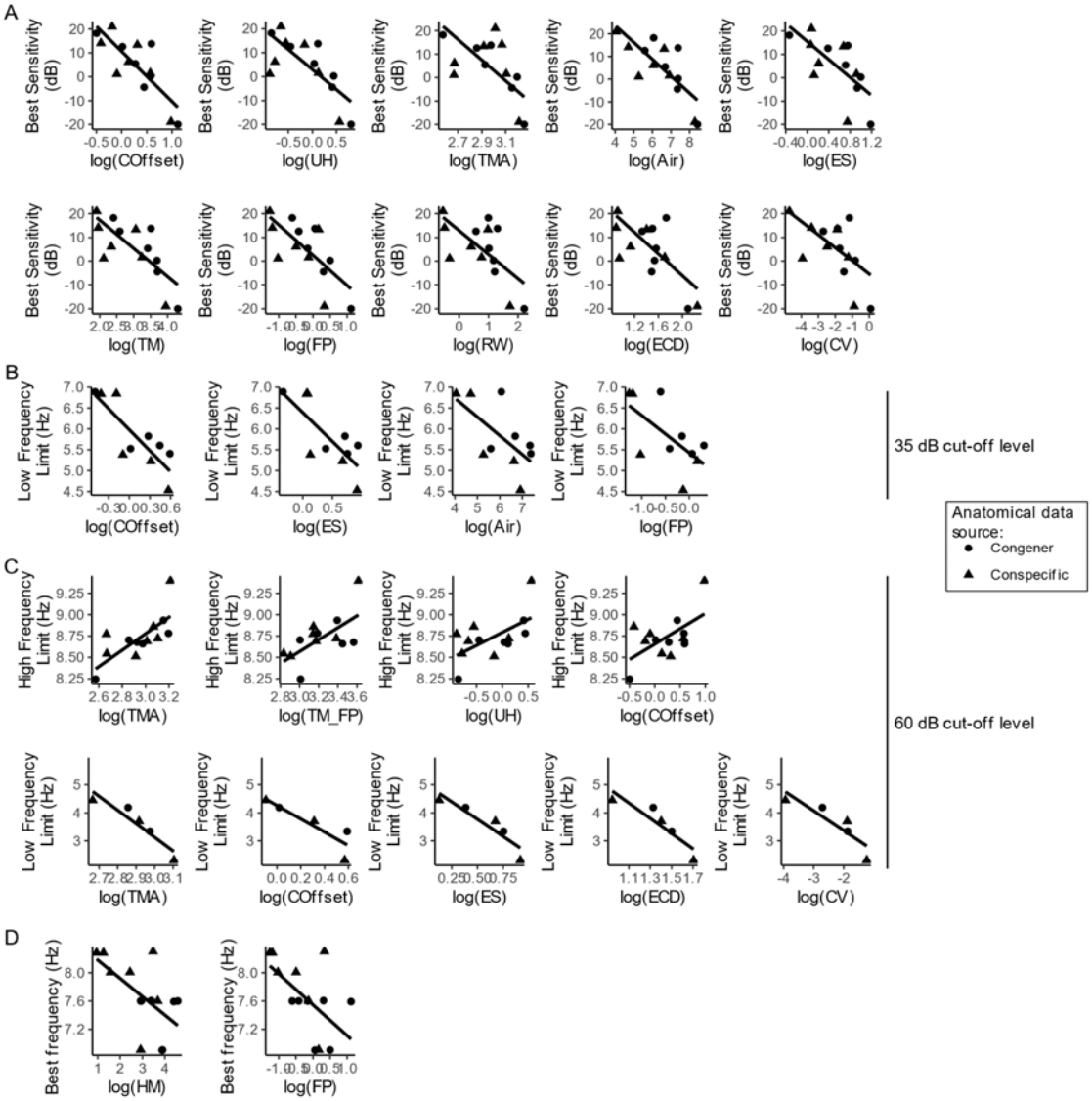

Fig. S6 Scatterplots showing significant relationships between auditory structures (unadjusted for head mass), or head mass (HM) alone, relative to (A) best sensitivity (dB), (B) 35 dB cut-off limits (high and low frequency hearing limit (Hz)), (C) 60 dB cut-off hearing limits (low frequency hearing limit (Hz)), and (D) best frequency (Hz) obtained from published audiograms. Black line shows the linear fit of the PGLS model. Structure abbreviations follow previous figure.