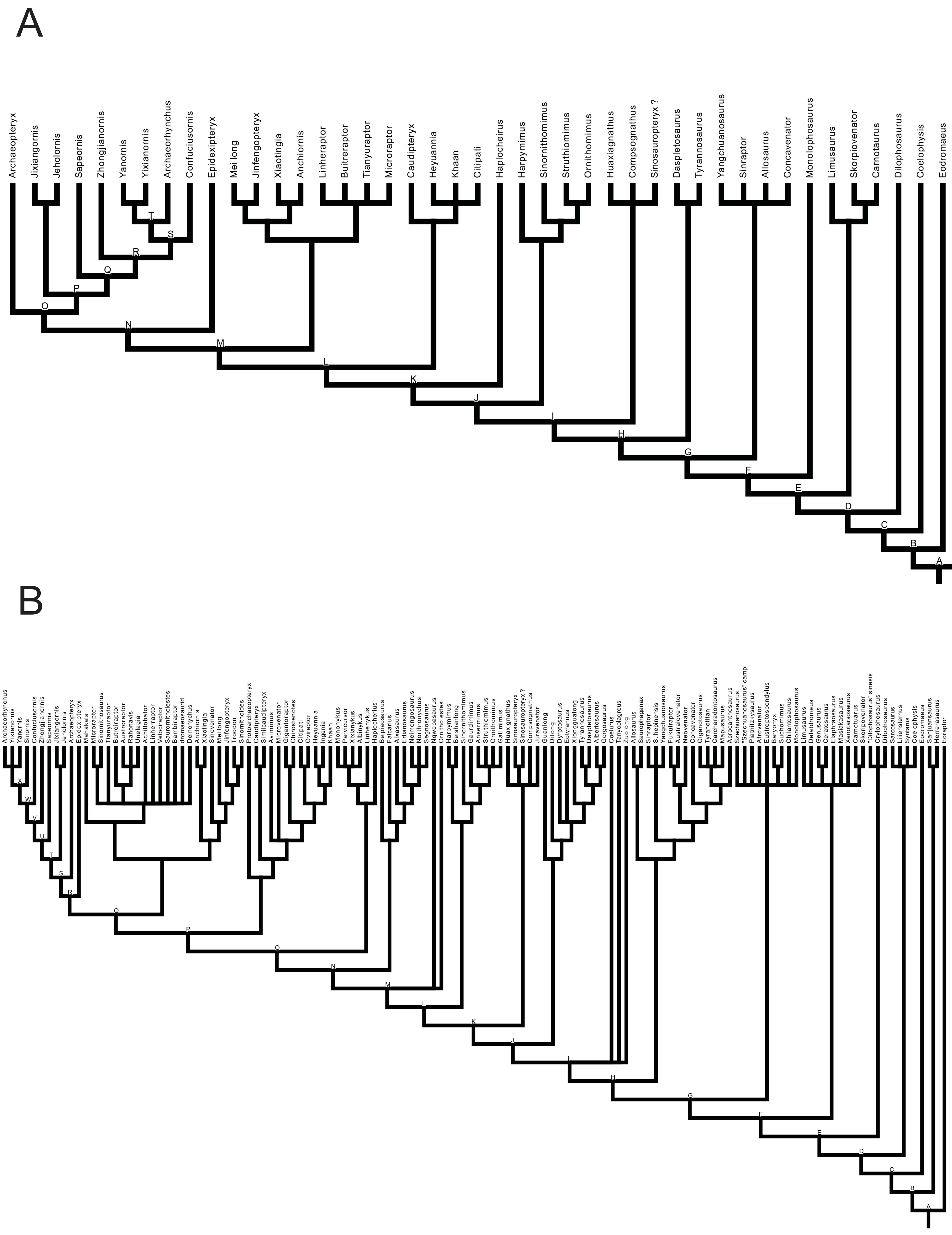
Supplementary Figure 1: Phylogeny used for dataset analysis. Only adult terminal taxa were used in this analysis. Trees based on Carrano et al. 2012,Hu et al. 2009, Li et al. 2010,Mackovicky et al. 2010, Nesbitt et al. 2010, Sereno et al. 2009, Turner et al. 2007, Novas et al. 2009 and Zanno 2010 Three permutations of the placement of *Epidexipteryx* were performed, though only the first is shown. The other two permutations involve Epidexipteryx being placed as a Maniraptora outside Paraves (Node L) or placing it after Aves (Node O). A) measured dataset, nodal labels: A- Theropoda, B- Neotheropoda, C-Neotheropoda I, D- Neotheropoda II, E- Ceratosauria, F- Tetanurae, G- Avetheropoda, H- Coelurosauria, I- Coelurosauria I , J- Manirpatoriformes, K- Maniraptora, L- Maniraptora I, M- Paraves, N- Avialae, O- Aves, P- Aves I, Q- Aves II, R- Aves III, S- Pygostylia, T- Ornithothoraces. B) larger dataset: A- Saurischia, B- Theropoda, C- Neotheropoda, D- Neotheropoda I, E- Neotheropoda II, F- Ceratosauria, G- Tetanurae, H- Avetheropoda, I- Coelurosauria, J- Coelurosauria I, K- Coelurosauria II, L- Manirpatoriformes, M- Maniraptora, N- Maniraptora I, O- Maniraptora II, P- Maniraptora III, Q- Paraves, R- Avialae, S- Aves, T- Aves I, U- Aves II, V- Aves III, W- Pygostylia, X- Ornithothoraces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Jeholornis
Sapeornis
Zhongjianornis
Yanornis
Yixianornis
Archaeorhynchus
Confuciusornis
Epidexipteryx
Mei long
Jinfengopteryx
Xiaotingia
Anchiornis
Linheraptor
Buitreraptor
Tianyuraptor
Microraptor
Caudipteryx
Heyuannia
Khaan
Citipati
Haplocheirus
Harpymimus
Sinornithomimus
Struthiomimus
Ornithomimus
Huaxiagnathus
Compsognathus
Sinosauropteryx ?
Daspletosaurus
Tyrannosaurus
Yangchuanosaurus
Sinraptor
Allosaurus
Concavenator
Monolophosaurus
Limusaurus
Skorpiovenator
Carnotaurus
Dilophosaurus
Coelophysis
Eodromaeus
Sanjuansaurus
T
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Archaeorhynchus
Yixianornis
Yanornis
Sinornis
Confuciusornis
Zhongjianornis
Sapeornis
Jixiangornis
Jeholornis
Archaeopteryx
Epidexipteryx
Mahakala
Microraptor
Sinornithosaurus
Tianyuraptor
Butreiraptor
Austroraptor
Rahonavis
Unelagia
Achillobator
Linherraptor
Velociraptor
Saurornitholestes
Bambiraptor
dromaeosaurid
Deinonychus
Anchiornis
Xiaotingia
Sinovenator
Mei long
Jinfengopteryx
Troodon
Sinornithoides
Protoarchaeopteryx
Caudipteryx
Similcaudipteryx
Avimimus
Microvenator
Gigantoraptor
Chirostenotes
Citipati
Oviraptor
Heyuannia
Ingenia
Khaan
Mononykus
Parvicursor
Xixianykus
Albinykus
Linhenykus
Haplocherius
Beipiaosaurus
Falcarius
Alxasaurus
Erlianosaurus
Neimongosaurus
Northronychus
Segnosaurus
Nqwebasaurus
Ornitholestes
Harpymimus
Beishanlong
Sinornithomimus
Gaurdimimus
Ansermimus
Struthiomimus
Ornithomimus
Gallimimus
Huaxignathus
Sinosauropteryx
Sinosauropteryx ?
Compsognathus
Juravenator
Guanlong
Dilong
Dyrptosaurus
Eotyrannus
Xiongguanlong
Tyrannosaurus
Daspletosaurus
Albertosaurus
Gorgosaurus
Coelurus
Tanycolagreus
Zuolong
Allosaurus
Saurophaganax
Sinraptor
S. hepinensis
Yangchuanosaurus
Fukuiraptor
Australovenator
Neovenator
Concavenator
Giganotosaurus
Tyranotitan
Carcharadontosaurus
Mapusaurus
Acrocanthosaurus
Szechuanosaurus
"Szechuanosaurus" campi
Piatnitzkysaurus
Afrovenator
Eustreptospondylus
Baryonyx
Suchomimus
Chilantosaurus
Monolophosaurus
Limusaurus
Delatdromeus
Genusaurus
Ceratosaurus
Elaphraosaurus
Masiakasaurus
Xenotarsosaurus
Carnotuarus
Skoripovenator
"Dilophosaurus" sinesis
Crylophosaurus
Dilophosaurus
Sarcosaurus
Liliensternus
Syntarus
Coelophysis
Eodromaeus
Sanjuansaurus
Herrerasaurus
Eoraptor
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Supplementary Figure 2: Nodal reconstruction (Solid line) for relative H (A,B), FL (C,D) and HL(E, F) lengths using the measured taxon dataset and the *Epidexipteryx* as Avialae tree topology. Estimated expected lengths derived from linear regressions (broken lines) with corresponding error bounds (grey shaded region) using both the total specimens dataset (A, C, E) and adult theropod only dataset (B, D, F). Note the correspondence in lines in pre-Paravian taxa. The node Aves is denoted by a vertical line. Similar patterns occur if using the *Epidexipteryx* as Maniraptora or post *Archaeopteryx* bird topologies (results not shown but see values in Table 5).

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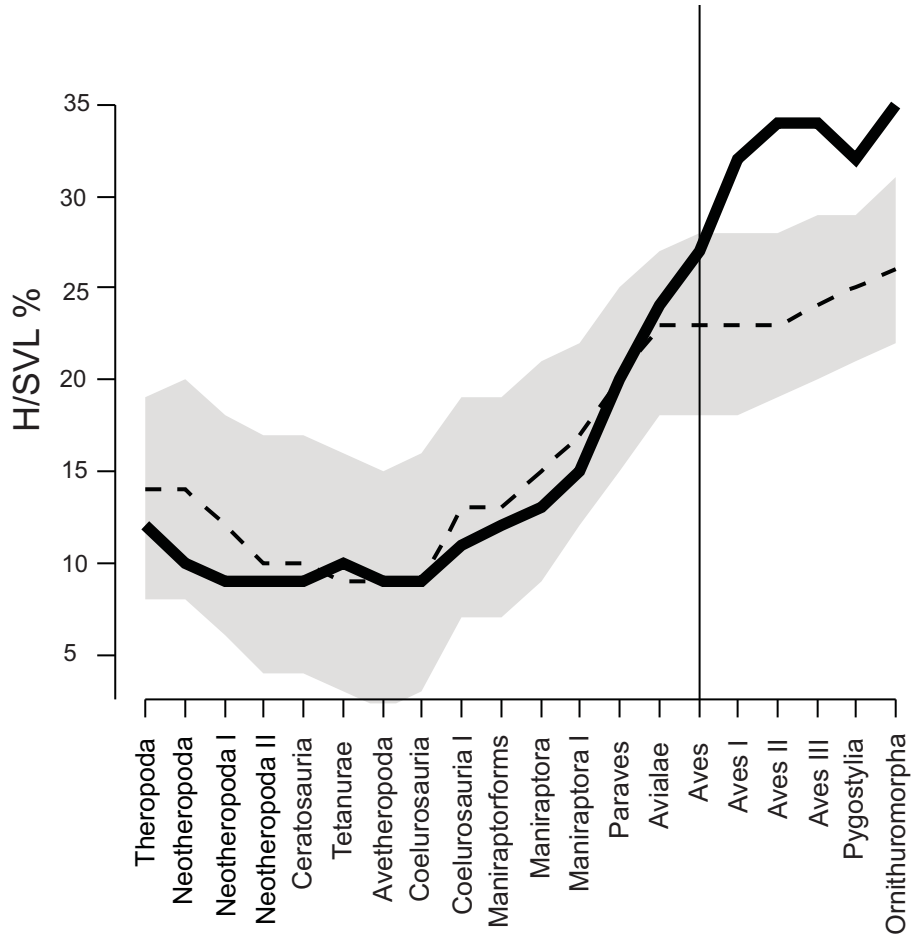
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Theropoda
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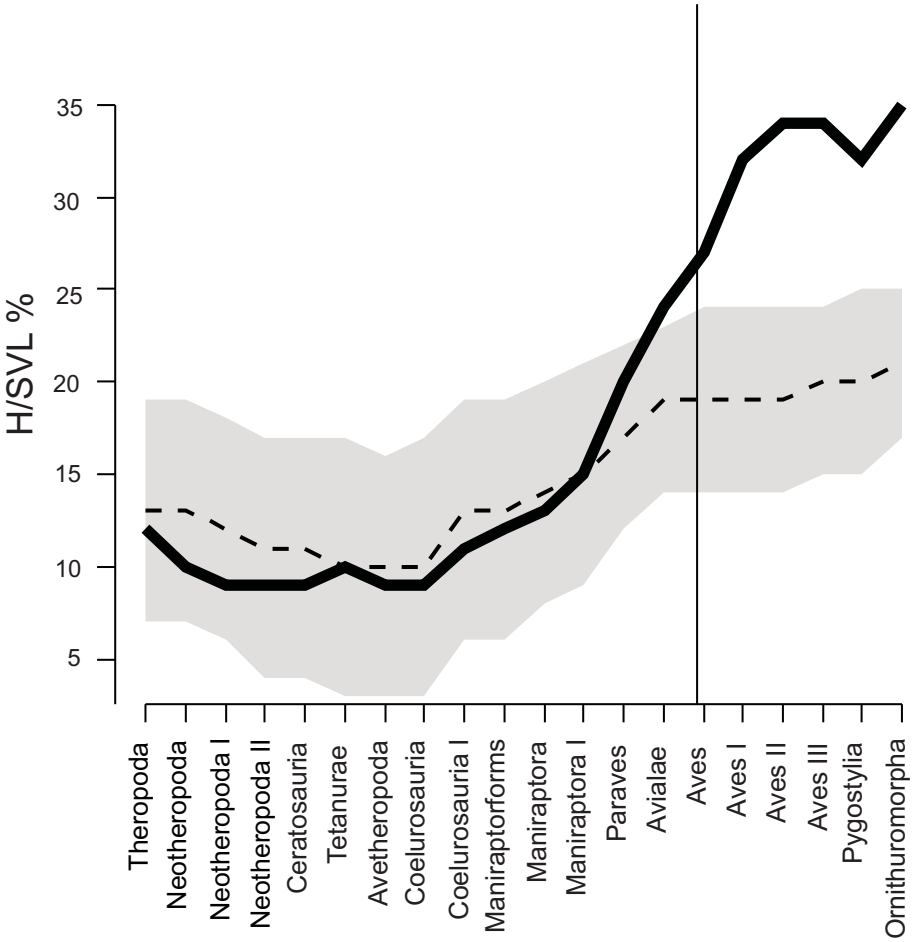
Neotheropoda II
Ceratosauria
Tetanurae
Avetheropoda
Coelurosauria
Coelurosauria I
Maniraptorforms
Maniraptora
Maniraptora I
Paraves
Avialae
Aves
Aves I
Aves II
Aves III
Pygostylia
Ornithuromorpha

B


H/SVL %
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Neotheropoda
Neotheropoda I
Neotheropoda II
Ceratosauria
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Avetheropoda
Coelurosauria
Coelurosauria I
Maniraptorforms
Maniraptora
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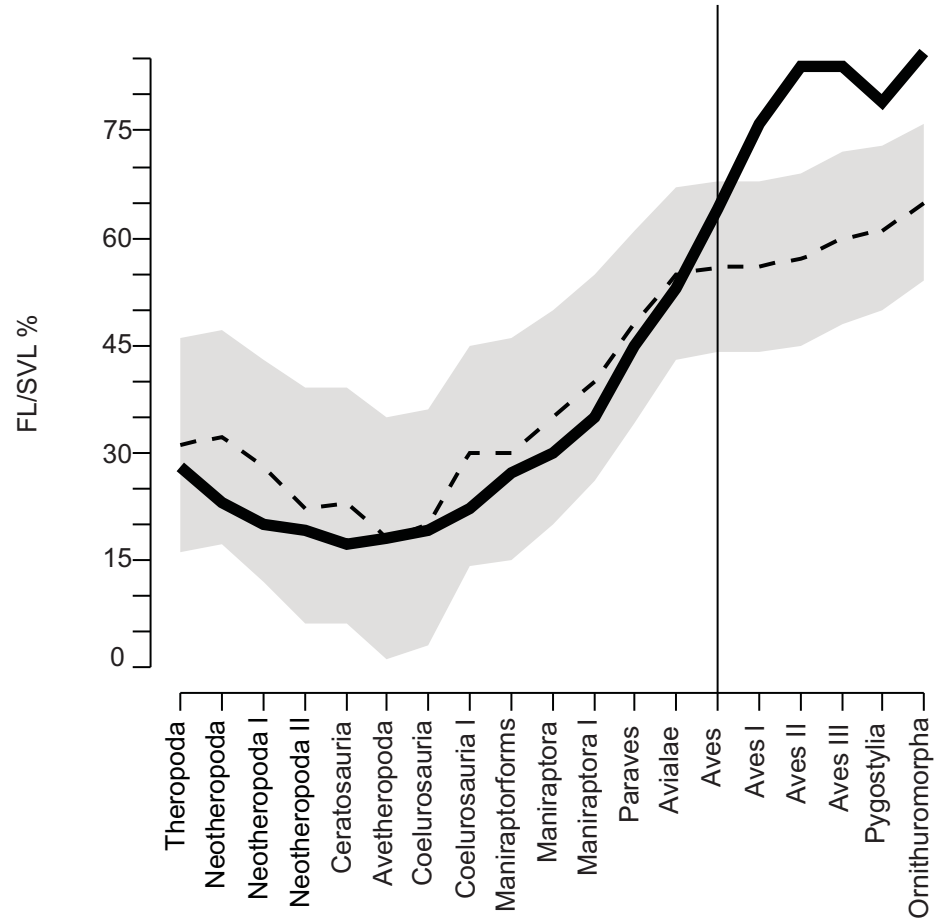
Paraves
Avialae
Aves
Aves I
Aves II
Aves III
Pygostylia
Ornithuromorpha

C


FL/SVL %
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Theropoda
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Neotheropoda II
Ceratosauria
Avetheropoda
Coelurosauria
Coelurosauria I
Maniraptorforms
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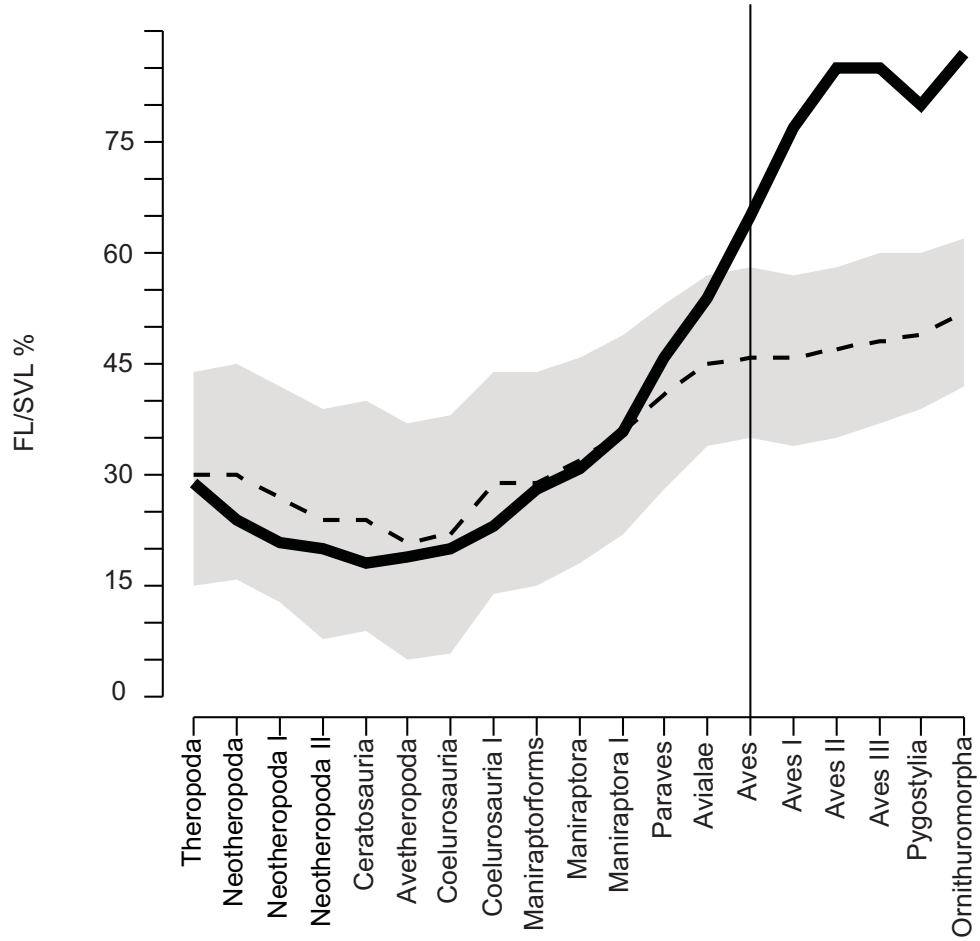
Paraves
Avialae
Aves
Aves I
Aves II
Aves III
Pygostylia
Ornithuromorpha

D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Ceratosauria
Avetheropoda
Coelurosauria
Coelurosauria I
Maniraptorforms
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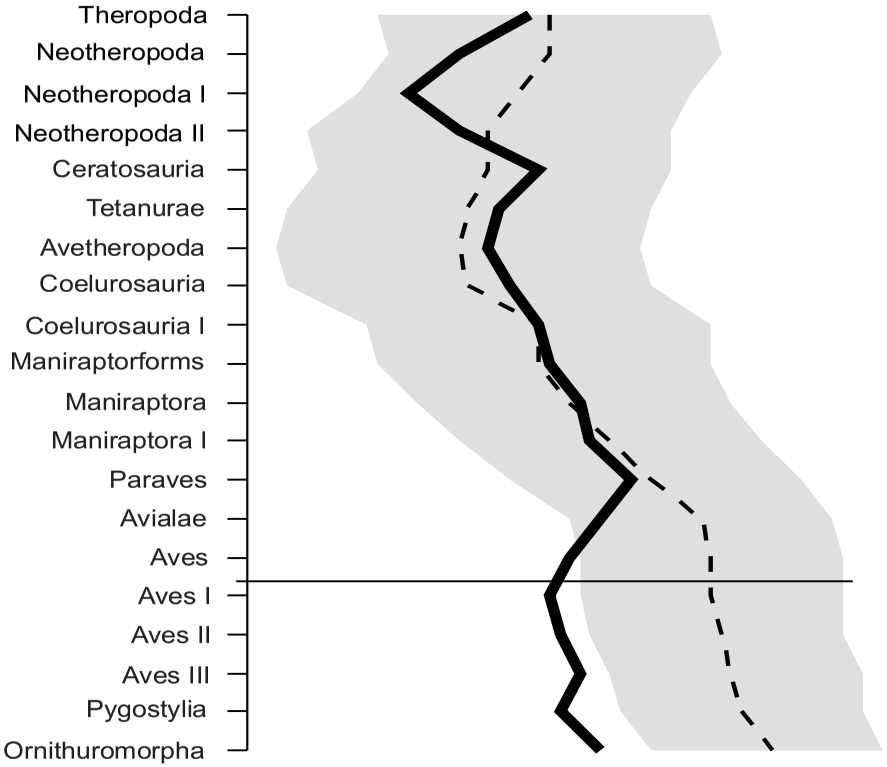
Paraves
Avialae
Aves
Aves I
Aves II
Aves III
Pygostylia
Ornithuromorpha

F


HL/SVL %
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Ceratosauria
Tetanurae
Avetheropoda
Coelurosauria
Coelurosauria I
Maniraptorforms
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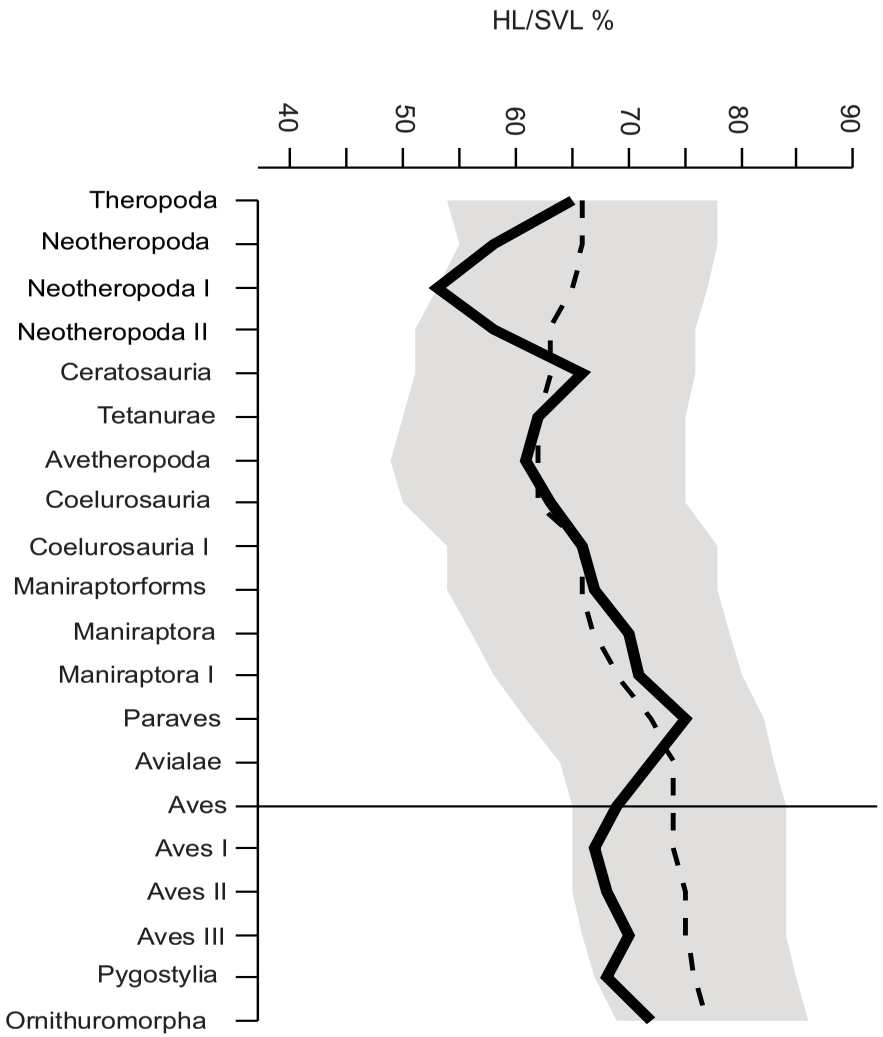
Paraves
Avialae
Aves
Aves I
Aves II
Aves III
Pygostylia
Ornithuromorpha

E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Avetheropoda
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Coelurosauria I
Maniraptorforms
Maniraptora
Maniraptora I
Paraves
Avialae
Aves
Aves I
Aves II
Aves III
Pygostylia
Ornithuromorpha

Supplementary Figure 3: Nodal reconstruction (Solid line) for relative H (A,B), FL (C,D) and HL(E, F) lengths using the larger taxon dataset and the *Epidexipteryx* as Avialae tree topology. Estimated expected lengths derived from linear regressions (broken lines) with corresponding error bounds (grey shaded region) using both the total specimens dataset (A, C, E) and adult theropod only dataset (B, D, F). Note the correspondence in lines in pre-Paravian taxa. The node Aves is denoted by a vertical line. Similar patterns occur if using the *Epidexipteryx* as Maniraptora or post *Archaeopteryx* bird topologies (results not shown but see values in Table 5).

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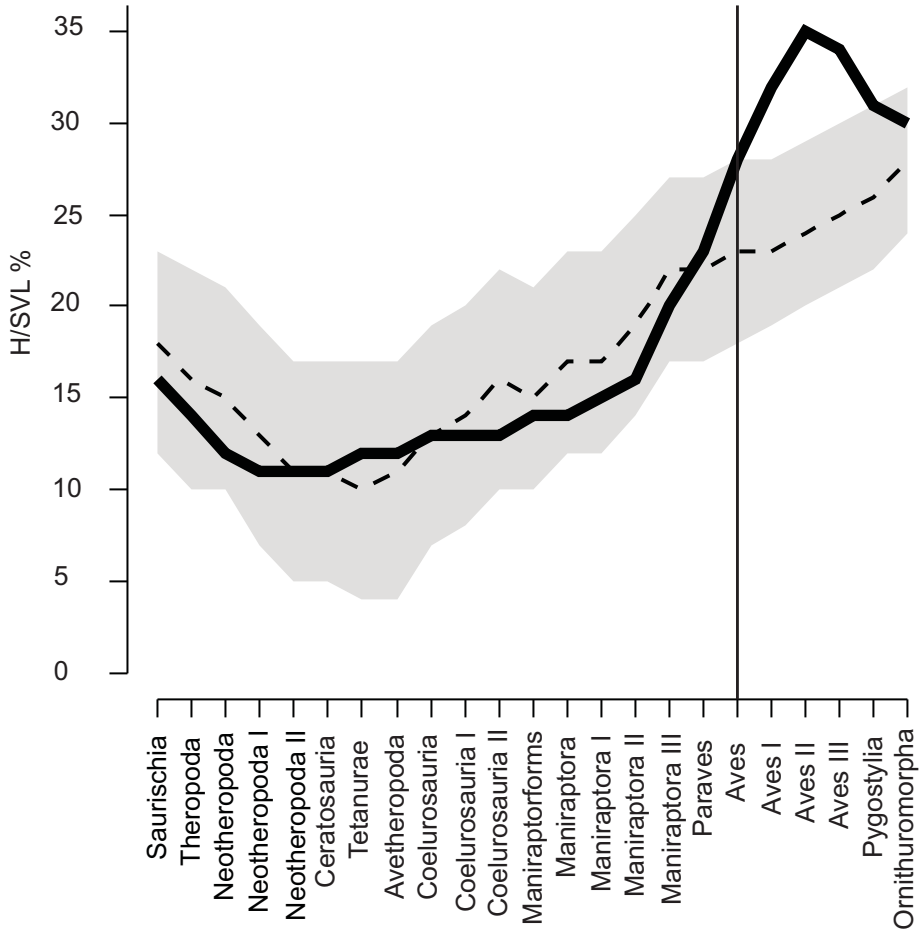
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Tetanurae
Avetheropoda
Coelurosauria
Coelurosauria I
Coelurosauria II
Maniraptorforms
Maniraptora
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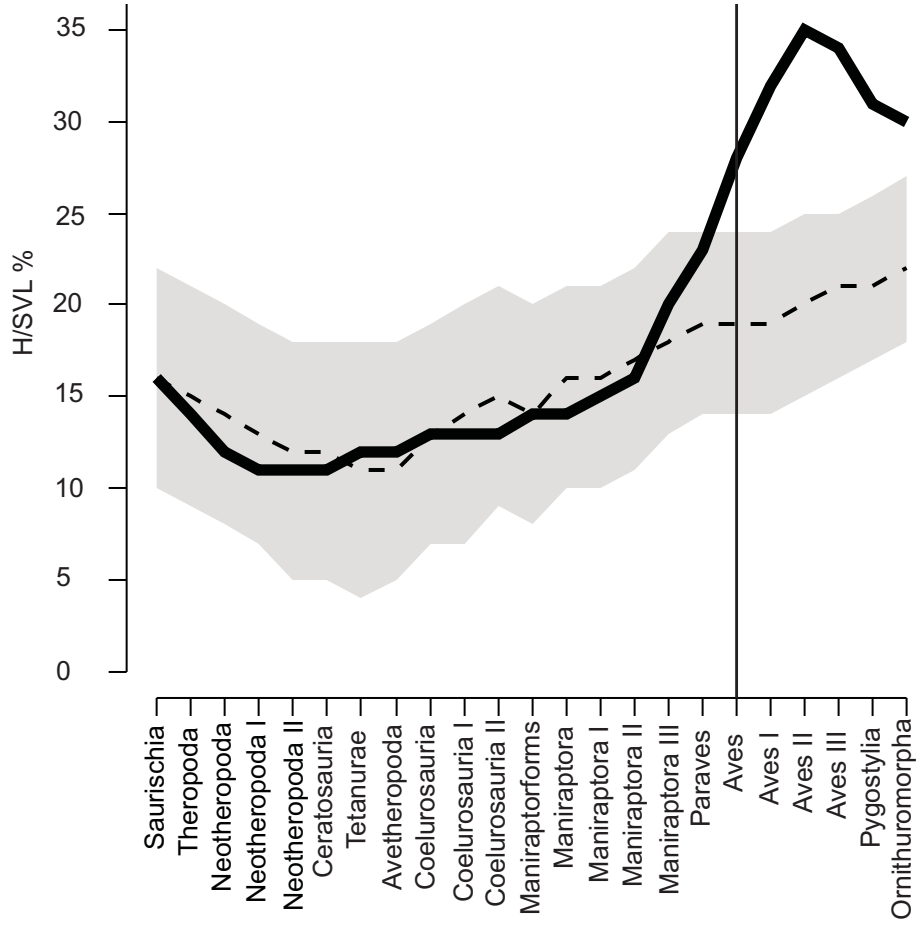
Paraves
Aves
Aves I
Aves II
Aves III
Pygostylia
Ornithuromorpha

B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Ceratosauria
Tetanurae
Avetheropoda
Coelurosauria
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Coelurosauria II
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Maniraptora I
Maniraptora II
Maniraptora III
Paraves
Aves
Aves I
Aves II
Aves III
Pygostylia
Ornithuromorpha

C

FL/SVL %
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Saurischia
Theropoda
Neotheropoda
Neotheropoda I
Neotheropoda II
Ceratosauria
Tetanurae
Avetheropoda
Coelurosauria
Coelurosauria I
Coelurosauria II
Maniraptorforms
Maniraptora
Maniraptora I
Maniraptora II
Maniraptora III
Paraves
Avialae
Aves
Aves I
Aves II
Aves III
Pygostylia
Ornithuromorpha

D

FL/SVL %
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Saurischia
Theropoda
Neotheropoda
Neotheropoda I
Neotheropoda II
Ceratosauria
Tetanurae
Avetheropoda
Coelurosauria
Coelurosauria I
Coelurosauria II
Maniraptorforms
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Maniraptora I
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Avialae
Aves
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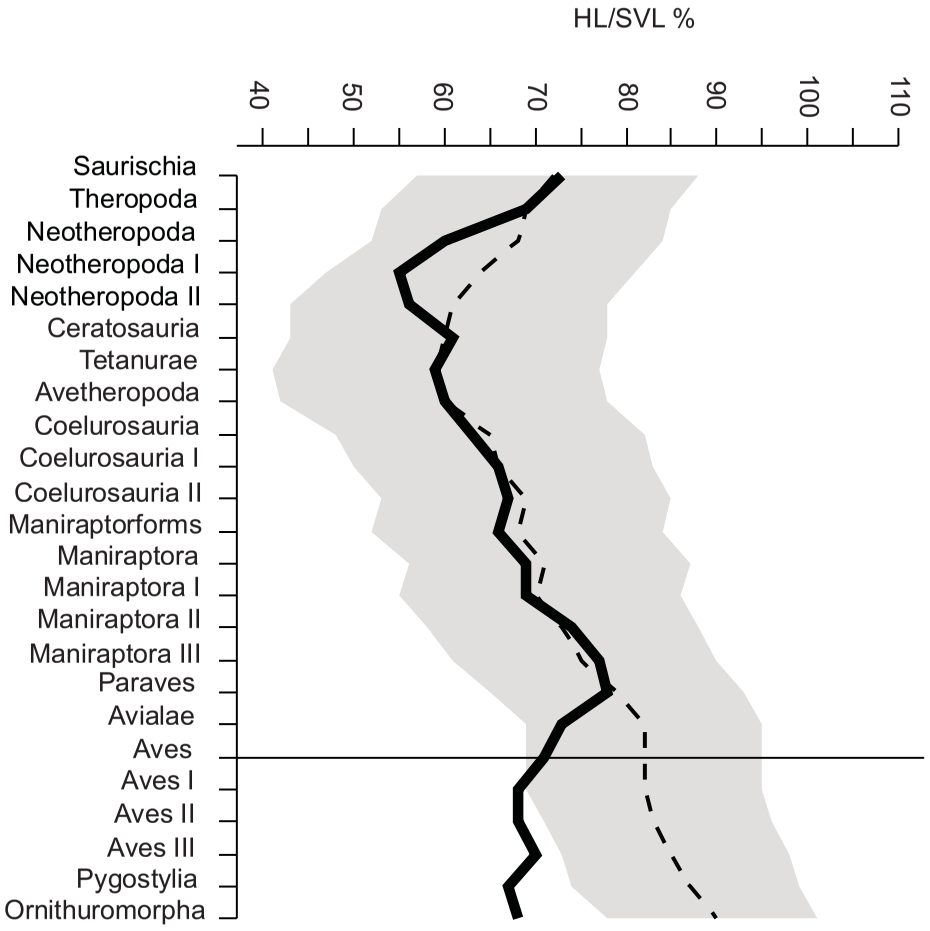
Aves II
Aves III
Pygostylia
Ornithuromorpha

F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Ceratosauria
Tetanurae
Avetheropoda
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Coelurosauria I
Coelurosauria II
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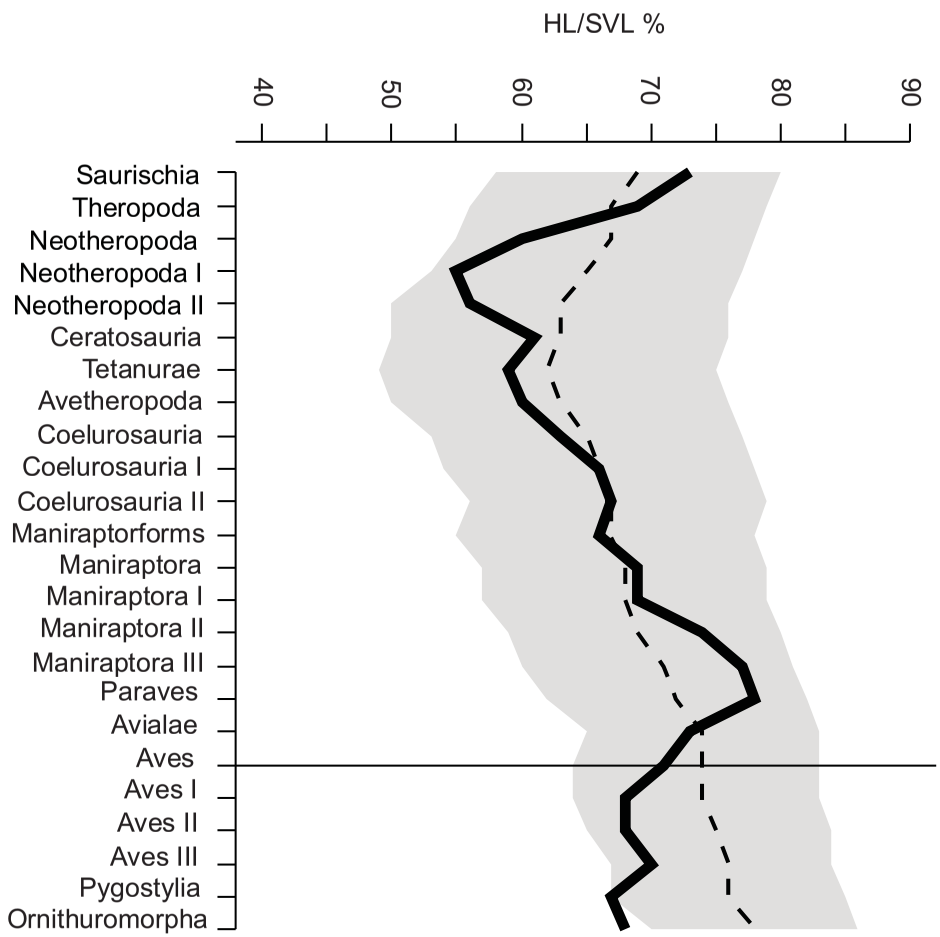
Ornithuromorpha

E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Maniraptora II
Maniraptora III
Paraves
Avialae
Aves
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Aves II
Aves III
Pygostylia
Ornithuromorpha

Supplementary Figure 4: Nodal reconstruction (Solid line) for relative H (A,B), FL (C,D) and HL(E, F) lengths using the Xu et al. 2009 topology with unequal branch length. Estimated expected lengths derived from linear regressions (broken lines) with corresponding error bounds (grey shaded region) using both the total specimens dataset (A, C, E) and adult theropod only dataset (B, D, F). Note the correspondence in lines in pre-Paravian taxa. The node Aves is denoted by a vertical line.

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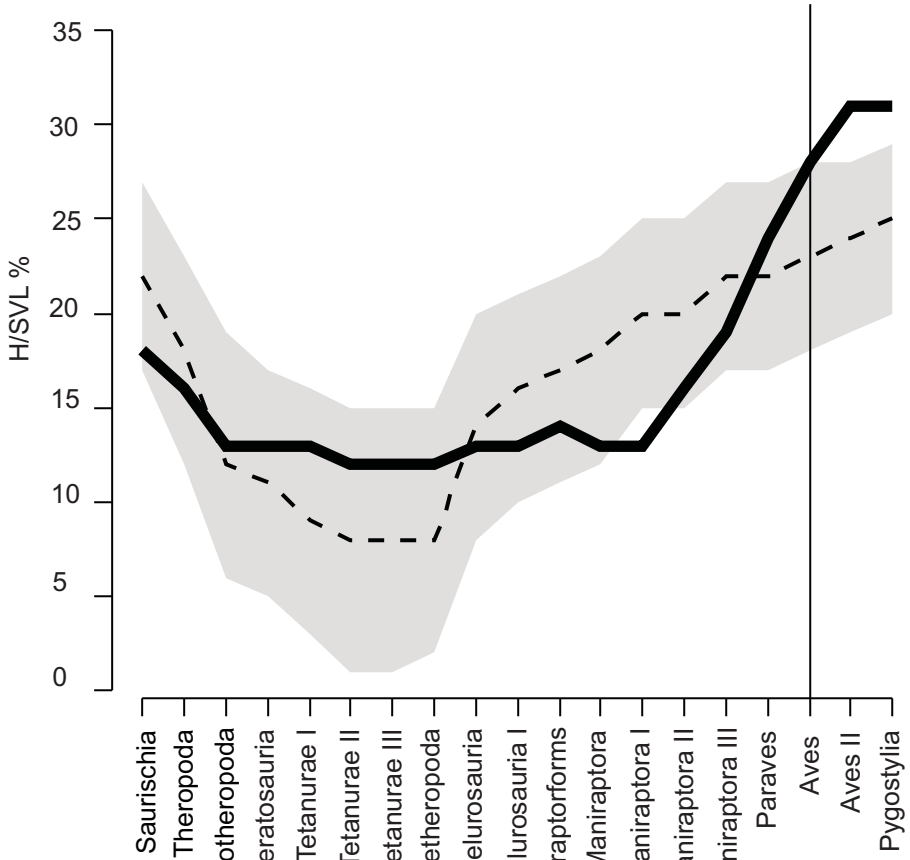
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Coelurosauria I
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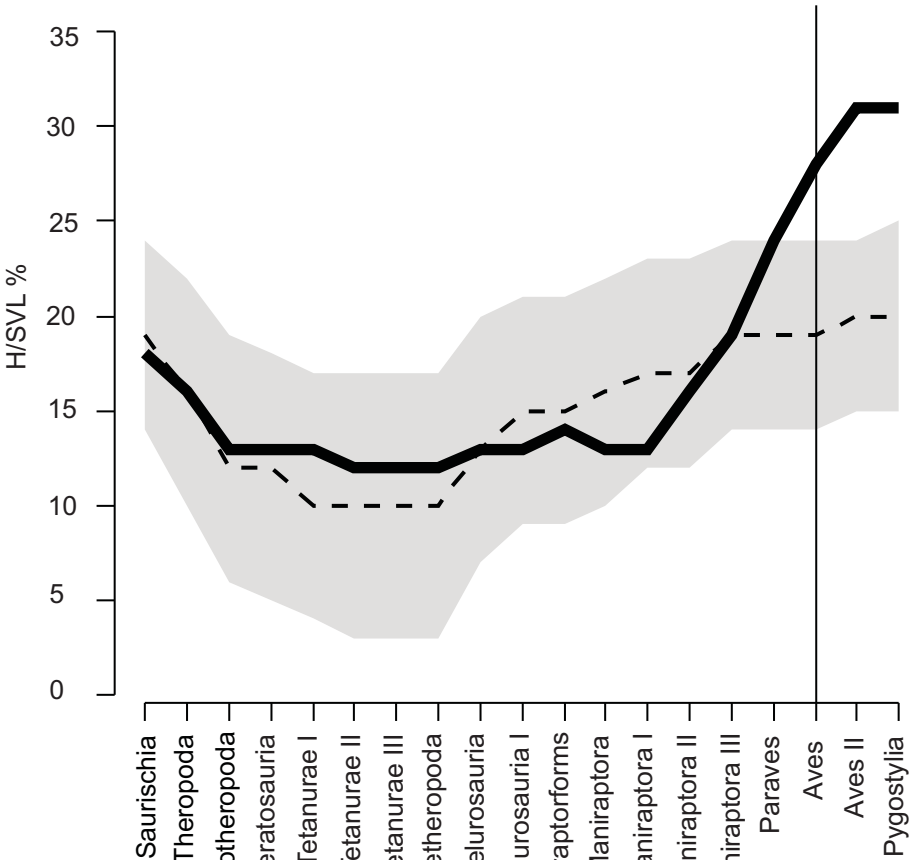
Maniraptora II
Maniraptora III
Paraves
Aves
Aves II
Pygostylia

B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Ceratosauria
Tetanurae I
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Tetanurae III
Avetheropoda
Coelurosauria
Coelurosauria I
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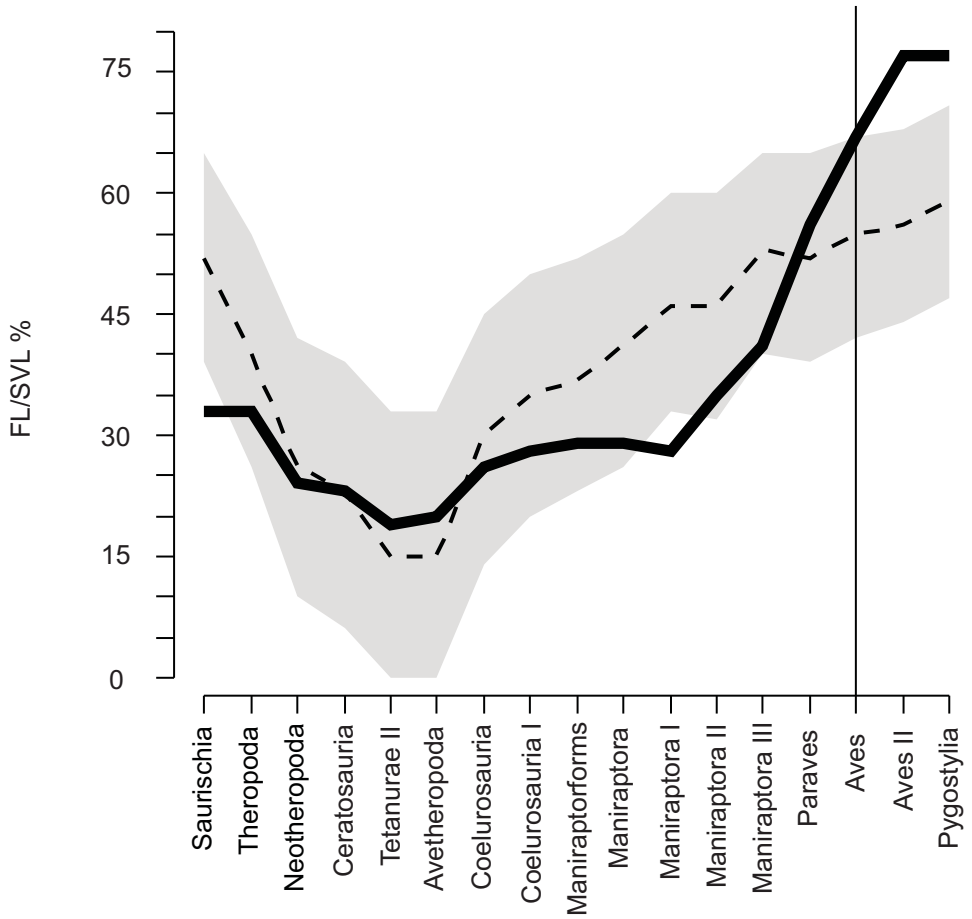
Maniraptora III
Paraves
Aves
Aves II
Pygostylia

C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Coelurosauria
Coelurosauria I
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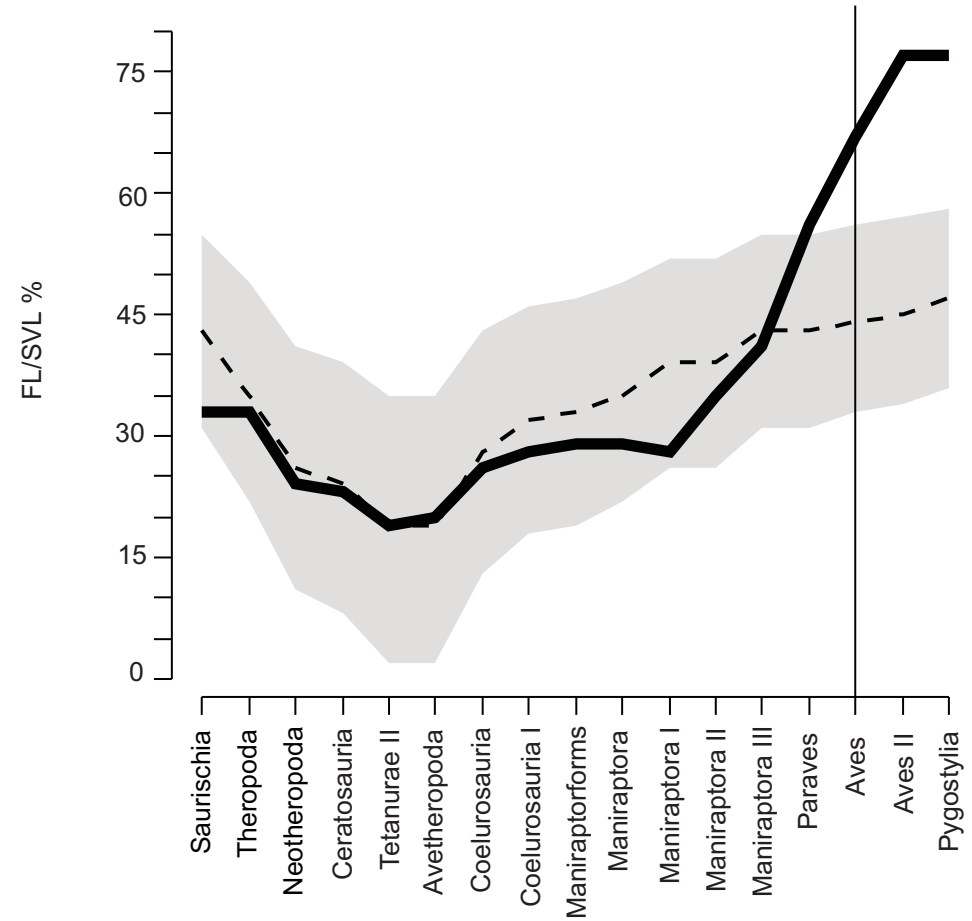
Maniraptora III
Paraves
Aves
Aves II
Pygostylia

D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Coelurosauria
Coelurosauria I
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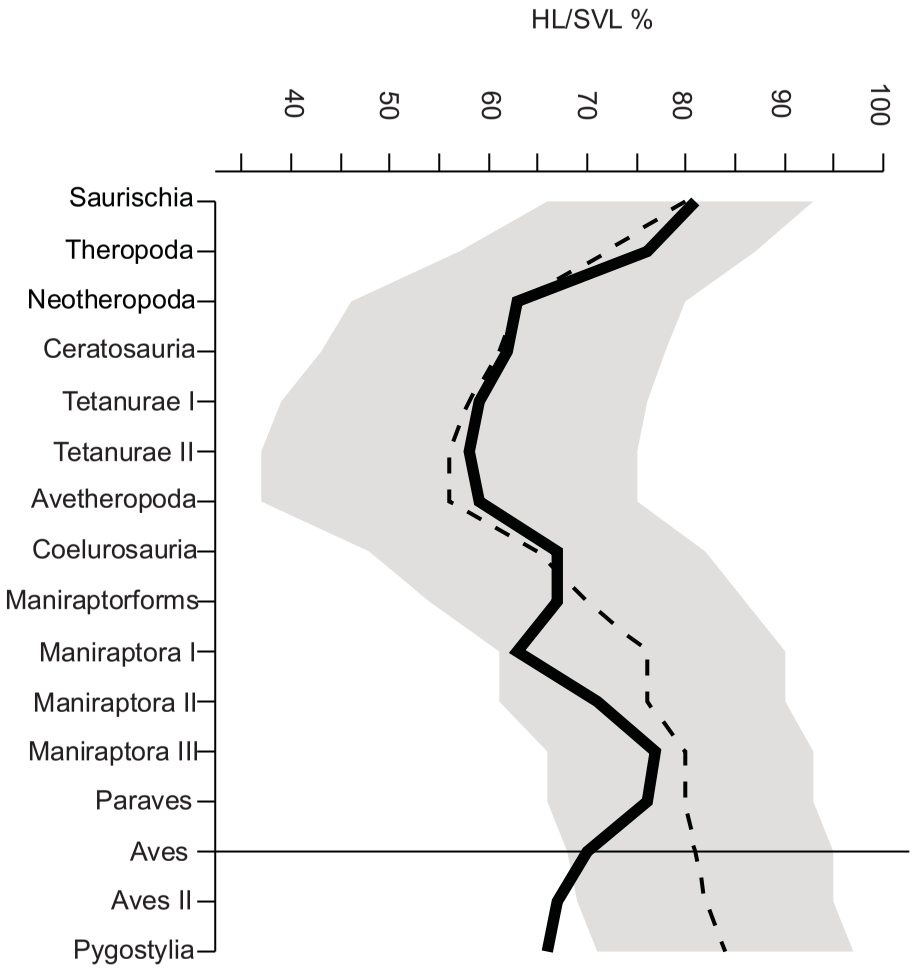
Maniraptora I
Maniraptora II
Maniraptora III
Paraves
Aves
Aves II
Pygostylia

F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Tetanurae II
Avetheropoda
Coelurosauria
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Maniraptora II
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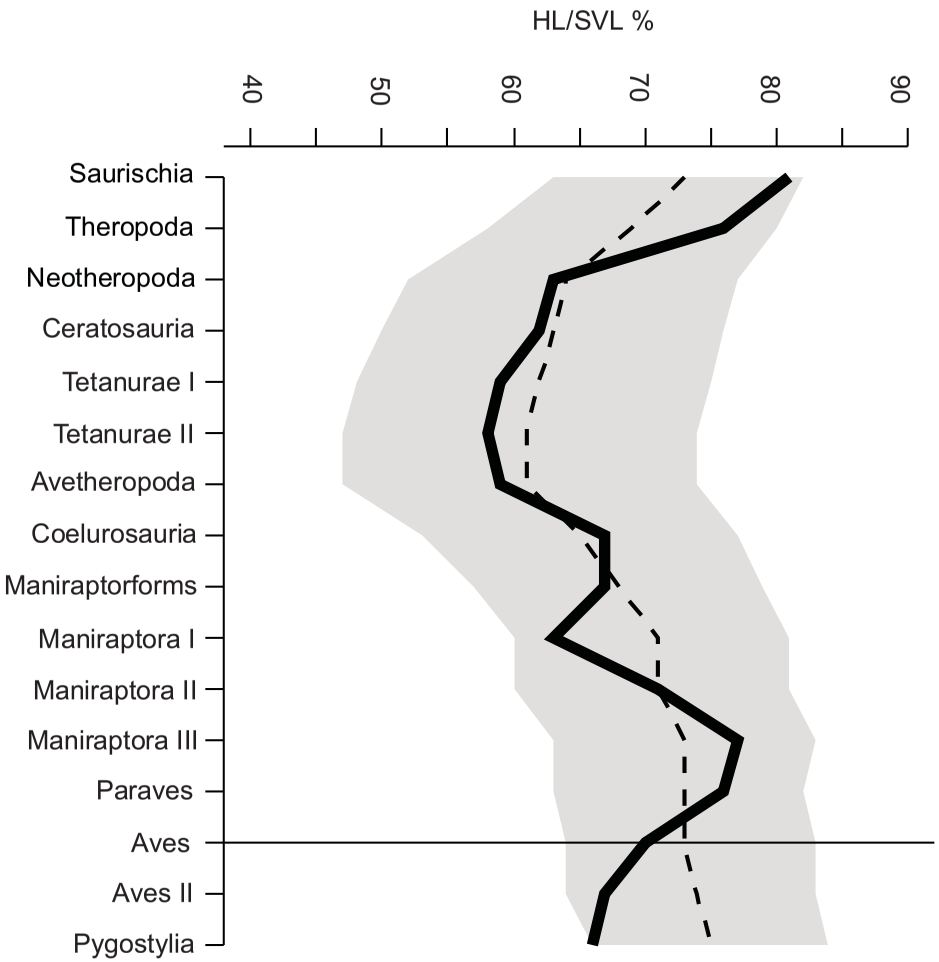
Paraves
Aves
Aves II
Pygostylia

E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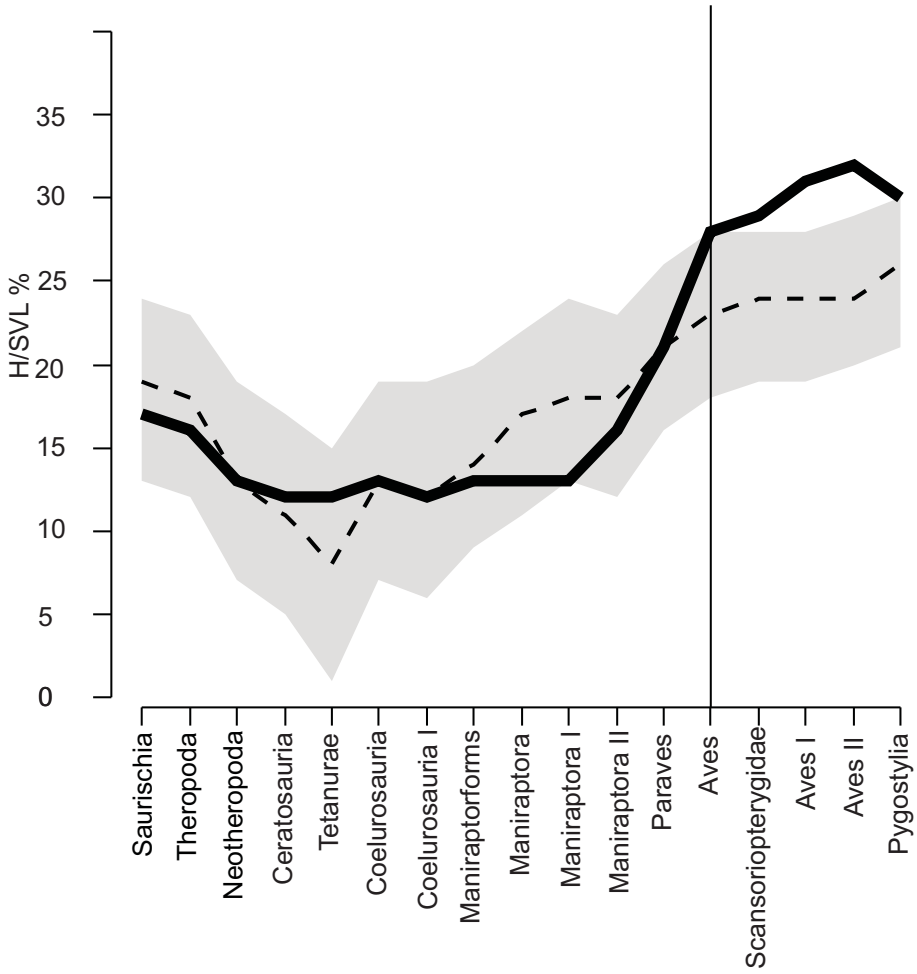
Avetheropoda
Coelurosauria
Maniraptorforms
Maniraptora I
Maniraptora II
Maniraptora III
Paraves
Aves
Aves II
Pygostylia

Supplementary Figure 5: Nodal reconstruction (Solid line) for relative H (A,B), FL (C,D) and HL(E, F) lengths using the Choiniere et al. 2010 topology with unequal branch length. Estimated expected lengths derived from linear regressions (broken lines) with corresponding error bounds (grey shaded region) using both the total specimens dataset (A, C, E) and adult theropod only dataset (B, D, F). Note the correspondence in lines in pre-Paravian taxa. The node Aves is denoted by a vertical line.

A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Theropoda
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Coelurosauria
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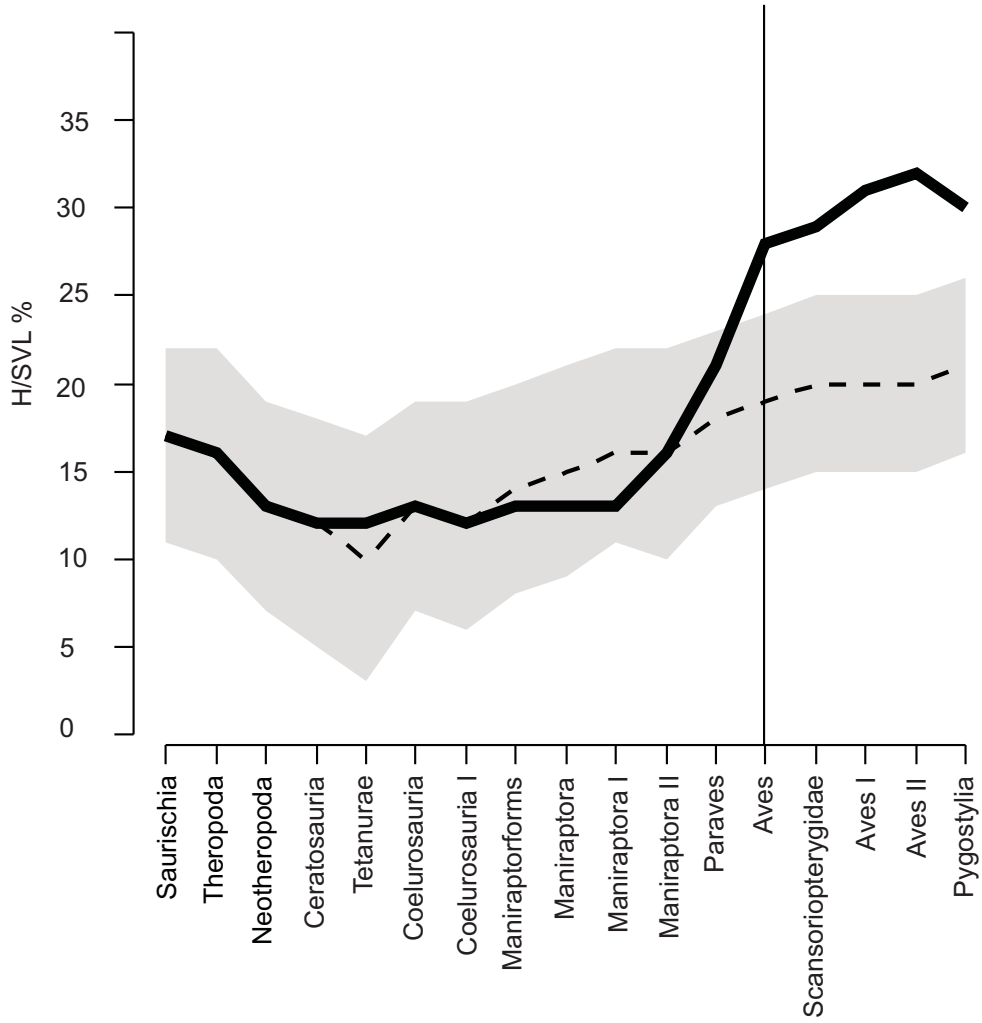
Maniraptorforms
Maniraptora
Maniraptora I
Maniraptora II
Paraves
Aves
Scansoriopterygidae
Aves I
Aves II
Pygostylia

B


H/SVL %
0
5
10
15
20
25
30
35
Saurischia
Theropoda
Neotheropoda
Ceratosauria
Tetanurae
Coelurosauria
Coelurosauria I
Maniraptorforms
Maniraptora
Maniraptora I
Maniraptora II
Paraves
Aves
Scansoriopterygidae
Aves I
Aves II
Pygostylia

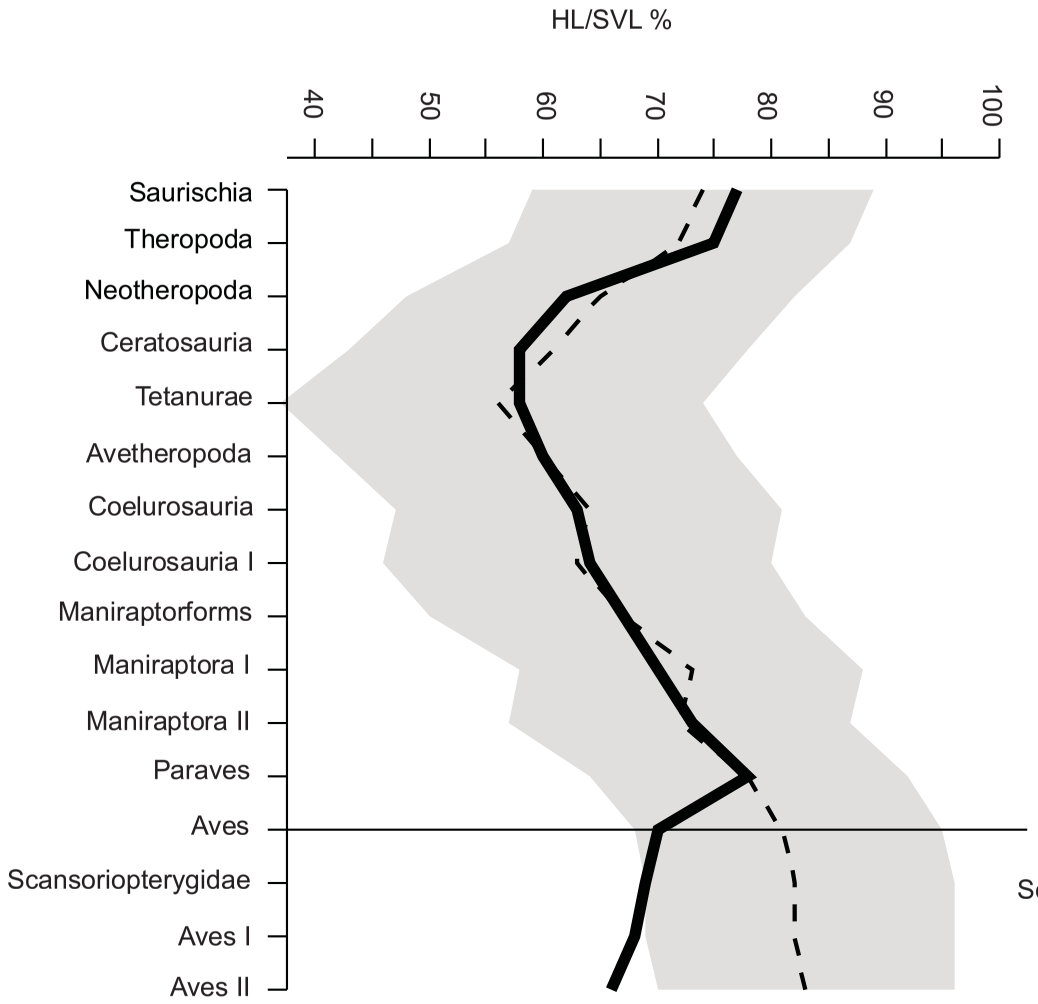
C

FL/SVL %
0
15
30
45
60
75
Saurischia
Theropoda
Neotheropoda
Ceratosauria
Tetanurae
Coelurosauria
Coelurosauria I
Maniraptorforms
Maniraptora
Maniraptora I
Maniraptora II
Paraves
Aves
Scansoriopterygidae
Aves I
Aves II

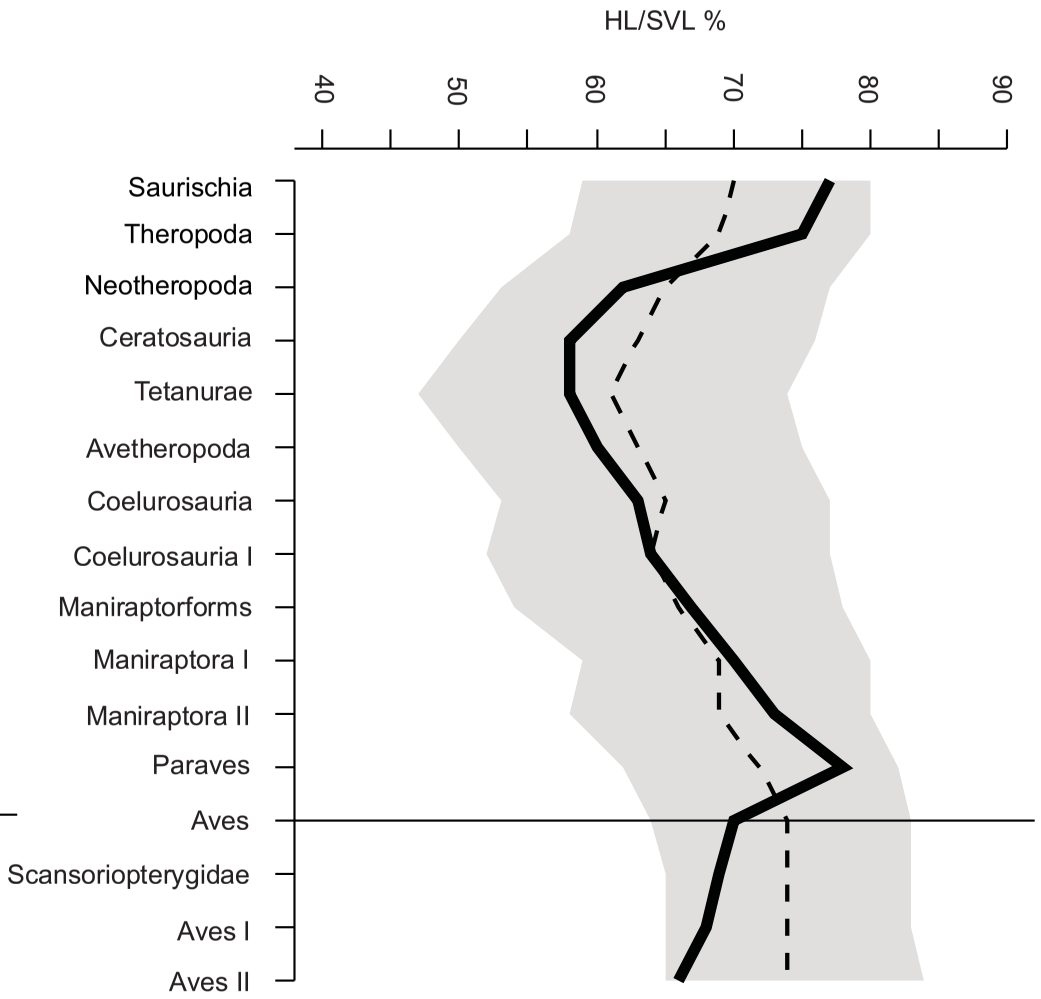
D

FL/SVL %
0
15
30
45
60
75
Saurischia
Theropoda
Neotheropoda
Ceratosauria
Tetanurae
Coelurosauria
Coelurosauria I
Maniraptorforms
Maniraptora
Maniraptora I
Maniraptora II
Paraves
Aves
Scansoriopterygidae
Aves I
Aves II

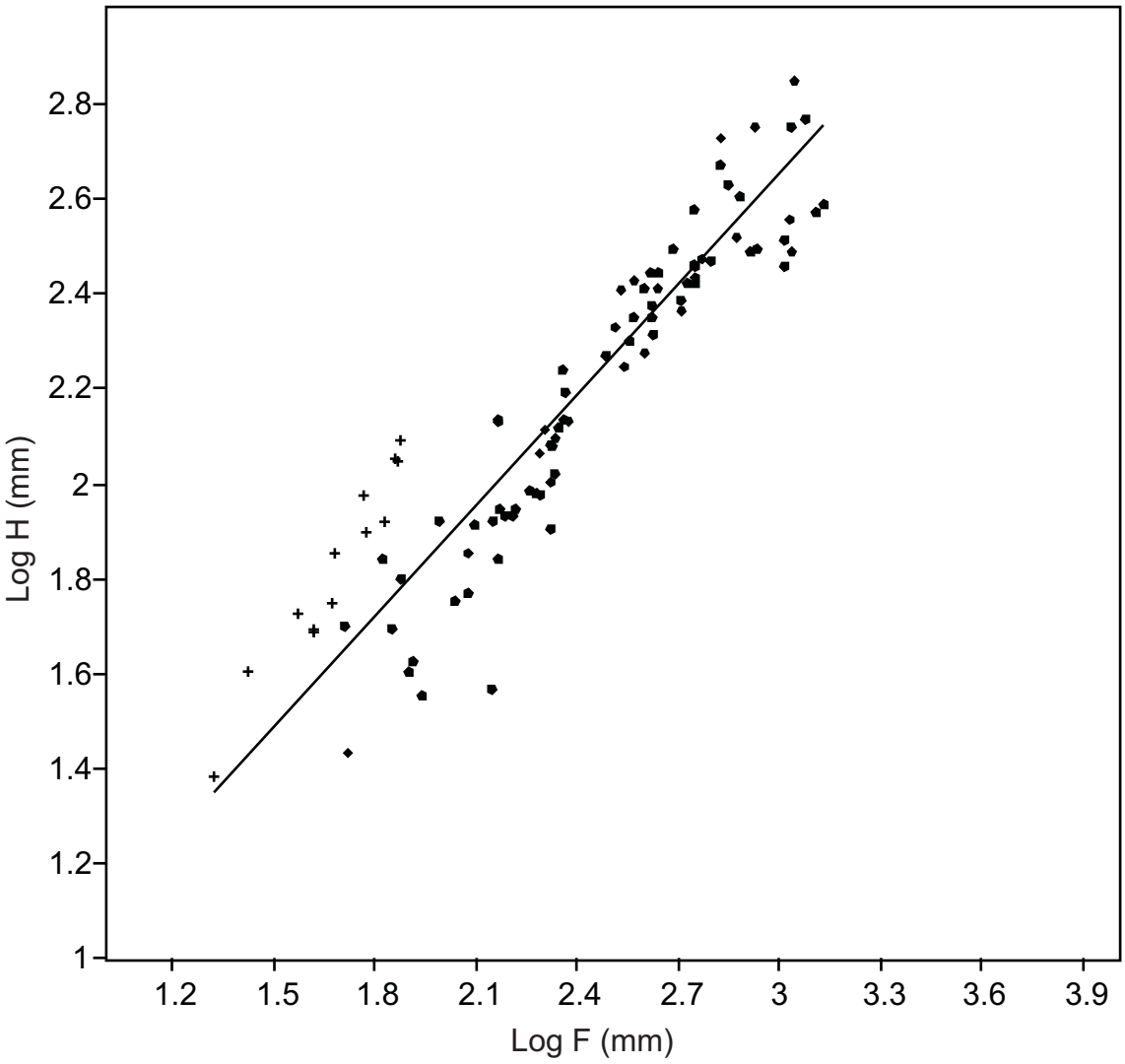
F


HL/SVL %
40
50
60
70
80
90
100
Saurischia
Theropoda
Neotheropoda
Ceratosauria
Tetanurae
Avetheropoda
Coelurosauria
Coelurosauria I
Maniraptorforms
Maniraptora I
Maniraptora II
Paraves
Aves
Scansoriopterygidae
Aves I
Aves II

E

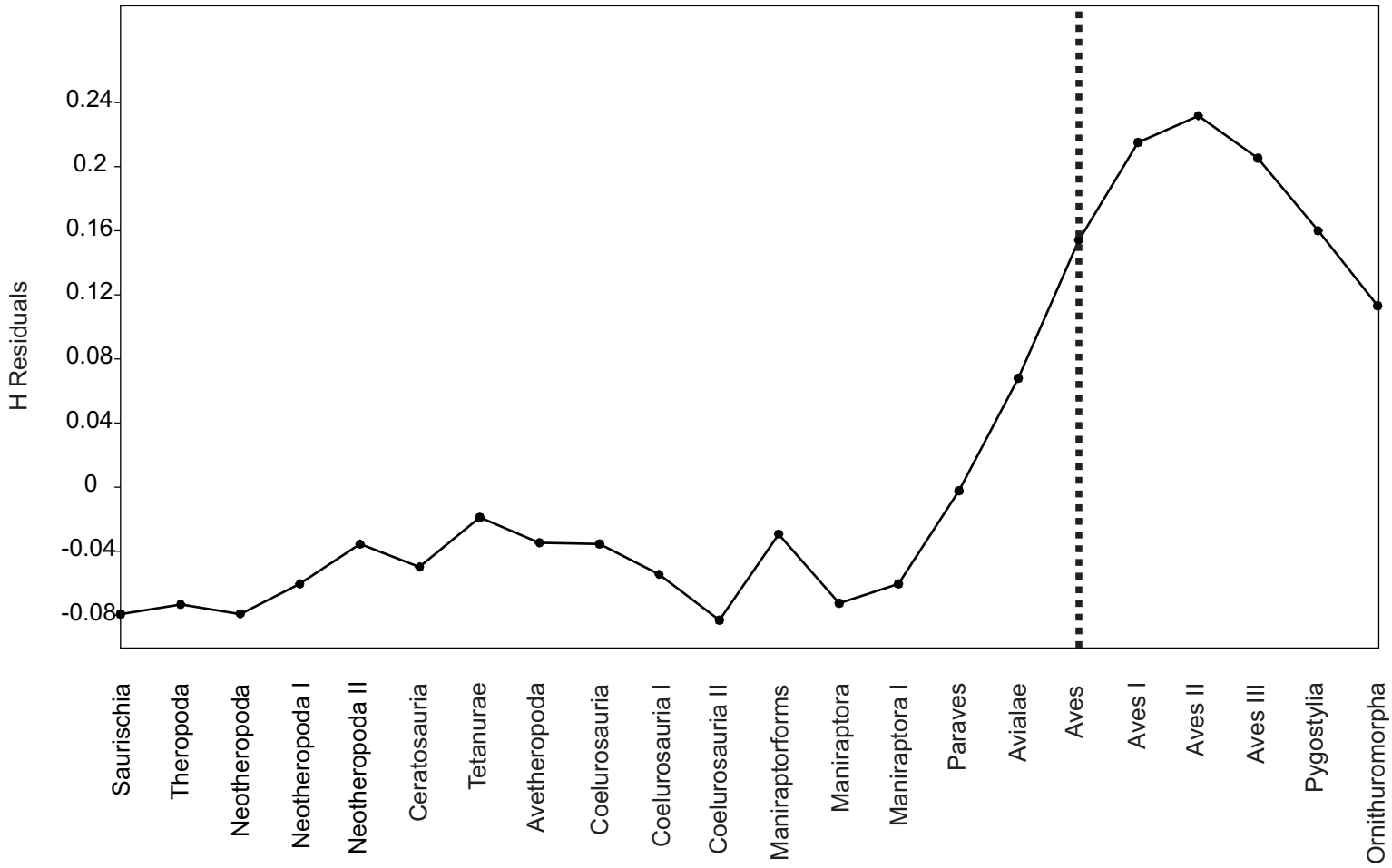

HL/SVL %
40
50
60
70
80
90
Saurischia
Theropoda
Neotheropoda
Ceratosauria
Tetanurae
Avetheropoda
Coelurosauria
Coelurosauria I
Maniraptorforms
Maniraptora I
Maniraptora II
Paraves
Aves
Scansoriopterygidae
Aves I
Aves II

Supplementary Figure 6: Log-log RMA regression of humeral versus femoral for avian and non avian theropods in Table 6.

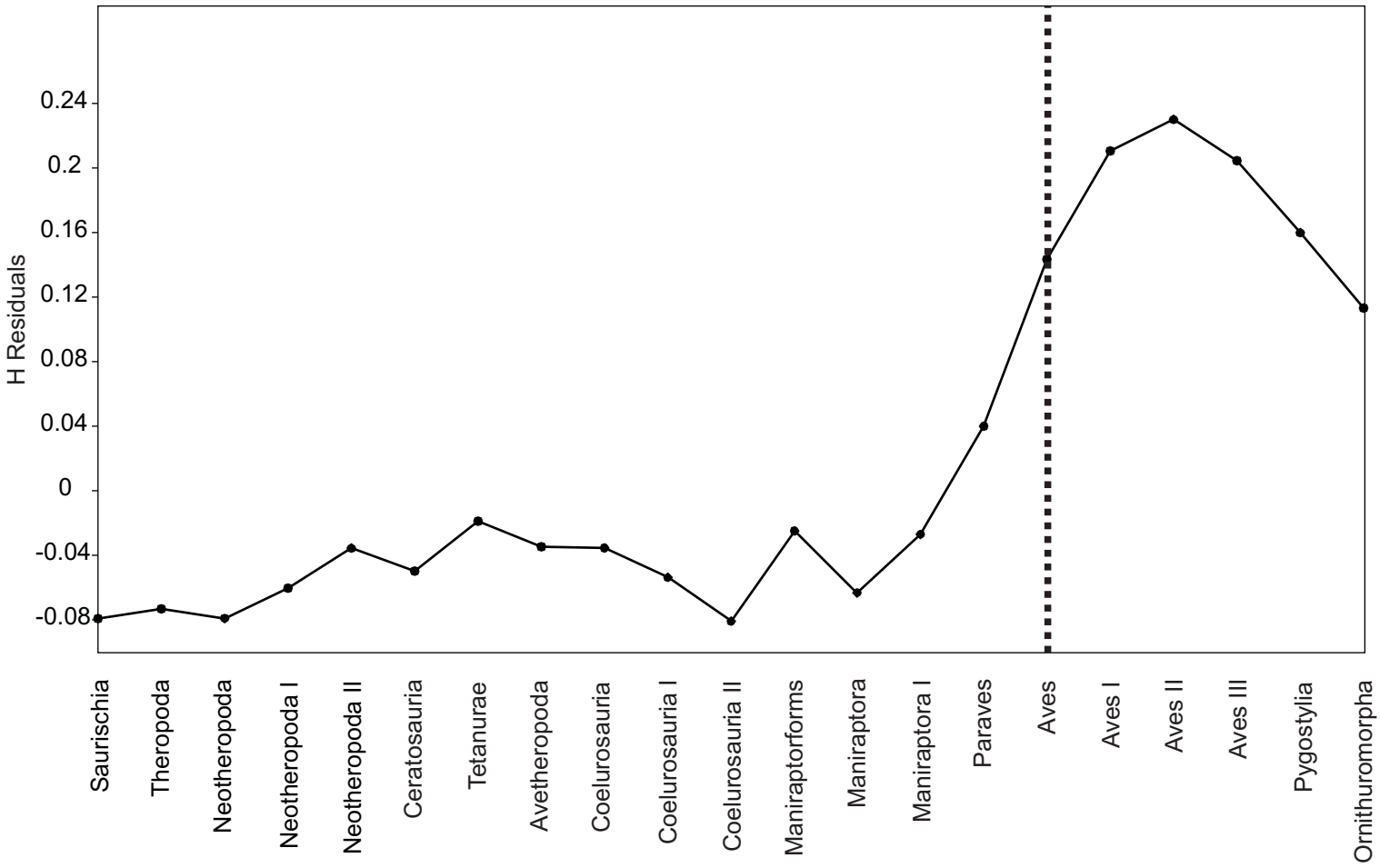


Supplementary Figure 7: Nodal reconstruction for humeral residuals from Figure 6 (See table 6). The node Aves denoted by vertical dashed line. A) Scansoriopterygidae as Avialae B) Scansoriopterygidae as Maniraptorans C) Scansoriopterygidae as Avialae and compsognathids as Maniraptorans.

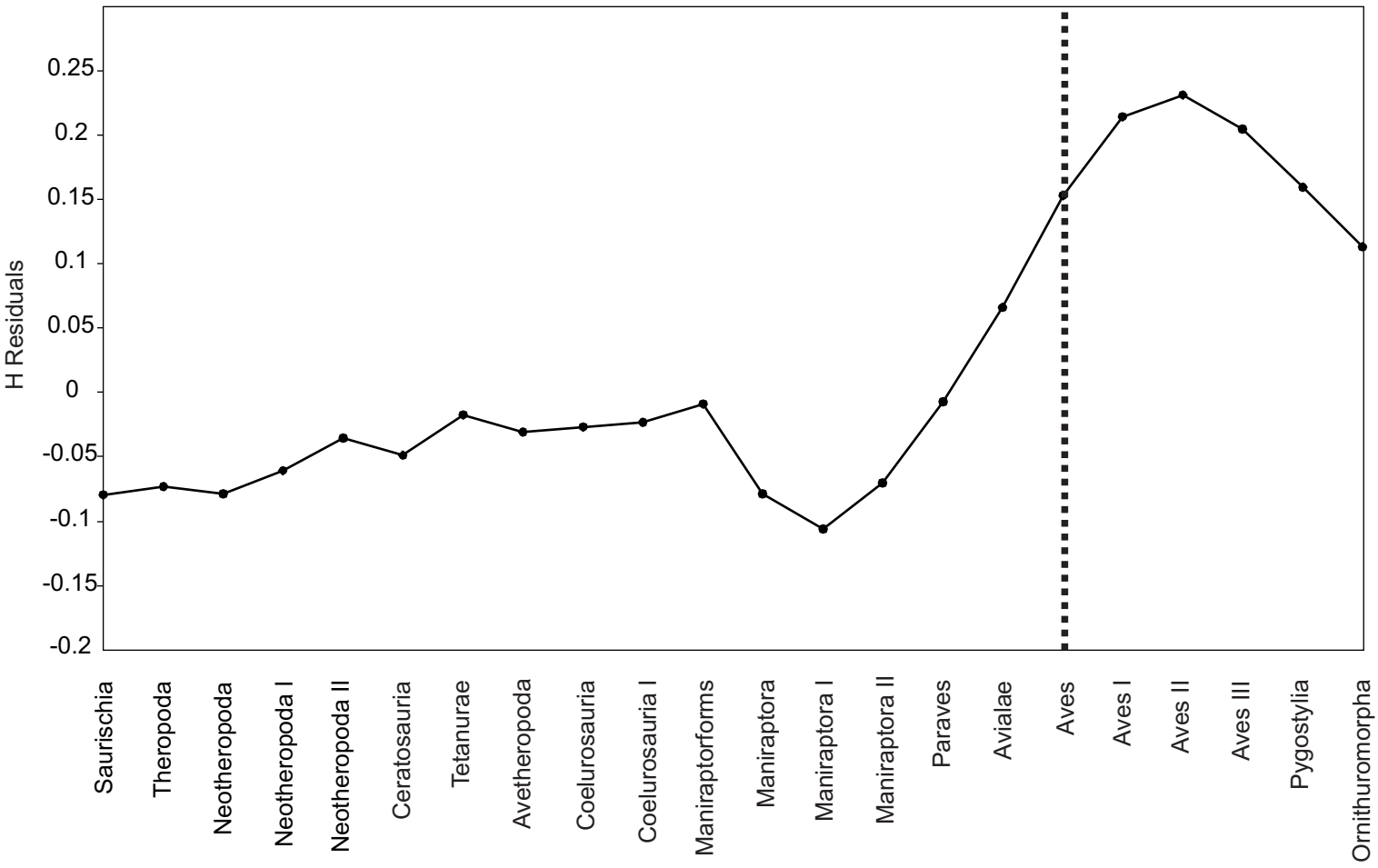
A



B


H Residuals
0.24
0.2
0.16
0.12
0.08
0.04
0
-0.04
-0.08
Saurischia
Theropoda
Neotheropoda
Neotheropoda I
Neotheropoda II
Ceratosauria
Tetanurae
Avetheropoda
Coelurosauria
Coelurosauria I
Coelurosauria II
Maniraptorforms
Maniraptora
Maniraptora I
Paraves
Aves
Aves I
Aves II
Aves III
Pygostylia
Ornithuromorpha

C


H Residuals
0.25
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
Saurischia
Theropoda
Neotheropoda
Neotheropoda I
Neotheropoda II
Ceratosauria
Tetanurae
Avetheropoda
Coelurosauria
Coelurosauria I
Maniraptorforms
Maniraptora
Maniraptora I
Maniraptora II
Paraves
Avialae
Aves
Aves I
Aves II
Aves III
Pygostylia
Ornithuromorpha