

# Supplement

## Histological measurements

**Table S1** Histological measurements for the predictor variable of primary osteon density in extant species. To obtain these values, we reanalyzed sections from Cubo et al. (2012) and Legendre et al. (2016). The measuring approach is explained in the main text. C = Cubo et al. (2012), L = Legendre et al. (2016), CL = Cubo et al. (2012) and Legendre et al. (2016).

	Primary osteon (vascular) density	Previously used in
<i>Anas platyrhynchos</i>	38.3615	CL
<i>Cavia porcellus</i>	25.4434	CL
<i>Chelodina siebenrocki</i>	0	CL
<i>Crocodylus niloticus</i>	15.3459	CL
<i>Varanus exanthematicus</i>	7.6233	CL
<i>Gallus gallus</i>	39.2857	L
<i>Microcebus murinus</i>	10.9231	CL
<i>Podarcis muralis</i>	0	CL
<i>Mus musculus</i>	8.0986	CL
<i>Varanus niloticus</i>	0	CL
<i>Pelodiscus sinensis</i>	0	CL
<i>Pleurodeles walti</i>	0	L
<i>Trachemys scripta</i>	0	CL
<i>Zootoca vivipara</i>	0	L
<i>Dromaius novaehollandiae</i>	58.2051	C
<i>Lacerta vivipara</i>	0	C
<i>Streptopelia decaocto</i>	62.7300	C
<i>Struthio camelus</i>	63.1929	C
<i>Turdus merula</i>	63.5380	C

**Table S2** Histological measurements for the predictor variable of primary osteon density in fossil eosauropterygians. The measuring approach is explained in the main text.

	Specimen number	Primary osteon (vascular) density
<i>Anarosaurus heterodontus</i>	Wijk. 06-38fe	29.1428
<i>Neusticosaurus edwardsii</i>	PIMUZ T3455	20.7594
<i>Nothosaurus</i> sp.	IGWH 21	20.4726
<i>Pistosaurus longaeus</i>	SMNS 84825	44.1756
<i>Plesiosaurus dolichodirus</i>	STIPB R90	61.2496
<i>Rhaeticosaurus mertensi</i>	LWL MfN P 64047, PM3	65.4465
<i>Cryptoclidus eurymerus</i>	STIPB R324	40.5865
Elasmosauridae indet.	OMNH MV 85	61.6824

## Mass-specific resting metabolic rate

**Table S3** R statistics of the model to predict resting metabolic rate. *t value* refers to the t-rest of the respective line in the table.  $Pr(> |t|)$  is the p value for the t-test. V6, V12, V4 and V5 are the selected vectors of the model.

	Estimate	Std. Error	t value	$Pr(>  t )$
Intercept	-2.60140	0.10986	-23.679	1.08e-08
Vascular density	1.25973	0.05662	22.250	1.76e-08
V6	-2.19179	0.28100	-7.800	5.24e-05
V12	1.85050	0.28680	6.452	0.000198
V4	1.12452	0.29526	3.809	0.005173
V5	-0.88714	0.28021	-3.166	0.013276

The multiple R-squared value of the model for metabolic rate is 0.9851, the adjusted R-squared value is 0.9758.

The F statistic of the overall analysis is 106 on 5 and 8 DF (degrees of freedom) with a p-value of 4.33e-07.

The AICc of the model including vascular (primary osteon) density as a predicting variable is 21.59739. The AICc of the model including phylogeny only is 24.34401.

The steepness parameter was estimated to be  $a = 0$ .

**Table S4** Mass-specific resting metabolic rate (RMR) in mL O<sub>2</sub> h<sup>-1</sup> g<sup>-0.67</sup> estimated from bone histology and taking into account phylogenetic relationships using the PEM approach. Lower and upper values correspond to 95 % confidence intervals.

	Lower	RMR	Upper
<i>Anarosaurus heterodontus</i>	3.431286	4.825407	6.785948
<i>Neusticosaurus edwardsii</i>	2.305951	3.200634	4.442441
<i>Nothosaurus</i> sp.	2.309282	3.14758	4.290194
<i>Pistosaurus longaevus</i>	5.452919	8.033297	11.83474
<i>Plesiosaurus dolichodirus</i>	7.186786	12.03066	20.13930
<i>Rhaeticosaurus mertensi</i>	7.86524	13.06124	21.68988
<i>Cryptoclidus eurymerus</i>	4.013786	7.237769	13.05134
Elasmosauridae indet.	6.31384	12.13612	23.32741

## Bone growth rate

**Table S5** R statistics of the model used to predict bone apposition rate. *t* value refers to the t-test of the respective line in the table.  $Pr(> |t|)$  is the p value for the t-test. V7, V14 and V5 are the selected vectors of the model.

	Estimate	Std. Error	t value	Pr(>  t )
Intercept	0.15086	0.15154	0.995	0.340895
Vascular density	1.08176	0.05716	18.926	9.65e-10
V7	-1.85088	0.37837	-4.892	0.000478
V14	1.19846	0.38776	3.091	0.010273
V5	0.95188	0.38500	2.472	0.030989

The multiple R-squared value of the model for bone growth rate is 0.9725, the adjusted R-squared value is 0.9624.

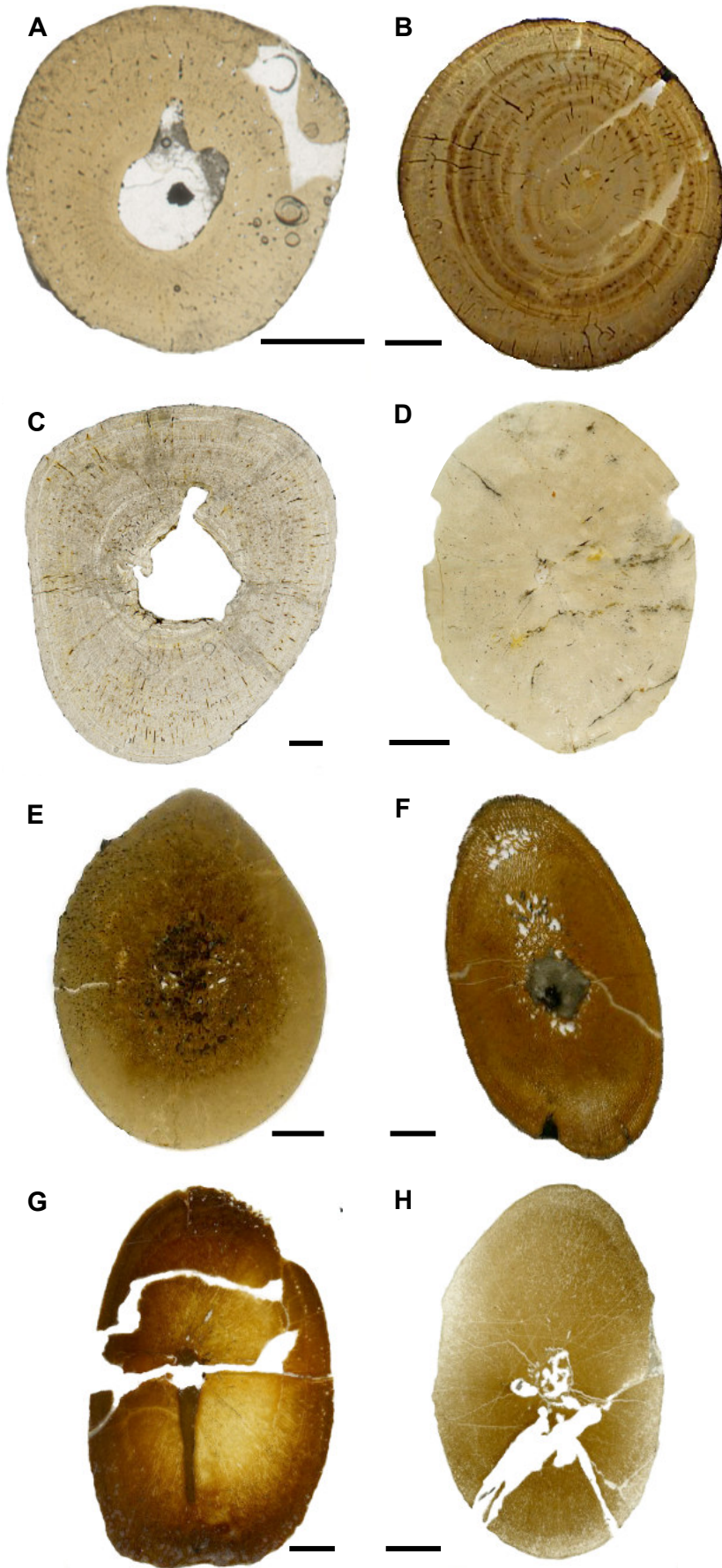
The F statistic of the overall analysis is 97.09 on 4 and 11 DF (degrees of freedom) with a p-value of 1.67e-08.

The AICc of the model including vascular (primary osteon) density as a predicting variable is 26.30375. The AICc of the model including phylogeny only is 31.2819.

The steepness parameter was estimated to be  $a = 0$ .

**Table S6** Bone growth rate in  $\mu\text{m}/\text{day}$  estimated from bone histology and taking into account phylogenetic relationships using the PEM approach. Lower and upper values correspond to 95% confidence intervals.

	Lower	RMR	Upper
<i>Anarosaurus heterodontus</i>	31.51501	42.39142	57.02153
<i>Neusticosaurus edwardsii</i>	22.84954	29.79674	38.85621
<i>Nothosaurus</i> sp.	22.54019	29.37212	38.27485
<i>Pistosaurus longaevus</i>	47.66656	65.66986	90.47287
<i>Plesiosaurus dolichodirus</i>	60.50754	92.89297	142.61200
<i>Rhaeticosaurus mertensi</i>	65.48237	99.68617	151.75600
<i>Cryptoclidus eurymerus</i>	35.91600	60.04474	100.38330
Elasmosauridae indet.	50.07065	93.59182	174.94140



**Figure S1** (Previous page) Bone cross sections analyzed in this study. **A** *Anarosaurus heterodontus* Wijk. 06-38fe, scale bar = 1 mm. **B** *Neusticosaurus edwardsii* PIMUZ T3455, scale bar = 1 mm. **C** *Nothosaurus* sp. IGWH 21, scale bar = 1 mm. **D** *Pistosaurus longaevus* SMNS 84825, scale bar = 5 mm. **E** *Rhaeticosaurus mertensi* LWL MfN P 64047, scale bar = 5 mm. **F** *Plesiosaurus dolichodirus* STIPB R90, scale bar = 5 mm. **G** *Cryptoclidus eurymerus* STIPB R 324, scale bar = 1 cm. **H** Elasmosauridae indet. OMNH MV 85, scale bar = 1 cm. Photos by Corinna V. Fleischle.