

```
setwd( "~/Documents/Christian Foth middle ear analyses/MIDDLE_EAR" )
```

```
require( sp )  
require(rgl)
```

```
files.all <- list.files()  
files.all <- files.all[ grepl( "Ascii" , files.all ) ]
```

```
files.FO <- files.all[ grepl( "fenestra-ovalis" , files.all ) | grepl( "fenestra_ovalis" , files.all ) | grepl( "fenestra-  
ovale" , files.all ) | grepl( "fenestra_ovale" , files.all ) | grepl( "fenstra_ovalis" , files.all ) ]  
files.CA <- files.all[ grepl( "columella-auris" , files.all ) | grepl( "columella_auris" , files.all ) | grepl(  
"columella-auris" , files.all ) | grepl( "columnella-auris" , files.all ) | grepl( "culumella_auris" , files.all ) ]  
files.CT <- files.all[ grepl( "cavum-tympanum" , files.all ) | grepl( "cavum_tympanum" , files.all ) | grepl(  
"cacum-tympanum" , files.all ) | grepl( "cavum_tympani" , files.all ) | grepl( "cavum-typanum" , files.all ) ]
```

```
landmarks <- list()
```

```
for( i in 1:length( files.all ) ) {  
  read.temp <- readLines( files.all[[ i ] ] , skip = 1 )  
  from <- 2 + which( grepl( "# Data section follows" , read.temp ) )  
  read.temp <- read.temp[ from:length(read.temp) ]  
  read.temp <- matrix( unlist( lapply( read.temp , strsplit , split = " " ) ) , ncol = 3 , byrow = T )  
  landmarks[[ i ] ] <- matrix( as.numeric( read.temp ) , ncol = 3 , byrow = F )  
}; names( landmarks ) <- files.all
```

```
fix.landmarks <- which( !( grepl( "Aldabrachelys" , files.all ) | grepl( "Batagur" , files.all ) | grepl( "Chelonia" , files.all )  
| grepl( "Chelus" , files.all ) | grepl( "Chelodina" , files.all ) | grepl( "Cuora_BONE" , files.all ) | grepl( "Eretmochelys" ,  
files.all ) | grepl( "Mauremys" , files.all ) | grepl( "Staurotypus" , files.all ) ) )
```

```
for( i in 1:length( fix.landmarks ) ) {  
  landmarks[[ fix.landmarks[i] ] ] <- landmarks[[ fix.landmarks[i] ] ]/1000 }
```

```
landmarks.FO <- list()  
landmarks.CA <- list()  
landmarks.CT <- list()
```

```
for( i in 1:length(files.FO) ) { landmarks.FO[[ i ] ] <- matrix( as.numeric( landmarks[[ which( files.all == files.FO[i] ) ] ]  
) , ncol = 3 ) }  
for( i in 1:length(files.CA) ) { landmarks.CA[[ i ] ] <- matrix( as.numeric( landmarks[[ which( files.all == files.CA[i] ) ] ]  
) , ncol = 3 ) }  
for( i in 1:length(files.CT) ) { landmarks.CT[[ i ] ] <- matrix( as.numeric( landmarks[[ which( files.all == files.CT[i] ) ] ]  
) , ncol = 3 ) }
```

```
i = 1  
plot3d( rbind( landmarks.FO[[ i ] ] , landmarks.CA[[ i ] ] , landmarks.CT[[ i ] ] ) )  
i = i + 1
```

```
plane.calc <- function( input ) {  
  PCresults.temp <- precomp( input )  
  #dev.new() ; plot( PCresults.temp$x[ , c(1,2) ] ); polygon( PCresults.temp$x[ , c(1,2) ] )  
  polygon.temp <- Polygon( PCresults.temp$x[ , c(1,2) ] )
```

```

output.temp <- c( polygon.temp@area , apply( input , 2 , mean ) , summary( PCresults.temp ) $
importance[ 2 , ] )
names( output.temp ) <- c( "Area" , "CentroidX" , "CentroidY" , "CentroidZ" , "PC1var" , "PC2var"
, "PC3var" )
output.temp }

```

```

params.FO <- matrix( ncol = 7 , nrow = length( landmarks.FO ) )
for( i in 1:length( landmarks.FO ) ) {
  params.FO[ i , ] <- plane.calc( landmarks.FO[[ i ]] )
}
colnames( params.FO ) <- c( "Area" , "CentroidX" , "CentroidY" , "CentroidZ" , "PC1var" , "PC2var" , "PC3var" )
rownames( params.FO ) <- files.FO

```

```

params.CT <- matrix( ncol = 7 , nrow = length( landmarks.CT ) )
for( i in 1:length( landmarks.CT ) ) {
  params.CT[ i , ] <- plane.calc( landmarks.CT[[ i ]] )
}
colnames( params.CT ) <- c( "Area" , "CentroidX" , "CentroidY" , "CentroidZ" , "PC1var" , "PC2var" , "PC3var" )
rownames( params.CT ) <- files.CT

```

```

params.CA <- matrix( ncol = 7 , nrow = length( landmarks.CT ) )
for( i in 1:length( landmarks.CA ) ) {
  params.CA[ i , ] <- plane.calc( landmarks.CA[[ i ]] )
}
colnames( params.CA ) <- c( "Area" , "CentroidX" , "CentroidY" , "CentroidZ" , "PC1var" , "PC2var" , "PC3var" )
rownames( params.CA ) <- files.CA

```

```

write.table( params.FO , "Fenestra ovalis measurements" )
write.table( params.CT , "Cavum tympanum measurements" )
write.table( params.CA , "Columella auris measurements" )

```

```

Edist <- function( A ) { sum( ( A[ c(1:3) ] - A[ c(4:6) ] ) ^ 2 ) ^ 0.5 }

```

```

straight.dist <- apply( cbind( params.FO[ , c( "CentroidX" , "CentroidY" , "CentroidZ" ) ] , params.CT[ , c(
"CentroidX" , "CentroidY" , "CentroidZ" ) ] ) , 1 , Edist )

```

```

bent.dist1 <- apply( cbind( params.FO[ , c( "CentroidX" , "CentroidY" , "CentroidZ" ) ] , params.CA[ , c(
"CentroidX" , "CentroidY" , "CentroidZ" ) ] ) , 1 , Edist )

```

```

bent.dist2 <- apply( cbind( params.CA[ , c( "CentroidX" , "CentroidY" , "CentroidZ" ) ] , params.CT[ , c(
"CentroidX" , "CentroidY" , "CentroidZ" ) ] ) , 1 , Edist )

```

```

bent.dist <- bent.dist1 + bent.dist2

```

#NEXUS[written Wed Mar 29 17:23:50 CEST 2017 by Mesquite version 3.02 (build 681) at
GEOSPC01/134.21.31.33]

BEGIN TREES;

LINK Taxa = Taxa;

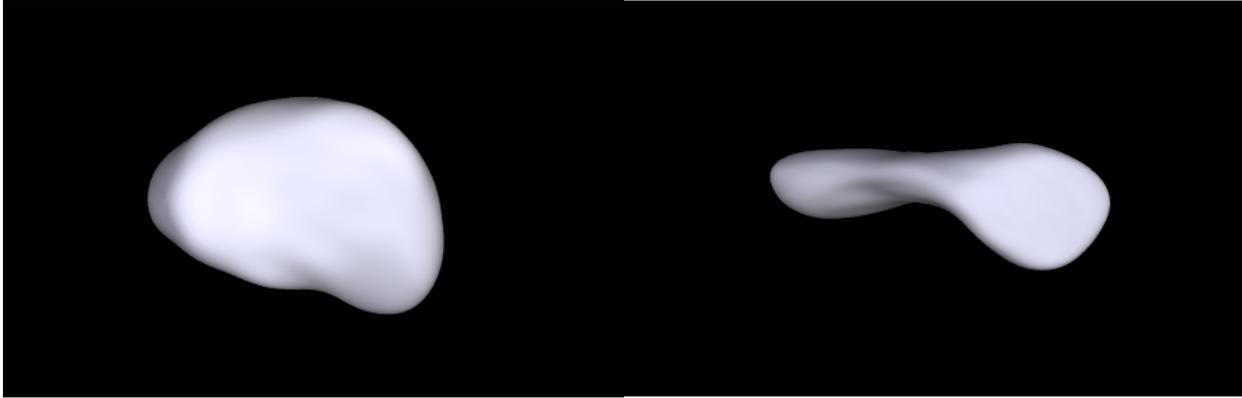
[! Trees from source: 'Current Tree (Tree(s) used from Trees from "tree2_equal_pruned.nex". Last tree used:
UNTITLED+ [tree: (((((1:94.6,2:94.6):21.4,(3:94,(4:72,5:72):22):22):48.1,(6:125,
(7:91.75,8:91.75):33.250000009):39.1):48.2,((9:162.8,(10:105,(11:101.26,
((12:46,13:46):51.52,14:97.52):3.74):3.74):57.8):27.6,(((15:91.1,(16:55.7,(17:21.700000003,(18:17.1,
(19:5.7,20:5.7):11.4):4.6):34):35.4):22,(21:78.02499999999999,(22:23.25,23:23.25):54.775000000000006):35.075):5.5,
((24:82.4,((25:28.8,((28:20.9,(26:16.4,27:16.4):4.5):4.5,(29:14.3,30:14.3):11.1):3.4):15.4,(31:31.8,
((32:6.966666667,33:6.966666667):13.933333334,34:20.9):10.9):12.4):38.2):3.4,(((35:38.325,(36:25.55,
(37:12.775,38:12.775):12.775):12.775):16.975,(((39:25.55,(40:12.775,41:12.775):12.775):12.775,42:38.325):12.775,
((43:21.29166667,44:21.29166666):21.29166666,
(45:34.06666666,46:34.066666668):8.516666667):8.516666667):4.2):17.35,((47:24.6,48:24.6):34.9,
(49:35.31428571,50:35.314285716):18.08571429,((51:20.6,52:20.6):20.6,((53:24.72,
(54:16.48,55:16.48):8.24):8.24,56:32.96):8.24):12.2):6.1):13.15):13.15):32.8):71.8):21.9):3.2000000010000003;)]]

TRANSLATE

- 1 Chelodina_oblonga,
- 2 Emydura_subglobosa,
- 3 Hydromedusa_tectifera,
- 4 Chelus_fimbriata,
- 5 Phrynops_geoffroanus,
- 6 Pelomedusa_subrufa,
- 7 Podocnemis_unifilis,
- 8 Peltocephalus_dumeriliana,
- 9 Carettochelys_insculpta,
- 10 Lissemys_punctata,
- 11 Chitra_indica,
- 12 Amyda_cartilaginea,
- 13 Pelodiscus_sinensis,
- 14 Apalone_spinifera,
- 15 Dermatemys_mawii,
- 16 Staurotypus_sp,
- 17 Sternotherus_minor,
- 18 Kinosternon_scorpioides,
- 19 Kinosternon_baurii,
- 20 Kinosternon_subrubrum,
- 21 Dermochelys_coriacea,
- 22 Chelonia_mydas,
- 23 Eretmochelys_imbricata,
- 24 Platysternon_megacephalum,
- 25 Glyptemys_insculpta,
- 26 Emydoidea_blandingii,
- 27 Emys_orbicularis,
- 28 Clemmys_guttata,
- 29 Terrapene_ornata,
- 30 Terrapene_coahuila,
- 31 Deirochelys_reticularia,
- 32 Pseudemys_concinna,
- 33 Pseudemys_floridana,
- 34 Malaclemys_terrapi,
- 35 Manouria_impressa,
- 36 Gopherus_agassizi,

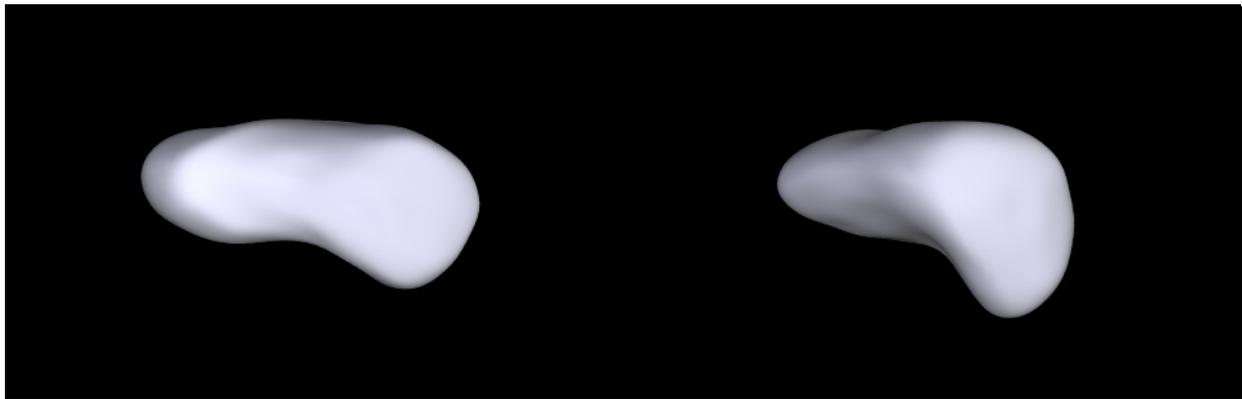
- 37 *Gopherus flavomarginatus*,
- 38 *Gopherus polyphemus*,
- 39 *Malacochersus tornieri*,
- 40 *Indotestudo elongata*,
- 41 *Indotestudo forstenii*,
- 42 *Testudo marginata*,
- 43 *Chelonoidis sp*,
- 44 *Kinixys erosa*,
- 45 *Aldabrachelys gigantea*,
- 46 *Psammobates tentorius*,
- 47 *Rhinoclemmys melanosterna*,
- 48 *Rhinoclemmys pulcherrima*,
- 49 *Geoemyda spengleri*,
- 50 *Batagur baska*,
- 51 *Heosemys annandalii*,
- 52 *Notochelys platynota*,
- 53 *Cuora amboinensis*,
- 54 *Cuora flavomarginata*,
- 55 *Cuora mouhotii*,
- 56 *Mauremys leprosa*;

TREE 'UNTITLED+' = (((((1:94.6,2:94.6):21.4,(3:94,(4:72,5:72):22):22):48.1,(6:125,(7:91.75,8:91.75):33.250000009):39.1):48.2,((9:162.8,(10:105,(11:101.26,((12:46,13:46):51.52,14:97.52):3.74):3.74):57.8):27.6,(((15:91.1,(16:55.7,(17:21.700000003,(18:17.1,(19:5.7,20:5.7):11.4):4.6):34):35.4):22,(21:78.02499999999999,(22:23.25,23:23.25):54.775000000000006):35.075):5.5,((24:82.4,((25:28.8,((28:20.9,(26:16.4,27:16.4):4.5):4.5,(29:14.3,30:14.3):11.1):3.4):15.4,(31:31.8,((32:6.966666667,33:6.966666667):13.933333334,34:20.9):10.9):12.4):38.2):3.4,(((35:38.325,(36:25.55,(37:12.775,38:12.775):12.775):12.775):16.975,(((39:25.55,(40:12.775,41:12.775):12.775):12.775,42:38.325):12.775,((43:21.29166667,44:21.29166666):21.29166666,(45:34.06666666,46:34.066666668):8.516666667):8.516666667):4.2):17.35,((47:24.6,48:24.6):34.9,((49:35.31428571,50:35.314285716):18.08571429,((51:20.6,52:20.6):20.6,((53:24.72,(54:16.48,55:16.48):8.24):8.24,56:32.96):8.24):12.2):6.1):13.15):13.15):32.8):71.8):21.9):3.2000000010000003; END;



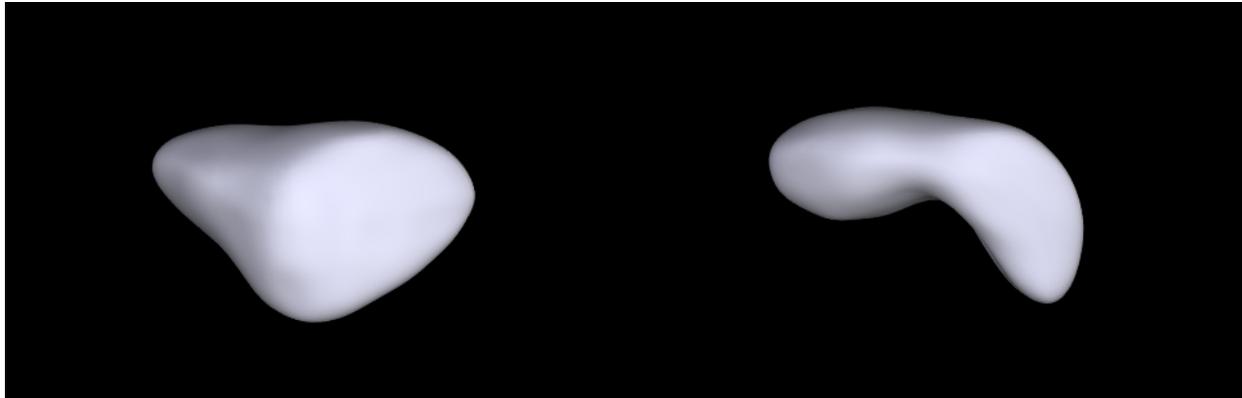
PC1 (+)

PC1 (-)



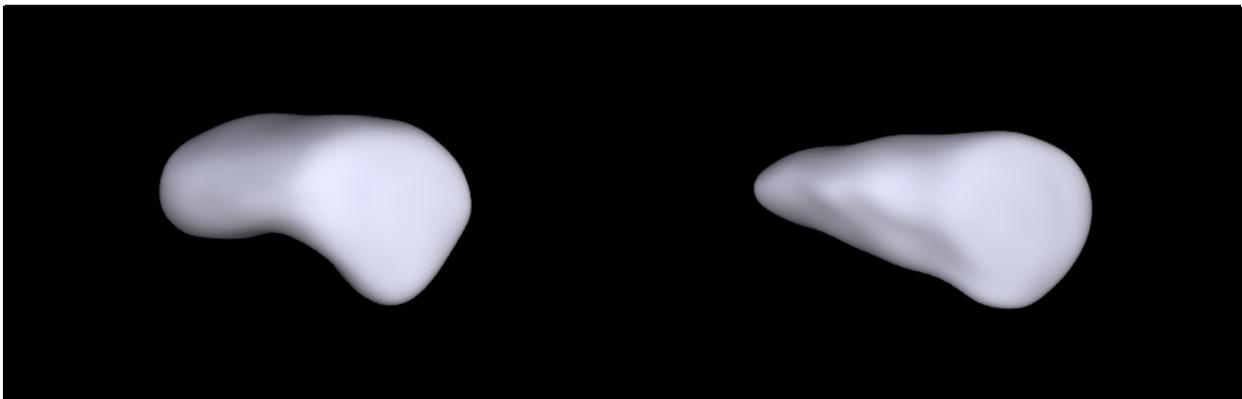
PC2 (+)

PC2 (-)



PC3 (+)

PC3 (-)



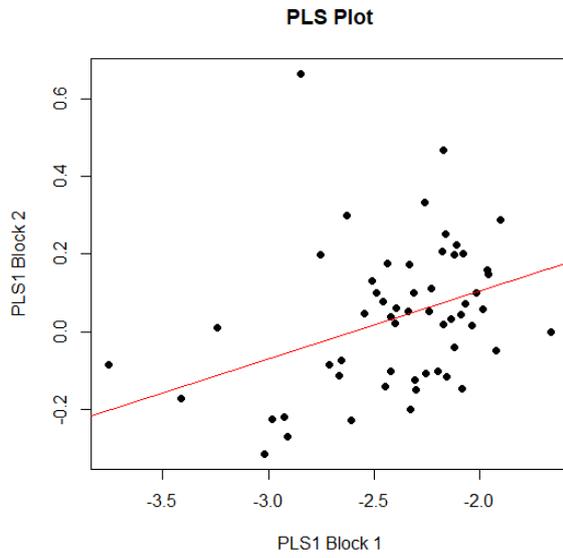
PC4 (+)

PC4 (-)

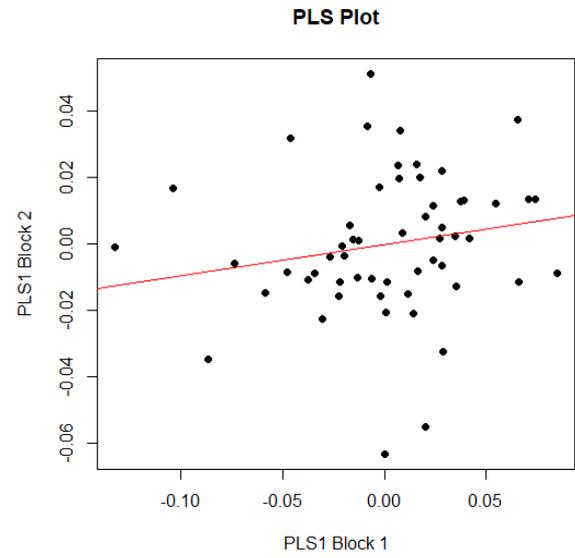
Two-block partial least squares analysis

Phylogenetic Two-Block Partial Least Squares Analyses

Morphometric measurements

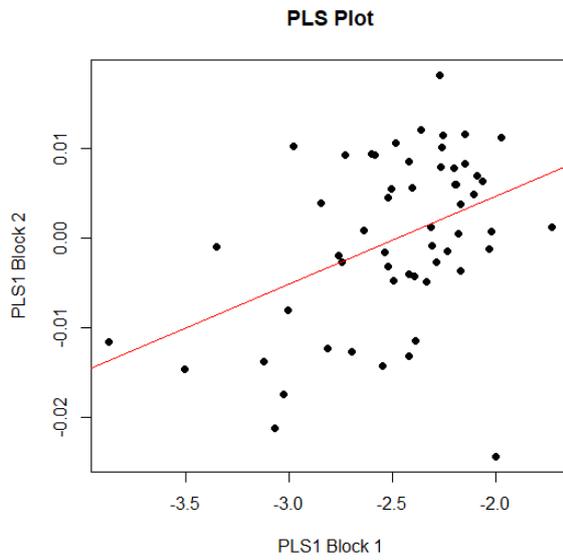


r-PLS: 0.298; P-value: 0.12

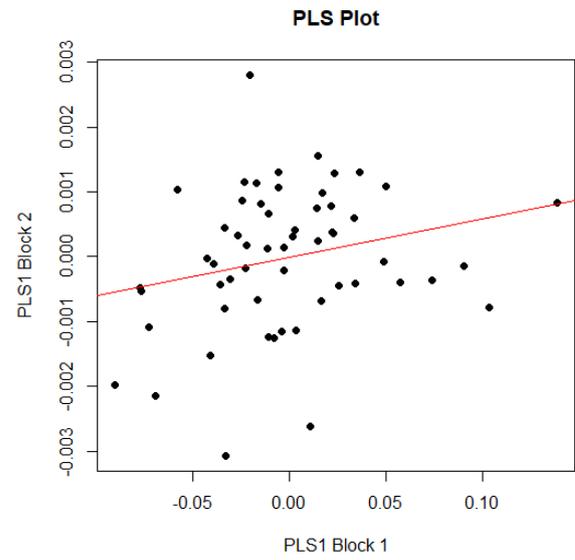


r-PLS: 0.144; P-value: 0.802

PC1-PC4

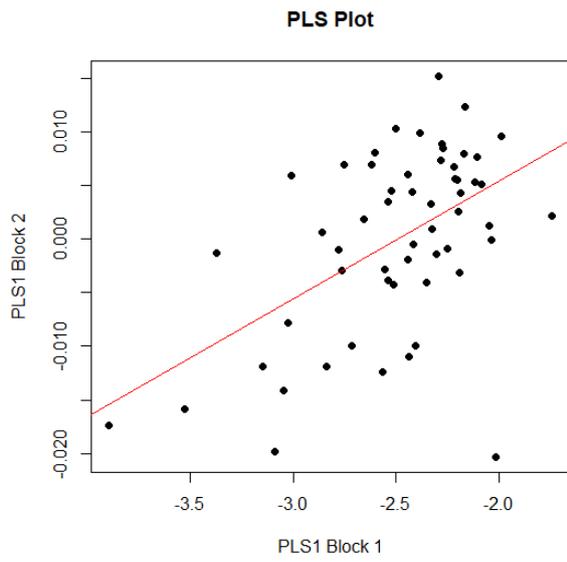


r-PLS: 0.419; P-value: 0.02

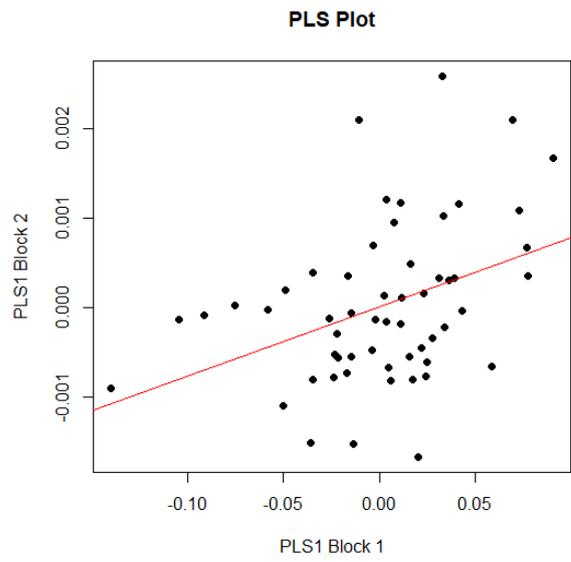


r-PLS: 0.242; P-value: 0.391

All PCs



r-PLS: 0.527; P-value: 0.008



r-PLS: 0.388; P-value: 0.246

Table S1. Specimens used in this study and CT data repository information.

Note that all CT scans for which we had explicit copyright holder permission have been made available.

"For scans for which we have no copyright or no permission, individuals that shared the scans with us are indicated, and, if applicable, the first literature mentioning of those data are indicated with an asterisk (*)."

Citations without asterisks refer to the MorphoSource projects.

Taxon	SpecimenRepository	Project	Media accession number	Data Source	Citation
<i>Aldabrachelys gigantea</i>	NHMUK	77.11.12.2	MorphoSourceP769	M42855	own scan Evers (2019)
<i>Amyda cartilaginea</i>	FMNH	244117	MorphoSourceP769	M42876	own scan Evers (2019)
<i>Apalone spinifera</i>	FMNH	22178	MorphoSourceP462	M22038	own scan Evers & Benson (2018)
<i>Batagur baska</i>	NHMUK	67.9.28.7	MorphoSourceP769	M42851	own scan Evers (2019)
<i>Carettochelys insculpta</i>	SMF	56626	noneNA	NA	shared by I. Werneburg none
<i>Chelodina oblonga</i>	NHMUK	64.12.22	MorphoSourceP769	M42849	own scan Evers (2019)
<i>Chelonia mydas</i>	NHMUK	1969.776	MorphoSourceP769	M42846	own scan Evers (2019)
<i>Chelonoidis</i> sp.	SMF	67582	noneNA	NA	shared by I. Werneburg none
<i>Chelus fimbriatus</i>	NHMUK	81.9.27.4	MorphoSourceP769	M42856	own scan Evers (2019)
<i>Chitra chitra</i>	NHMUK	1936.12.16.1	MorphoSourceP769	M42842	own scan Evers (2019)
<i>Clemmys guttata</i>	FMNH	22114	MorphoSourceP769	M42870	own scan Evers (2019)
<i>Cuora amboinensis</i>	NHMUK	69.42.145	MorphoSourceP769	M42852	own scan Evers (2019)
<i>Cuora flavomarginata</i>	FMNH	21515	MorphoSourceP769	M42867	own scan Evers (2019)
<i>Cuora mouhotii</i>	SMF	71599	noneNA	NA	shared by I. Werneburg none
<i>Deirochelys reticularia</i>	FMNH	98754	MorphoSourceP769	M42883	own scan Evers (2019)
<i>Dermatemys mawii</i>	SMF	59463	noneNA	NA	shared by I. Werneburg none
<i>Dermochelys coriacea</i>	FMNH	171756	MorphoSourceP769	M42864	own scan Evers (2019)
<i>Emydoidea blandingii</i>	FMNH	22144	MorphoSourceP769	M42871	own scan Evers (2019)
<i>Emydura subglobosa</i>	PIMUZ	lab# 2009.37	noneNA	NA	shared by I. Werneburg Lautenschlager et al. (2018)*
<i>Emys orbicularis</i>	SMF	1987	noneNA	NA	shared by I. Werneburg Lautenschlager et al. (2018)*
<i>Eretmochelys imbricata</i>	NMB	C2417	noneNA	NA	shared by I. Raselli Raselli 2018*
<i>Geoemyda spengleri</i>	FMNH	260381	MorphoSourceP769	M42877	own scan Evers (2019)
<i>Glyptemys insculpta</i>	FMNH	22240	MorphoSourceP769	M42873	own scan Evers (2019)
<i>Gopherus agassizi</i>	FMNH	216746	MorphoSourceP769	M42868	own scan Evers (2019)
<i>Gopherus flavomarginatus</i>	FMNH	98916	MorphoSourceP769	M42884	own scan Evers (2019)
<i>Gopherus polyphemus</i>	FMNH	211815	MorphoSourceP462	M22041	own scan Evers & Benson (2018)
<i>Heosemys annandalei</i>	FMNH	260389	MorphoSourceP769	M42878	own scan Evers (2019)
<i>Hydromedusa tectifera</i>	SMF	70500	noneNA	NA	shared by I. Werneburg none
<i>Indotestudo forstenii</i>	SMF	73257	noneNA	NA	shared by I. Werneburg none
<i>Intestudo elongata</i>	SMF	71585	noneNA	NA	shared by I. Werneburg none
<i>Kinosternon baurii</i>	FMNH	211705	MorphoSourceP769	M42865	own scan Evers (2019)
<i>Kinosternon scorpioides</i>	SMF	71893	noneNA	NA	shared by I. Werneburg none
<i>Kinosternon suburum</i>	FMNH	211711	MorphoSourceP769	M42866	own scan Evers (2019)
<i>Kinyxis erosa</i>	SMF	40166	noneNA	NA	shared by I. Werneburg none
<i>Lissemys punctata</i>	SMF	74141	noneNA	NA	shared by I. Werneburg none
<i>Malaclemys terrapin</i>	SMF	36419	noneNA	NA	shared by I. Werneburg none
<i>Malacochersus tornieri</i>	SMF	58702	noneNA	NA	shared by I. Werneburg Lautenschlager et al. (2018)*
<i>Manouria impressa</i>	SMF	69777	noneNA	NA	shared by I. Werneburg none
<i>Mauremys leprosa</i>	NHMUK	unnumbered	MorphoSourceP769	M42862	own scan Evers (2019)
<i>Notochelys platynota</i>	FMNH	224048	MorphoSourceP769	M42874	own scan Evers (2019)
<i>Pelodiscus sinensis</i>	IW576-2b	noneNA	NA	NA	shared by I. Werneburg Lautenschlager et al. (2018)*
<i>Peltocephalus dumerilianus</i>	SMF	55470	noneNA	NA	shared by I. Werneburg Lautenschlager et al. (2018)*
<i>Pelomedusa subrufa</i>	SMF	70504	noneNA	NA	shared by I. Werneburg none
<i>Phrynops geoffroanus</i>	SMF	45470	MorphoSourceP462	M22118	own scan Evers & Benson (2018)
<i>Platysternon megacephalum</i>	SMF	69684	noneNA	NA	shared by I. Werneburg none
<i>Podocnemis unifilis</i>	FMNH	45657	MorphoSourceP769	M42880	own scan Evers (2019)
<i>Psammobates tentorius</i>	SMF	57142	noneNA	NA	shared by I. Werneburg none
<i>Pseudemys concinna</i>	FMNH	22146	MorphoSourceP769	M42872	own scan Evers (2019)
<i>Pseudemys floridana</i>	FMNH	8222	MorphoSourceP769	M42882	own scan Evers (2019)
<i>Rhinoclemmys melanosterna</i>	FMNH	44446	MorphoSourceP769	M42879	own scan Evers (2019)

Rhinoclemmys pulcherrima	Digimorph unnumbered	Digimorph	NA	NA	downloaded	none
Staurotypus salvinii	NHMUK 1879.1.7.5	MorphoSourceP769	M42838	own scan	Evers (2019)	
Sternotherus minor	FMNH 211696	MorphoSourceP462	M22123	own scan	Evers & Benson (2018)	
Terrapene coahuila	FMNH 47372	MorphoSourceP769	M42881	own scan	Evers (2019)	
Terrapene ornata	FMNH 23014	MorphoSourceP769	M42875	own scan	Evers (2019)	
Testudo marginata	FMNH 51672	MorphoSourceP769	M42885	own scan	Evers (2019)	

References

- "Evers SW, Benson RBJ (2018) Project: Evers & Benson 2018, Turtle CT data and 3D models. MorphoSource. Available at http://www.morphosource.org/Detail/ProjectDetail/Show/project_id/462. "
- "Evers SW (2019) Project: Evers 2019, CT scans of extant turtle skulls. MorphoSource. Available at https://www.morphosource.org/Detail/ProjectDetail/Show/project_id/769."
- "Lautenschlager S, Ferreira GS, Werneburg I (2018) Sensory evolution and ecology of early turtles revealed by digital endocranial reconstructions. *Front Ecol Evol* 6, 7:1-16."
- "Raselli I (2018) Comparative cranial morphology of the Late Cretaceous protostegid sea turtle *Desmatochelys lowii*. *PeerJ* 6, e5964."

"Table S2. Morphometric measurements of turtle skulls and middle ears, habitat preferences, and values for the first four PCs."

Skull paramters (against logCS)		Habitat grouping PCA Results [SPHARM]				Middle ear parameters						Ratio: Residuals of Middle									
Species	Specimen	Skull length [mm]	Skull width [mm]	Skull height [mm]	logV [mm ³]	Forelimb	Forelimb1	Forelimb2	Forelimb3	Forelimb4	Forelimb5	Forelimb6	CS								
logCS	V [mm ³]	logV	AreaCT [mm ²]	logCT	AreaFO [mm ²]	logFO	LengthD	logD	AreaCT/AreaFO	RESlogV	RESlogCT	RESlogFO	RESlogD	Axis 1	Axis 2						
Axis 3	Axis 4																				
Aldabrachelys gigantea	NHMUK77.11.12.2	147.7800	108.4300	51.7900	5.9190	not webbed	-00	0	0	0	0	0	800.4643	2.9033	11887.3330	4.0751	510.8319	2.7083			
34.6161	1.5393	38.2408	1.5825	14.7571	0.208760	-0.135713	0.079780	-0.034821	0.002615	-0.003391	-0.002486	0.000440									
Amyda cartilaginea	FMNH 244117	97.7600	70.2300	32.8800	5.3536	extensive	-3	3	2	2	1	1	497.9813	2.6972	2674.1254	3.4272	364.1208	2.5612	17.7427		
1.2490	20.3903	1.3094	20.5223	0.147856	0.171765	0.114323	-0.053519	0.010312	0.002873	0.016150	-0.001394										
Apalone spinifer	FMNH 22178	65.9500	41.9300	22.0200	4.7846	extensive	-3	3	2	2	1	1	297.6649	2.4737	530.1349	2.7244	117.7513	2.0710	9.7697	0.9899	
11.6729	1.0672	12.0527	0.081483	0.174268	0.207337	-0.019937	0.005710	0.001272	0.013473	-0.004849											
Batagur baska	NHMUK 67.9.28.791.2100	67.6500	33.5100	5.3155	extensive	-3	3	2	2	1	1	1	492.8359	2.6927	2103.3687	3.3229	391.1809	2.5924	26.7536	1.4274	
20.9059	1.3203	14.6216	0.056435	0.212845	0.299795	-0.037107	0.008017	-0.000593	0.003055	-0.009007											
Carettochelys insculpta	SMF 56626	101.0000	86.6700	38.2500	5.5248	flipper	-44	3	3	2	1	1	549.6876	2.7401	3222.2785	3.5082	600.0117	2.7782	21.4677	1.3318	
24.3648	1.3868	27.9495	0.106661	0.294080	0.129487	-0.029131	0.010663	0.009607	0.012304	0.002946											
Chelodina oblonga	NHMUK 64.12.22	51.7000	30.8200	10.6000	4.2276	extensive	-3	3	2	2	1	1	301.2057	2.4789	361.0728	2.5576	46.6082	1.6685	3.3186	0.5210	
10.6051	1.0255	14.0444	-0.099931	-0.239559	-0.269678	-0.067937	-0.012088	-0.001772	-0.005612	-0.002780											
Chelonia mydas	NHMUK 1969.776	159.5100	113.4300	80.8300	6.1651	flipper	-44	3	3	2	1	1	710.8949	2.8518	6805.1353	3.8328	666.3803	2.8237	31.2758	1.4952	
40.8983	1.6117	21.3066	0.113276	0.093369	0.116919	0.057964	0.016877	-0.003885	0.002300	-0.006360											
Chelonoidis sp.	SMF 67582	43.5500	31.6500	14.6100	4.3040	not webbed	0	0	0	0	0	0	230.2957	2.3623	300.6277	2.4780	35.4527	1.5496	3.7989	0.5797	
7.2153	0.8583	9.3324	0.152482	-0.101321	-0.027289	-0.091320	0.010757	-0.000013	-0.005850	0.007481											
Chelus fimbriata	NHMUK 81.9.27.4	98.4700	104.1000	20.5600	5.3238	extensive	-2	2	2	2	1	1	0	771.3347	2.8872	2488.1763	3.3959	220.1778	2.3428	12.1015	
1.0828	38.0000	1.5798	18.1943	-0.424598	-0.465719	-0.351291	-0.017695	-0.027440	-0.031787	0.005464	0.012390										
Chitra chitra	NHMUK 1926.12.16.1	89.1400	53.7600	21.3400	5.0097	extensive	-3	3	3	2	2	1	1	325.5846	2.5127	697.2859	2.8434	106.3584	2.0268	7.2314	0.8592
14.3712	1.1575	14.7079	0.089629	0.044220	0.015323	0.022322	0.013404	-0.002627	0.002950	-0.007651											
Clemmys guttata	FMNH 22114	24.2600	15.6900	8.5300	3.5115	small	-1	1	0	0	0	0	158.3839	2.1997	55.9437	1.7478	10.7499	1.0314	1.9921	0.2993	5.0588
0.7040	5.3963	-0.114827	-0.261092	-0.051467	-0.044876	-0.012227	0.006213	-0.001618	-0.003141												
Cuora amboinensis	NHMUK 69.42.145	34.7700	22.8000	10.8000	3.9186	extensive	-2	2	2	1	1	1	0	231.8457	2.3652	190.5400	2.2800	31.1311	1.4932	3.5744	
0.5532	7.3278	0.8650	8.7096	-0.053856	-0.164198	-0.058337	-0.088192	-0.004795	0.003149	-0.005656	-0.003591										
Cuora flavomarginata	FMNH 21515	33.2600	21.7400	10.1800	3.8669	small	-1	1	0	0	0	0	206.5600	2.3150	176.4465	2.2466	29.8874	1.4755	3.5914	0.5553	
6.8146	0.8334	8.3218	0.055593	-0.071318	0.022762	-0.057829	-0.002444	0.006158	-0.001117	-0.002172											
Cuora mouhotii	SMF 71599	36.5800	25.7100	13.2800	4.0965	not webbed	-00	0	0	0	0	0	239.3363	2.3790	332.7875	2.5222	29.4373	1.4689	4.9952	0.6986	
8.3941	0.9240	5.8931	0.148998	-0.218946	0.065258	-0.046237	0.003027	0.001824	-0.001448	0.003708											
Deirochelys reticularia	FMNH 98754	41.0800	24.3300	10.8000	4.0332	extensive	-2	2	2	1	1	1	0	221.2665	2.3449	169.1333	2.2282	42.7948	1.6314	3.8368	0.5840
7.4058	0.8696	11.1539	-0.047853	0.018721	0.004390	-0.058560	-0.011358	0.003035	-0.001913	-0.001722											
Dermatemys mawii	SMF 59463	66.9700	49.6200	23.3900	4.8906	extensive	-2	2	2	1	1	0	412.4972	2.6154	1270.0393	3.1038	192.0737	2.2835	15.2399	1.1830	
15.3454	1.1860	12.6034	0.057412	0.074339	0.177166	-0.076015	-0.001257	0.006571	0.006581	0.001454											
Dermochelys coriacea	FMNH 171756	219.0000	250.3800	117.3700	6.8086	flipper	-44	3	3	2	1	1	1318.8044	3.1202	45042.5803	4.6536	2323.2833	3.3661			
43.5020	1.6385	93.3719	1.9702	53.4063	0.169805	0.043986	-0.162665	0.085245	0.012734	0.008770	0.006427	0.009015									
Emydoidea blandingii	FMNH 22144	40.2500	26.2500	10.1500	4.0304	small	-1	1	0	0	0	0	267.4280	2.4272	246.1861	2.3913	44.8232	1.6515	3.0437	0.4834	
9.0167	0.9550	14.7265	-0.119160	-0.142618	-0.225838	-0.074650	-0.013760	0.005339	-0.000509	-0.003836											
Emydura subglobosa	PIMUZ lab# 2009.37	15.9300	12.3300	6.1900	3.0849	extensive	-2	2	2	1	1	1	0	97.0596	1.9870	19.2604	1.2847	6.4547	0.8099	1.0173	
0.0075	3.1567	0.4992	6.3449	0.027718	-0.013680	-0.008206	0.012794	0.001796	-0.002519	-0.004728	-0.001900										
Emys orbicularis	SMF 1987	28.4500	19.9400	8.6200	3.6893	small	-1	1	0	0	0	0	197.7575	2.2961	134.0057	2.1271	28.2260	1.4506	3.2980	0.5182	6.5520
0.8164	8.5586	-0.010038	-0.054454	0.015539	-0.051551	-0.005070	0.001872	-0.003589	-0.005118												
Eretmochelys imbricata	NMB C2417	96.6000	67.2800	40.3000	5.4182	flipper	-44	3	3	2	1	1	437.2608	2.6407	1777.8015	3.2499	250.3808	2.3986	16.0126	1.2045	
22.4357	1.3509	15.6365	0.131377	0.133644	0.158753	0.057696	0.022410	-0.007111	0.005228	-0.002990											
Geoemyda spengleri	FMNH 260381	23.9200	15.5300	10.3200	3.5836	not webbed	-00	0	0	0	0	0	156.8814	2.1956	84.0010	1.9243	12.2612	1.0885	2.3448		
0.3701	4.4084	0.6443	5.2292	0.073492	-0.194834	0.025848	-0.099529	0.002852	0.009633	-0.001228	0.002977										
Glyptemys insculpta	FMNH 22240	41.0000	33.9600	14.4800	4.3045	small	-1	1	0	0	0	0	276.2149	2.4412	345.7768	2.5388	40.8428	1.6111	5.6691	0.7535	
11.2005	1.0492	7.2045	-0.011610	-0.213962	0.022147	0.002211	-0.005259	0.004442	-0.005932	-0.001423											
Gopherus agassizi	FMNH 216746	44.9600	37.4800	18.3300	4.4898	not webbed	-00	0	0	0	0	0	270.5898	2.4323	442.0455	2.6455	71.6636	1.8553	7.6102	0.8814	
11.3547	1.0552	9.4167	0.120508	0.049924	0.164113	0.019179	0.006237	0.008279	-0.001873	0.008154											
Gopherus flavomarginatus	FMNH 98916	50.1900	39.5500	16.9000	4.5257	not webbed	-00	0	0	0	0	0	325.1360	2.5121	831.4995	2.9199	64.4825	1.8094	7.4230		
0.8706	12.0649	1.0815	8.6869	0.167786	-0.171789	0.027624	-0.052907	0.023812	-0.014335	-0.009296	0.000520										
Gopherus polyphemus	FMNH 211815	43.0600	41.3200	15.2200	4.4326	not webbed	-00	0	0	0	0	0	274.7341	2.4389	447.9904	2.6513	43.1594	1.6351	14.6989		
1.1673	8.1512	0.9112	2.9362	0.107510	-0.184856	0.439598	-0.132927	0.011976	-0.004312	-0.007317	0.005767										
Heosemys annandalii	FMNH 260389	54.5700	41.2900	17.4000	4.5933	extensive	-2	2	2	1	1	1	0	356.2682	2.5518	685.2824	2.8359	87.3079	1.9411	10.4951	
1.0210	13.5513	1.1320	8.3189	-0.029295	-0.127741	0.115457	-0.051465	-0.008993	0.002546	-0.003385	-0.001139										
Hydromedusa tectifera	SMF 70500	46.1200	28.0000	9.2000	4.0748	extensive	-3	3	3	2	2	1	1	267.1395	2.4267	170.7259	2.2323	25.6322	1.4088	4.4273	0.6461
9.0976	0.9589	5.7896	-0.276789	-0.384300	-0.062363	-0.070191	-0.024566	-0.000812	-0.000588	-0.005792											
Indotestudo elongata	SMF 71585	51.4900	39.2200	15.1200	4.4848	not webbed	-00	0	0	0	0	0	268.4538	2.4289	401.0904	2.6032	63.7809	1.8047	7.8476	0.8947	
11.4678	1.0595	8.1274	0.088082	0.006904	0.182877	0.027727	0.001811	0.005179	-0.007539	-0.006524											
Indotestudo forstenii	SMF 73257	33.8500	28.0900	12.1800	4.0638	not webbed	-00	0	0	0	0	0	213.3								

7.7295 0.8882 12.7025 0.160660 0.091234 -0.018150 0.035706 0.011339 -0.005042 -0.008494 0.009567
Manouria impressa SMF 69777 49.9400 34.5000 17.2800 4.4738 not webbed - 00 0 0 0 0 287.7281 2.4590 469.7853 2.6719 43.5824 1.6393 5.9053 0.7712
9.6173 0.9831 7.3802 0.070989 -0.224873 0.011934 -0.085862 0.014258 0.001092 -0.010791 -0.000737
Mauremys leprosa NHMUK unnumbered 35.0100 27.4100 11.3300 4.0363 extensive - 2 2 2 1 1 1 0 229.0314 2.3599 216.1426 2.3347 26.5396 1.4239 3.0139
0.4791 9.0960 0.9588 8.8059 0.016002 -0.221803 -0.124055 0.012226 -0.009424 0.001145 -0.001181 -0.001581
Notochelys platynota FMNH 224048 55.1200 40.3400 18.5700 4.6159 extensive - 2 2 2 1 1 1 0 313.3287 2.4960 489.3803 2.6896 55.4066 1.7436 8.9034
0.9496 13.5965 1.1334 6.2231 -0.016681 -0.202246 0.131916 0.018824 -0.007353 0.006423 -0.004236 -0.001044
Pelodiscus sinensis IW576-2b 45.7700 29.0600 13.3400 4.2490 extensive - 3 3 3 2 2 1 1 213.5494 2.3295 201.3778 2.3040 50.8288 1.7061 3.9093 0.5921
8.4836 0.9286 13.0021 0.071836 0.127437 0.036818 0.019478 0.007625 -0.004974 0.007494 -0.007004
Pelomedusa subrufa SMF 70504 38.5300 35.1900 13.8200 4.2727 extensive - 2 2 2 1 1 1 0 258.7172 2.4128 247.6382 2.3938 47.8210 1.6796 4.0088 0.6030
12.6092 1.1007 11.9289 -0.075650 -0.082790 -0.083562 0.088739 -0.010142 0.005262 0.004547 0.009999
Peltoccephalus dumerilianus SMF 55470 67.0000 46.9300 23.2900 4.8647 extensive - 2 2 2 1 1 1 0 388.9386 2.5899 813.7381 2.9105 189.7552 2.2782 9.0274
0.9556 16.9216 1.2284 21.0200 -0.063189 0.125380 -0.010010 -0.002030 -0.002464 0.000222 0.006771 -0.011935
Phrynosops geoffroanus SMF 45470 64.3900 55.9500 19.7900 4.8531 extensive - 2 2 2 1 1 1 0 434.8478 2.6383 759.4040 2.8805 115.0122 2.0607 8.1946 0.9135
19.2007 1.2833 14.0352 -0.231190 -0.198915 -0.128398 -0.006959 -0.019966 -0.019036 0.002230 -0.002667
Platysternon megacephalum SMF 69684 60.2600 57.9500 29.8500 5.0180 small - 1 1 1 0 0 0 0 297.1738 2.4730 453.9376 2.6570 34.9586 1.5436 7.9476 0.9002
18.5606 1.2686 4.3986 0.016135 -0.351563 0.118821 0.182361 -0.006624 0.007365 0.003841 0.005119
Podocnemis unifilis FMNH 45657 32.8300 23.8300 12.0100 3.9729 extensive - 2 2 2 1 1 1 0 197.1146 2.2947 141.1733 2.1498 41.6906 1.6200 3.3639 0.5268
7.7130 0.8872 12.3936 0.016617 0.118052 0.026363 0.021045 -0.001564 0.002465 0.004851 0.003767
Psammobates tentorius SMF 57142 24.0100 17.3900 8.6800 3.5592 not webbed - 00 0 0 0 0 137.6756 2.1389 59.6551 1.7756 13.3231 1.1246 2.4804 0.3945
4.7438 0.6761 5.3714 0.086365 -0.033706 0.139636 0.002308 0.026585 -0.012473 0.003671 -0.000253
Pseudemys concinna FMNH 22146 45.3800 36.1500 17.0300 4.4462 extensive - 2 2 2 1 1 1 0 297.3492 2.4733 398.6426 2.6006 70.5862 1.8487 7.8635 0.8956
10.7106 1.0298 8.9765 -0.041006 -0.046962 0.113795 -0.056732 -0.002283 -0.000984 -0.006284 -0.008004
Pseudemys floridana FMNH 8222 33.0700 16.1000 14.0200 3.8730 extensive - 2 2 2 1 1 1 0 249.3201 2.3968 242.2972 2.3843 51.2454 1.7097 4.8365 0.6845
9.2357 0.9655 10.5956 -0.039363 -0.017323 0.023267 -0.026646 -0.002266 -0.000840 -0.006972 -0.008034
Rhinoclemmys melanosterna FMNH 44446 28.5000 19.5100 9.5300 3.7242 extensive - 2 2 2 1 1 1 0 173.2564 2.2387 93.0750 1.9688 18.1756 1.2595 2.4148
0.3829 6.6609 0.8235 7.5266 -0.004744 -0.118951 -0.029301 0.026507 -0.004501 0.007308 -0.003314 0.004674
Rhinoclemmys pulcherrima PCHP unnumbered 30.8100 23.1300 9.6700 3.8383 small - 1 1 1 0 0 0 0 203.0292 2.3076 142.7172 2.1545 26.3896 1.4214 3.9132
0.5925 7.8029 0.8923 6.7438 -0.015224 -0.108866 0.071818 0.010230 -0.007812 0.005048 -0.002388 -0.000272
Staurotypus salvinii NHMUK 1879.1.7.5 51.9300 44.0000 20.4700 4.6700 extensive - 2 2 2 1 1 1 0 276.7451 2.4421 406.2031 2.6087 51.6678 1.7132 5.1187
0.7092 14.4109 1.1587 10.0939 0.055965 -0.113695 -0.023517 0.110637 -0.009229 -0.010820 0.005775 -0.000036
Sternotherus minor FMNH 211696 32.0500 26.2800 14.8900 4.0983 extensive - 2 2 2 1 1 1 0 199.6290 2.3002 146.9211 2.1671 23.5222 1.3715 4.7818 0.6796
8.1241 0.9098 4.9191 0.018273 -0.142647 0.170437 0.036800 -0.009866 -0.011956 0.005604 0.003480
Terrapene coahuila FMNH 47372 29.5200 19.2300 11.5400 3.8163 small - 1 1 1 0 0 0 0 204.7572 2.3112 121.9629 2.0862 24.1926 1.3837 3.1478 0.4980 6.1938
0.7920 7.6857 -0.093951 -0.154729 -0.028508 -0.094613 -0.017467 0.014526 0.006420 0.006027
Terrapene ornata FMNH 23014 27.5700 17.9500 11.0000 3.7359 not webbed - 00 0 0 0 0 0 163.7954 2.2143 79.7702 1.9018 18.3896 1.2646 3.2335 0.5097
5.6547 0.7524 5.6873 -0.002288 -0.060094 0.135904 -0.014517 0.002939 -0.002202 -0.011444 -0.000669
Testudo marginata FMNH 51672 39.4000 26.6300 13.4100 4.1483 not webbed - 00 0 0 0 0 0 210.9351 2.3241 216.9965 2.3365 39.8785 1.6007 4.8056 0.6817
7.5167 0.8760 8.2983 0.119510 0.033860 0.134898 -0.026478 0.010544 -0.000090 -0.004319 0.004227

- Abbreviations:
CS Centroid size
V Volume
CT Cavum tympanum
FO Fenestra ovale
D Distance between cavum tympanum and fenestr ovale

-0.000639 0.000033 0.000294 -0.000220 0.000015 0.000521 0.000458 0.000401 -0.000026 -0.000404 0.000090 0.000403 0.000786 -0.000215 0.000387 -0.000116 -0.000114 0.000138 -0.000595 -0.000012 -0.000324 0.000030 -0.000382 -0.000236 -0.000066 0.000009 0.000056
Mauremys leprosa -0.009424 0.001145 -0.001181 -0.001581 0.000867 0.000334 -0.003902 0.000860 0.000742 -0.000723 0.000061 -0.000075 -0.001562 -0.002999 0.000808 -0.000490 -0.000876 0.000309 -0.000487 -0.000025 -0.001852 -0.000307 0.000169 -0.001490 0.000710 -0.000392 -0.000679
0.000674 0.000397 -0.000830 0.000155 0.000116 -0.000168 0.000075 0.000482 0.000164 0.000331 -0.000208 0.000341 -0.000132 -0.000740 0.000309 0.000032 -0.000939 -0.000246 0.000261 0.000104 -0.000354 -0.000198 -0.000125 0.000022 -0.000096 0.000110 0.000115 0.000185
Notocyclus platynota -0.007353 0.006423 -0.004236 -0.001044 -0.002076 0.002575 -0.000331 0.001038 0.001493 0.000297 0.001397 -0.001270 0.000968 -0.000117 0.001140 -0.001045 0.000872 -0.000230 0.001123 -0.000157 -0.000581 0.000337 0.000149 -0.000457 0.000268 -0.000368 0.000446 0.000363
-0.000426 -0.000445 0.000437 0.000656 -0.000411 0.000347 -0.000258 0.000443 -0.000420 -0.000340 -0.000067 0.000236 -0.000405 -0.000145 0.000076 0.001380 0.000373 0.000620 0.000088 0.000308 -0.000046 0.000194 0.000407 -0.000069 -0.000132 0.000129 0.000089
Pelodiscus sinensis 0.007625 -0.004974 0.007494 -0.007004 -0.001761 -0.003894 -0.000128 -0.000087 0.000933 0.000452 -0.001383 -0.000179 0.000654 -0.000913 -0.000104 0.001666 -0.001261 -0.000502 -0.000503 -0.001049 -0.000049 0.000687 0.0002014 0.000429 -0.001366 -0.000481 0.000128
-0.001124 -0.000463 0.000063 0.000111 0.000355 0.000097 -0.000049 0.000367 -0.000578 -0.000794 0.000217 0.000753 0.000229 -0.000048 -0.000542 0.000582 -0.000253 0.000070 0.000318 0.000146 -0.000042 -0.000019 0.000142 0.000074 0.000389 -0.000053 0.000046 0.000039
Pelomedusa subrufa -0.010142 0.005262 0.004547 0.009999 -0.000237 -0.001370 0.000803 0.007021 -0.000582 -0.000090 -0.002514 -0.002379 -0.001554 0.000735 -0.001421 -0.000083 0.000469 -0.000881 0.000582 0.001709 -0.000805 -0.000357 0.000707 -0.000071 -0.000704 -0.000245 0.000738
0.000315 -0.000773 -0.000477 -0.000526 -0.000473 -0.000013 -0.000269 -0.000312 -0.000016 -0.000097 -0.000018 -0.000026 -0.000357 -0.000668 0.000188 -0.000115 -0.000326 0.000357 0.000360 -0.000266 0.000144 0.000023 0.000187 -0.000012 0.000092 0.000181 -0.000200 -0.000019
Peltoccephalus dumerilianus -0.002464 0.000222 0.006771 -0.011935 -0.001255 -0.000613 0.006274 -0.003994 -0.004204 -0.003899 0.003993 0.001307 -0.001739 -0.002969 -0.001755 -0.000039 0.000685 0.000660 0.001656 0.000306 0.000278 0.000603 -0.000759 -0.000226 -0.000548 -0.000354
0.000005 0.000672 -0.000680 0.000052 0.000435 -0.000197 -0.000101 -0.000231 -0.000045 0.000022 -0.000346 0.000166 0.000599 -0.000021 -0.000083 0.000228 0.000145 -0.000008 0.000007 -0.000098 -0.0000159 -0.000001 0.000002 -0.000004 0.000213 -0.000134 0.000194 0.000026 0.000006
Phrynosoma geoffroyana -0.019956 -0.019036 0.002230 -0.002667 -0.002448 0.000713 -0.000048 -0.004079 0.000205 -0.001570 0.000042 -0.000081 -0.000843 0.001124 0.001608 -0.000132 0.000792 -0.000807 -0.000106 -0.001504 0.000076 0.001476 0.000150 0.000898 -0.000621 0.000010 -0.000242
0.000719 0.000208 0.000394 -0.001131 -0.000242 0.000216 0.000170 -0.000007 -0.000103 0.000060 0.000235 0.001093 0.000358 0.000315 0.000691 0.000019 -0.000280 0.000260 0.000226 -0.000134 0.000069 -0.000036 0.000414 -0.000087 0.000145 0.000008 0.000251 0.000001
Platysternon megacephalum -0.006624 0.007365 0.003841 0.005119 -0.005299 0.000567 0.000333 0.005005 0.000227 -0.000297 0.003808 -0.001795 0.001562 -0.002035 0.002163 0.001436 -0.000465 0.001065 -0.001060 -0.001047 0.001537 0.001119 0.001232 0.001977 0.001258 0.001967 -0.000129 -0.000341 0.000946
0.000058 0.000078 0.000037 -0.000176 -0.000012 -0.000048 -0.000093 0.000384 0.000102 0.000167 0.000406 -0.000297 -0.000013 -0.000200 0.000066 -0.000012 -0.000066 -0.000227 -0.000047 -0.000023 -0.000062 0.000035 0.000008 0.000244 -0.000072 0.000005
Podocnemis unifilis -0.001564 0.002465 0.004851 0.003767 -0.000149 -0.003037 0.009501 -0.001188 -0.003638 -0.001196 -0.002195 0.002474 0.000377 -0.002192 0.000123 -0.002182 0.000481 0.004054 -0.000537 0.000025 -0.002027 0.000352 0.000775 -0.000307 0.000280 -0.000066 0.000706 -0.000608
0.000587 0.000351 -0.000343 0.000160 -0.000475 0.000667 0.000375 -0.000007 0.000050 -0.000241 -0.000108 0.000317 0.000315 -0.000074 -0.000072 0.000212 -0.000205 -0.000106 0.000206 -0.000011 -0.000020 -0.000025 -0.000207 0.000018 -0.000072 0.000172 -0.000011
Psammodromus tentorius 0.026585 -0.012473 0.003671 -0.000253 0.001086 -0.000964 -0.002219 -0.001524 0.001353 0.000950 -0.000384 -0.002332 -0.000170 0.000679 -0.002647 -0.001924 0.001876 -0.000122 -0.000079 0.001633 0.002229 0.001408 0.000951 -0.000712 0.002279 0.000445 0.001279 -0.000319
-0.000095 -0.000170 -0.000286 0.000114 0.000110 -0.000023 0.000715 0.000158 0.000307 0.000064 -0.000050 -0.000367 -0.000224 -0.000382 -0.000175 -0.000028 0.000129 -0.000109 -0.000323 -0.000114 0.000037 0.000110 -0.000045 -0.000006 -0.000038 0.000175 0.000030
Pseudemys concinna -0.002283 -0.000984 -0.006284 -0.008004 -0.000903 -0.001923 0.001003 0.001712 0.000324 0.000845 0.000251 0.001187 0.000517 0.001784 -0.001114 0.000800 -0.000413 -0.000114 0.000347 0.000725 -0.000102 0.001099 -0.000229 0.000670 -0.000439 0.000323 0.000309 0.000563 0.001120
-0.000456 -0.000436 -0.000960 -0.000852 -0.000075 -0.000206 -0.000138 0.000295 -0.000359 0.000243 0.000007 -0.000176 0.000039 0.000391 0.000184 0.000713 -0.000222 0.000413 -0.000678 0.000604 -0.000160 -0.000077 -0.000094 -0.000217 -0.000009 0.000025
Pseudemys floridana -0.002266 -0.000840 -0.006972 -0.008034 0.000576 -0.000329 -0.001099 0.000624 0.000652 0.000561 -0.000780 0.001806 -0.000554 0.000219 0.000537 0.000369 0.000772 0.000108 0.000684 0.000464 0.000955 0.001251 -0.001122 -0.000047 -0.000041 0.000562 0.000080 -0.000446 0.000200
-0.000528 -0.000884 -0.000777 0.000001 -0.000291 0.000130 0.000616 0.000391 -0.000280 0.000518 0.000326 -0.000274 -0.000582 -0.000304 -0.000077 -0.000280 0.000273 0.000537 0.000907 -0.000378 -0.000090 -0.000348 0.000071 0.000045 -0.000052 -0.000013
Rhinclemmys melanosterna -0.004501 0.007308 -0.003314 0.004674 0.003182 0.000953 0.001224 -0.000844 -0.000661 0.001714 -0.000398 -0.004421 -0.000210 0.000700 -0.001549 -0.000469 0.001092 0.001012 -0.000084 -0.000942 0.000733 0.001904 0.000175 0.000657 -0.001358 -0.000990 -0.000590
-0.000591 0.001269 -0.000314 0.000126 -0.000148 0.001213 -0.000358 -0.000121 0.000171 0.000257 0.000029 0.000181 -0.000219 -0.000009 0.000234 0.000005 0.000092 -0.000542 0.000358 0.000146 -0.000319 -0.000135 -0.000113 0.000076 -0.000422 -0.000085 0.000117 -0.000051
Rhinclemmys pulcherrima -0.007812 0.005048 -0.002388 -0.000272 0.001580 0.000828 -0.001364 -0.000307 0.000638 0.000166 -0.000055 -0.002315 -0.001477 0.000201 0.000205 0.000036 -0.000467 -0.000024 -0.000159 -0.000278 -0.000664 0.001828 -0.000300 -0.000660 -0.000263 -0.000035
-0.000478 -0.000929 -0.000380 0.000127 0.000549 0.000346 -0.000160 -0.000383 0.000590 -0.000157 -0.000492 -0.000629 0.000222 -0.000165 -0.000278 0.000918 -0.000057 0.000425 0.000269 -0.001153 -0.000147 0.000230 -0.000064 0.000137 -0.000511 0.000121 -0.000035 -0.000101 0.000019
Staurotyphlus salvinii -0.009229 -0.010820 0.005775 -0.000036 0.002327 -0.003916 0.000021 0.001241 0.000308 -0.001755 -0.000353 0.001310 -0.000710 -0.000128 -0.000359 0.000242 -0.003040 -0.000107 -0.001235 0.001071 0.000959 -0.002346 -0.000291 0.001202 -0.000284 -0.000524 0.000805
-0.000177 0.000841 0.000246 -0.000526 0.000756 0.000498 -0.000593 0.000178 0.000305 0.000186 -0.000123 0.000078 -0.000128 0.000020 0.000441 0.000229 0.000549 0.000151 0.000211 -0.000387 0.000162 -0.000214 -0.000487 -0.000164 -0.000055 -0.000161 0.000042 0.000033
Sternotherus minor -0.009866 -0.011956 0.005604 0.003480 0.000491 -0.003438 0.000332 0.000844 0.003338 -0.001097 -0.001115 0.000911 0.004412 -0.000172 0.001019 -0.000405 -0.002328 -0.000894 0.000120 -0.000646 0.000463 0.001399 0.000224 -0.001046 -0.000892 -0.000081 -0.000370 0.000364
-0.000374 -0.000715 0.000575 -0.000227 -0.000313 0.000720 -0.000483 -0.000097 0.0000548 -0.000267 0.000577 -0.000297 0.000449 -0.000149 -0.000609 -0.000089 -0.000073 -0.000038 -0.000429 0.000069 0.000044 0.000250 -0.000072 -0.000234 -0.000082 -0.000075 -0.000047
Terrapene carolina -0.017467 0.014526 0.006420 0.006027 0.007050 0.008799 0.002253 -0.000641 0.001575 0.000425 0.000532 0.001431 -0.000270 0.000713 -0.000377 0.000093 -0.001620 -0.001414 -0.001055 -0.000352 0.000158 -0.000477 0.000225 -0.000299 0.000735 0.000226 0.000128 -0.000134 -0.000264
0.000006 -0.000274 -0.000134 -0.000142 -0.000019 -0.000137 0.000067 0.000698 0.000017 0.000108 0.000106 0.000050 -0.000007 0.000168 0.000045 0.000002 0.000005 -0.000021 -0.000044 0.000006 0.000134 0.000028 0.000013 0.000039 -0.000021 0.000009
Terrapene ornata 0.002939 -0.002202 -0.011444 -0.000669 0.003012 0.002309 -0.003323 -0.001501 -0.002079 -0.001641 0.000221 0.000707 -0.000612 -0.000667 -0.000389 0.000813 -0.000647 0.000408 0.000648 0.000340 -0.000183 -0.000330 0.000242 -0.000094 -0.001754 0.000850 0.001751 -0.000981
0.000024 0.000547 0.000352 0.000129 0.000310 -0.000356 -0.000633 -0.000389 0.000819 0.001152 0.000017 -0.000350 -0.000297 -0.000131 -0.000441 0.000299 -0.000162 -0.000046 -0.000145 -0.000045 0.000167 0.000122 -0.000022 0.000035 0.000092 0.000040 0.000075
Testudo marginata 0.010544 -0.000090 -0.004319 0.004227 -0.000636 -0.003968 0.002921 -0.000448 -0.001350 -0.000450 0.000249 0.002637 0.000800 -0.001232 -0.000686 0.0001233 -0.000453 -0.000249 -0.002406 0.000542 0.000180 0.000711 -0.001878 -0.000050 0.000875 0.000933 -0.000618 -0.000997
-0.000603 -0.001884 0.000453 0.000305 0.000621 -0.000222 -0.000087 -0.000139 -0.000282 0.000515 -0.000761 0.000052 0.000013 0.000368 0.000166 -0.000086 0.000053 0.000223 0.000179 0.000080 0.000132 0.000177 0.000050 -0.000012 -0.000228 -0.000068 0.000016

% Variance 39.488019 17.566809 10.938477 8.601069 4.029454 3.052191 2.807890 1.964856 1.521204 1.275720 1.029773 0.911694 0.749610 0.659395 0.553857 0.503167 0.467870 0.430386 0.375128 0.326784 0.323196 0.304293 0.230703 0.212771 0.193446 0.147563 0.139120 0.128484 0.111399 0.086498 0.076787 0.068771 0.067971 0.059911
0.055274 0.052336 0.051878 0.046003 0.044154 0.043806 0.043364 0.039597 0.032593 0.031737 0.028252 0.026355 0.020967 0.019111 0.013836 0.012867 0.012712 0.008692 0.006441 0.004932 0.000827

Table S5. Results of phylogenetic flexible discriminant analyses (pFDA) exploring shape of the lateral middle ear cavity against habitat preferences for morphometric measurements and principal components.

	Forelimb1	Forelimb2	Forelimb3	Forelimb4	Forelimb5	Forelimb6
"Middle ear volume, length of columella, size of cavum tympani, size of fenestra ovale (all log-transformed)"						
Lambda	0.17	0.16	0.22	0.21	0.24	0.36
Error	0.43	0.41	0.46	0.43	0.29	0.14
"Length of columella, size of cavum tympani, size of fenestra ovale (all log-transformed)"						
Lambda	0.2	0.19	0.24	0.23	0.27	0.36
Error	0.61	0.54	0.55	0.5	0.39	0.14
"Size of cavum tympani, size of fenestra ovale (all log-transformed)"						
Lambda	0.22	0.21	0.27	0.26	0.3	0.36
Error	0.59	0.52	0.59	0.54	0.41	0.14
PC1 -PC4 (PCA from SPHARM analysis)						
Lambda	0.09	0.05	0.14	0.1	0.11	0.22
Error	0.3	0.3	0.34	0.3	0.27	0.09

Table S6. Results of the D.pGLS testing ecological constraints (Forelimb1 to Forelimb6) for middle ear measurements and shape.

PC 1-4	logCS	Forelimb01	Forelimb02	Forelimb03	Forelimb04	Forelimb05	Forelimb06
Sums of squares	0.00001	0.00001	0.00001	0.00000	0.00000	0.00000	0.00000
Mean square	0.00001	0.00001	0.00001	0.00000	0.00000	0.00000	0.00000
R ²	0.03005	0.03431	0.04373	0.01181	0.01287	0.01089	0.02730
F value	1.67290	1.91870	2.46950	0.64510	0.70390	0.59430	1.51530
Z score	0.91662	1.19550	1.35980	0.42370	0.34183	0.01547	1.54380
p value	0.16900	0.09900	0.06200	0.35900	0.38200	0.50800	0.04800

all PCs

Sums of squares	0.00001	0.00001	0.00001	0.00000	0.00000	0.00000	0.00001
Mean square	0.00001	0.00001	0.00001	0.00000	0.00000	0.00000	0.00001
R ²	0.02819	0.03243	0.03945	0.01314	0.01454	0.01225	0.02284
F value	1.56640	1.80970	2.21800	0.71890	0.79690	0.66980	1.26240
Z score	1.04210	1.46070	1.63620	0.53814	0.42817	-0.07725	1.74580
p value	0.14900	0.07600	0.05300	0.31000	0.34000	0.50800	0.05100

"logV,logD,logCT, logFO"

Sums of squares	0.00160	0.00159	0.00175	0.00166	0.00099	0.00201
Mean square	0.00160	0.00159	0.00175	0.00166	0.00099	0.00201
R ²	0.03323	0.03307	0.03626	0.03454	0.02049	0.04182
F value	1.85620	1.84710	2.03190	1.93200	1.12960	2.35700
Z score	1.16950	1.05610	1.65940	1.41260	0.70197	1.97770
p value	0.11300	0.13400	0.03300	0.06100	0.24500	0.02500

"logD,logCT, logFO"

Sums of squares	0.00115	0.00099	0.00171	0.00156	0.00066	0.00197
Mean square	0.00115	0.00099	0.00171	0.00156	0.00066	0.00197
R ²	0.02668	0.02290	0.03959	0.03614	0.00153	0.04560
F value	1.48010	1.26580	2.22620	2.02470	0.84040	2.58000
Z score	0.91184	0.68551	1.59060	1.35990	0.42168	1.82530
p value	0.18200	0.26100	0.03100	0.06300	0.36200	0.01400

"logCT, logFO"

Sums of squares	0.00115	0.00099	0.00170	0.00156	0.00065	0.00197
Mean square	0.00115	0.00099	0.00170	0.00156	0.00065	0.00197
R ²	0.02857	0.02457	0.04229	0.03870	0.01616	0.04892
F value	1.58820	1.36010	2.38430	2.17400	0.88690	2.77730
Z score	0.93546	0.73292	1.49420	1.28780	0.48412	1.66370
p value	0.17200	0.23500	0.02800	0.06100	0.34300	0.01400