

SUPPLEMENTARY MATERIAL

Appendix S1: Volume Renderings and CT Scan Slice Examples of the Specimens



Figure S1.1: Volume rendering of *Desmatochelys lowii*



Figure S1.2: Cross-section images of *Desmatochelys lowii*. A: coronal plane, B: saggital plane
C: transverse plane.



Figure S1.3: Volume rendering of the *Eretmochelys imbricata*.



Figure S1.4: Cross-section images of *Eretmochelys imbricata*. A: coronal plane, B: saggital plane C: transverse plane.

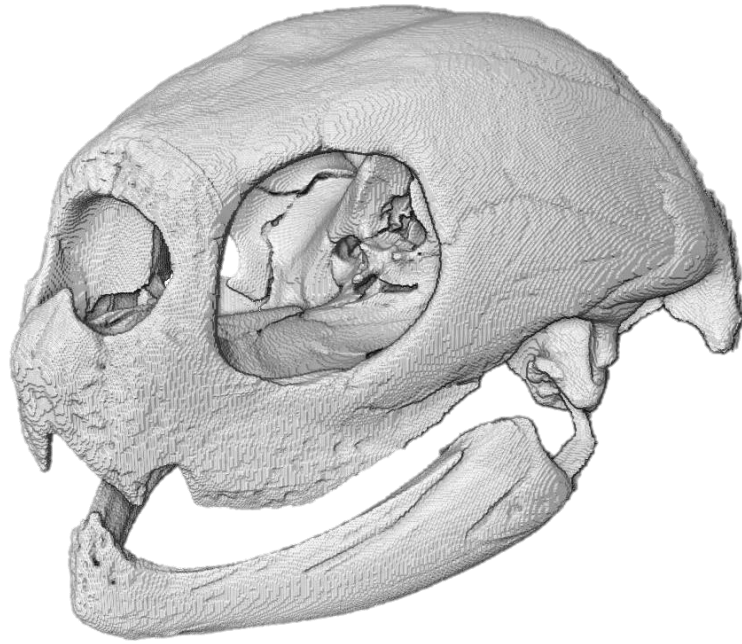


Figure S1.5: Volume rendering of *Dermochelys coriacea*.

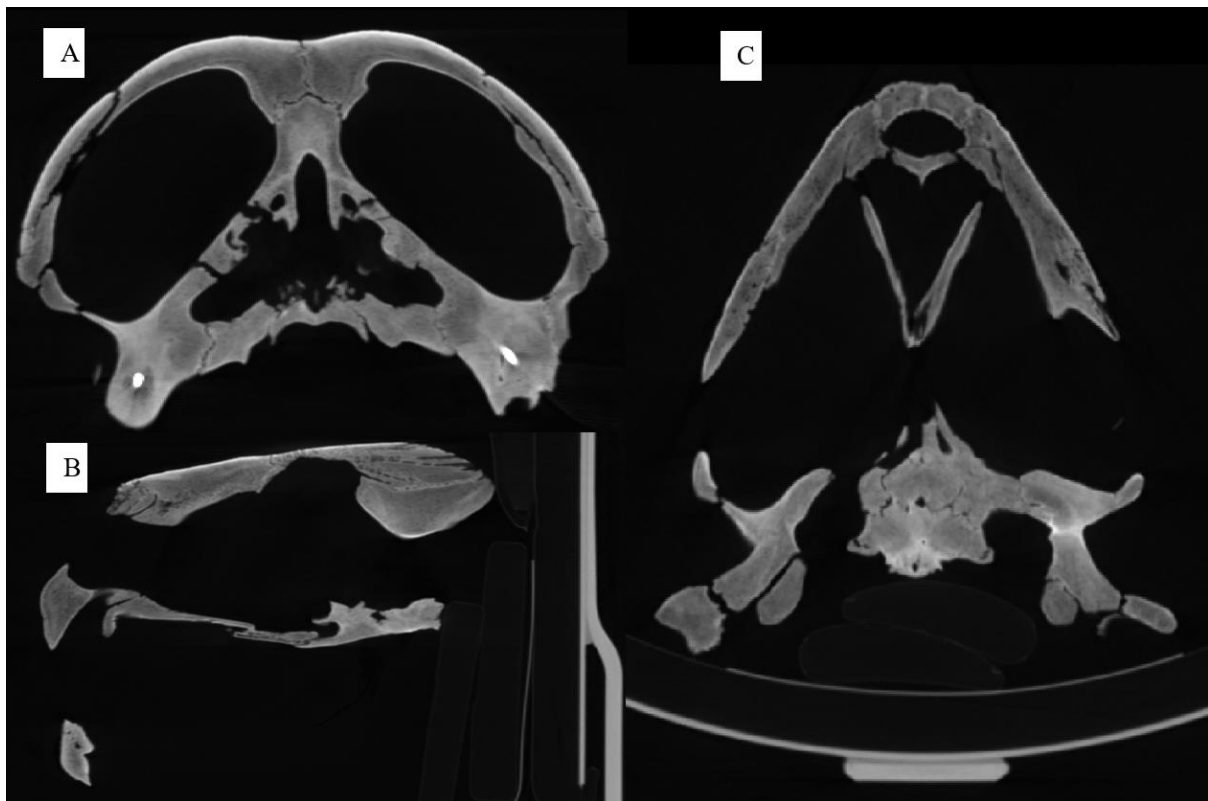


Figure S1.6: Cross-section images of *Dermochelys coriacea*. A: coronal plane, B: saggital plane
C: transverse plane.

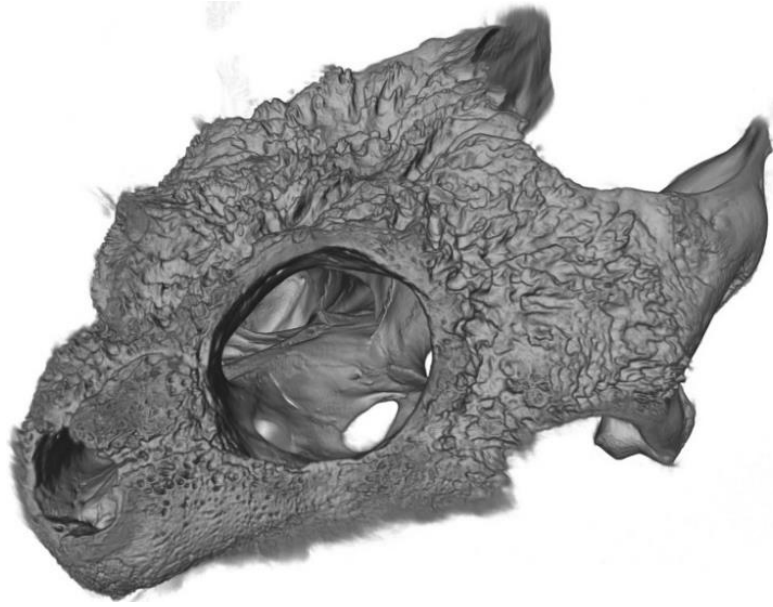


Figure S1.7: Volume rendering of *Chelydra serpentina*.

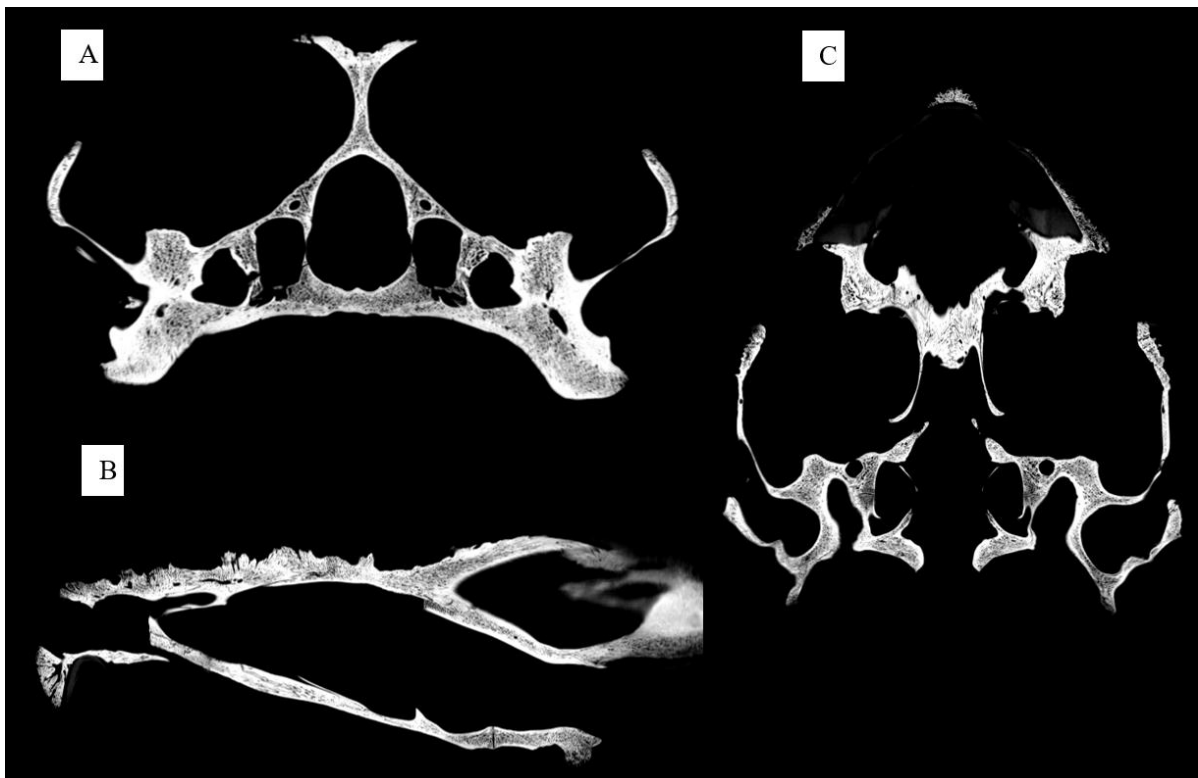


Figure S1.8: Cross-section images of *Chelydra serpentina*. A: coronal plane B: saggital plane C: transverse plane.

Appendix S2: List of Segmented Bones

Out of four specimens, in total 81 skull bones were segmented. Every bone was segmented only once per specimen, although some bones occur twice in a skull, e.g. the parietals.

Table S2.1: Segmented bones listed for each specimen. 0 = absent, 1 = present, ? = determination unclear.

	ossified elements	<i>Desmatochelys lowii</i>	<i>Eretmochelys imbricata</i>	<i>Dermochelys coriacea</i>	<i>Chelydra serpentina</i>
dermal roofing	Nasal	1	0	0	0
	Prefrontal	1	1	1	1
	Frontal	1	1	1	1
	Parietal	1	1	1	1
	Poostorbital	1	1	1	1
	Jugal	1	1	1	1
	Quadratojugal	1	1	1	1
	Squamosal	1	1	1	1
palate	Premaxilla	1	1	1	1
	Maxilla	1	1	1	1
	Vomer	1	1	1	1
	Palatine	1	1	1	1
basicranium & braincase	Pterygoid	1	1	1	1
	Epipterygoid	1	?/1	0	1
	Basisphenoid	1/?	1	1	1
	Parasphenoid	?	0	1	?/1
	Prootic	1	1	1	1
	Opistotic	1	1	1	1
	Quadratojugal	1	1	1	1
	Basioccipital	1/?	1	1	1
	Exoccipital	1	1	1	1
	Supraoccipital	1	1	1	1

Appendix S3: Phenetic Analysis-Tables

Table S3.1: Bone contacts in *Desmatochelys lowii*. p: parallel; o: overlapping; u: underlying; c: clasping; cb: clasped by; t: vertically transverse; s: smooth; if: faintly interfingering; im: moderately interfingering; ?: determination unclear

A	B	Na	Pf	Fr	Pa	Po	Ju	Qj	Sq	Pm	Mx	Vo	Pal	Pt	Epi	Bs	Ps	Pr	Op	Qu	Bo	Exo	So
	Nasal	p+if	o	u							o+is												
	Prefrontal	u		o+im							u+is, c	u+s, o+ is, p+hi	u?										
	Frontal	o	u+im	p+im	o+im	u+im								t+is	t			t+im					o
	Parietal			u+im	p+im	u+if																	
	Postorbital			o+im	o+if		c	o+is	o+s, cb u+s, c														
	Jugal					cb		o			o+im												
	Quadratojugal					u+is	u	o												s			
	Squamosal					u+s, c o+s, c		u											p	u+if, c			
	Premaxilla									p+im	p	p?											
	Maxilla	u+is	o+is, cb				u+im			p		u?cb?	cb, o										
	Vomer		o+s, u+ is, p+hi							p?	o?c?	-	u?+i										
	Palatine		o?								c, u	o?+i	p+im	u+hi									
	Pterygoid				t+is								o+hi	p+hi	t	?		?	c+if	?			
	Epipterygoid				t									t									
	Basisphenoid													?							?		?
	Parashipenoid																						
	Prootic				t+im									?					o	p+if			t, p
	Opisthotic							p						?				u		p, u, p			p
	Quadrate						s	o+if, cb						cb+if				p+if	p, o, p				
	Basioccipital													?							-		?
	Exoccipital																						?
	Supraoccipital				u													t, p	p				-

Tab. S3.2: Bone contacts in *Eretmochelys imbricata*. p: parallel; o: overlapping; u: underlying; c: clasping; cb: clasped by; t: vertically transverse; s: smooth; if: faintly interfingering; im: moderately interfingering; ?: determination unclear.

	A	B	Na	Pf	Fr	Pa	Pa	Po	Ju	Qj	Sq	Pm	Mx	Vo	Pal	Pt	Epi	Bs	Ps	Pr	Op	Qu	Bo	Exo	So
		Nasal																							
		Prefrontal		p+im	o+im								t+is	p+is											
		Frontal		u+im	p+im	o+im, cb+is	u+im																		o+is, o+is
		Parietal			u+im, c+is	p+im	p+im				p+is					t+is									
		Postorbital			o+im	p+im			t+im	p+is	p+is														
		Jugal					t+im			o+is			o+im		c+s										
		Quadratojugal						p+is	u+is		t+im											p+im			
		Squamosal					p+is	p+is														c+if	p+im		
		Premaxilla										p+im	o+im	o+is											
		Maxilla		t+is					u+im			u+im		p+im, o+im	o+im, cb+im, p+im										
		Vomer		p+is								u+is	p+im, u+im	-	o+is, s, u+if	o+im									
		Palatine											u+im, c+im, p+im	u+is, s, o+if	o+im										
		Pterygoid					t+is							u+im	u+im	p+im	u+s, u+im, cb+im					u+im	cb+im, o+im	u+is	
		Epipterygoid																							
		Basisphenoid															o+is, o+im, c+im								p+s, u+is
		Parashphenoid																							
		Prootic																							t+im
		Opisthotic									cb+if														o+s+im
		Quadrat								p+im															
		Basioccipital																							u+im
		Exoccipital																							t+is, cb
		Supraoccipital					u+s, u+is																		t+is, c

Tab. S3.3: Bone contacts in *Dermochelys coriacea*. p: parallel; o: overlapping; u:

underlying; c: clasping; cb: clasped by; t: vertically transverse; s: smooth; if: faintly

interfingering; im: moderately interfingering; ?: determination unclear.

A	B	Na	Pf	Fr	Pa	Po	Ju	Qj	Sq	Pm	Mx	Vo	Pal	Pt	Epi	Bs	Ps	Pr	Op	Qu	Bo	Exo	So
	Nasal																						
	Prefrontal		p+if	cb+if		o+is					t+if	t+s											
	Frontal		c+if	p+im	cb+if	c+if																	o+s, o+if
	Parietal			c+if	p+im	u+im			c,u+s														
	Postorbital		u+is	cb+if	o+im		c+if	t+s	o+if														
	Jugal					cb+if		o+if	t+s		o+is												
	Quadratopugal					t+s	u+if		cb+if											o+im, p+if			
	Squamosal				cb,o+s	u+if	t+s	c+if												o+if, p+im,cb			
	Premaxilla									p+if	p+if	o+s											
	Maxilla		t+if				u+is			p+if			p+im										
	Vomer		t+s							u+s		-	p+if, o+s	o+s									
	Palatine										p+im	p+if, u+s		o+s, u+s									
	Pterygoid											u+s	u+s, o+s	p+is		p+is	o+if	t+if		u+im	cb+im		
	Epipterygoid																						
	Basisphenoid													p+is	-	p+if	t+s					p+im	
	Parashphenoid													u+if		p+if	-					u+if	
	Prootic													t+if		t+s			p+im	p+im			p+if
	Opisthotic																	p+im		cb+if		o+if	p+if
	Quadrate							u+im, p+if	u+if, p+im,c					o+im				p+im	c+if				
	Basioccipital													c+im		p+im	o+if				-	u+im	
	Exoccipital																					u+im	
	Supraoccipital				u+s, u+if													p+if	p+if			o+im	-

Tab. S3.4: Bone contacts in *Chelydra serpentina*. p: parallel; o: overlapping; u: underlying; c: clasping; cb: clasped by; t: vertically transverse; s: smooth; if: faintly interfingering; im: moderately interfingering; ?: determination unclear.

A	B	Na	Pf	Fr	Pa	Po	Ju	Qj	Sq	Pm	Mx	Vo	Pal	Pt	Epi	Bs	Ps	Pr	Op	Qu	Bo	Exo	So
	Nasal																						
	Prefrontal	p+im	c+im, p+im		o+if					t+is, p+im	c+is	o+im											
	Frontal	cb+im, p+im	p+if	o+is, p+im	p+im																		
	Parietal		u+is, p+im	p+if	o+im									t+s	o+if, c+s								o+im
	Postorbital	u+if	p+im	u+im			t+if, p+im	p+if	p+im		o+im		p+s	cb+is									
	Jugal					t+if, p+im		p+if															
	Quadratojugal				p+im	p+if			c+if											p+im			
	Squamosal				p+im			cb+if												p+im	c+if		
	Premaxilla									p+im	p+im	cb+im											
	Maxilla	t+is, p+im			u+im					p+im	o+if	cb+if	cb+im										
	Vomer	cb+is								c+im	u+if		u+if	cb+im									
	Palatine	u+im					p+s				c+if	o+if	cb+im										
	Pterygoid						c+is				c+im	c+im	c+im	p+is	u+im, t+s	u+s, p+im	o+s	u+if, cb+s		u+if	cb+if	u+im	
	Epipterygoid				t+s									o+im, t+s									
	Basisphenoid													o+s, p+im			p+if	p+im, p+s			p+s, p+im		
	Parashphenoid													u+s		p+if							
	Prootic			u+if, cb+s										o+if, c+s	p+im, p+s				p+s	p+im			o+im, p+s
	Opisthotic								p+im									p+s		c+is	(p+s)	o+is	p+s
	Quadrate							p+im	cb+if					o+if				p+im	cb+is				
	Basioccipital													c+if	p+s, p+im				(p+s)		-	?	
	Exoccipital													o+im					u+is		?	?	u+im, cb
	Supraoccipital				u+im										u+im, p+s				p+s				o+im, c

Appendix S4: Backbone Constraint Tree Topology

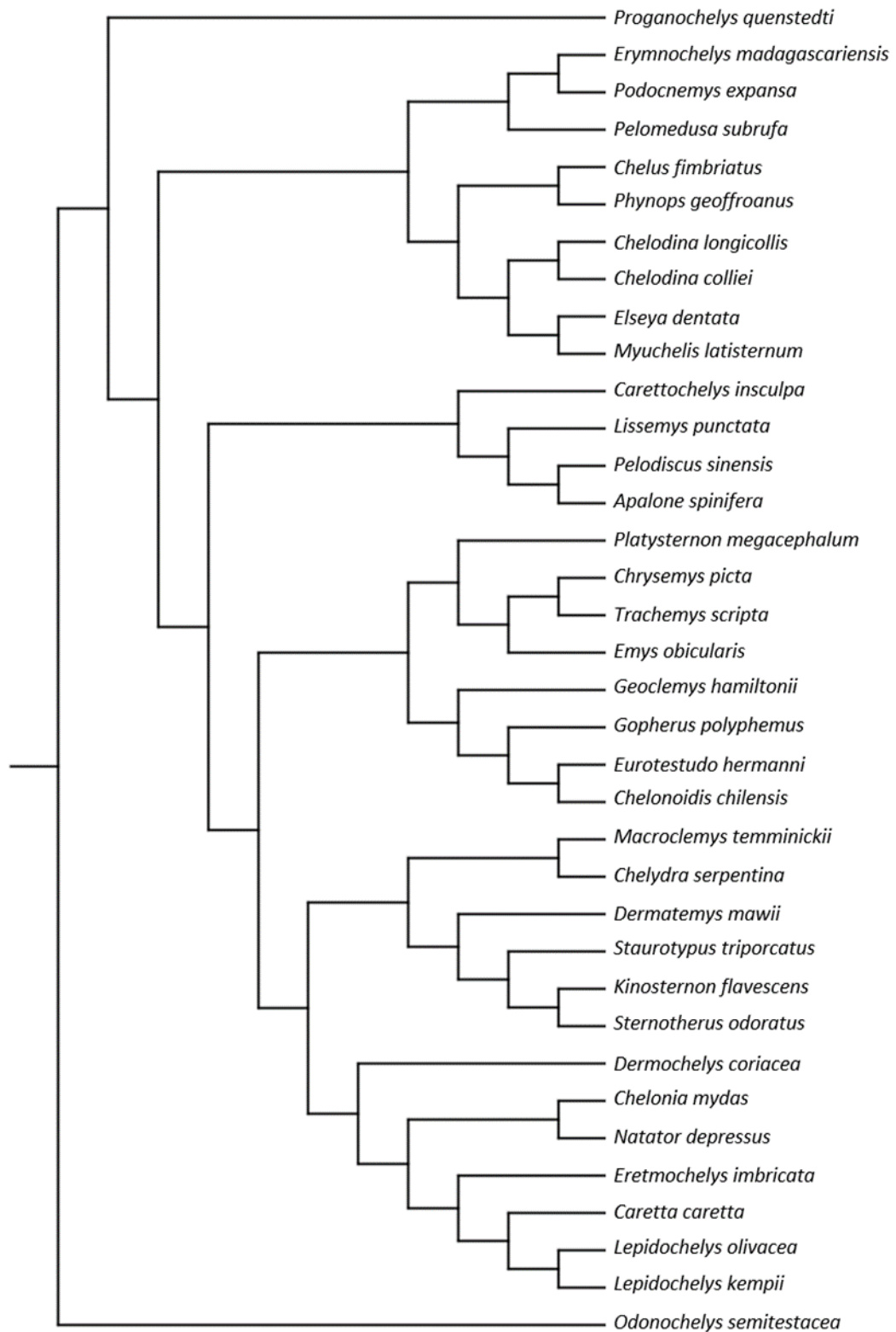


Figure S4.1: Backbone constraint tree topology after Crawford et al. 2015

Appendix S5: Inactive Taxa

Inactive taxa (81/154) from the initial matrix of Cadena & Parham (2015)

1	<i>Annemys latiens</i>	28	<i>Chisternon undatum</i>	55	<i>Niolamia argentina</i>
2	<i>Basilochelys macrobios</i>	29	<i>Chitracephalus dumonii</i>	56	<i>Notoemys laticentralis</i>
3	<i>Changmachelys bohlini</i>	30	<i>Condorchelys antiqua</i>	57	<i>Notoemys oxfordiensis</i>
4	<i>Eileanchelys waldmani</i>	31	<i>Corsochelys haliniches</i>	58	<i>Notoemys zapatoacaensis</i>
5	<i>Chubutemys copelloi</i>	32	<i>Ctenochelys stenoporus</i>	59	<i>Ocepechelon bouyai</i>
6	<i>Liaochelys jianchangensis</i>	33	<i>Dinochelys whitei</i>	60	<i>Ordosemys skull</i>
7	<i>Manchurochelys</i>	34	<i>Dorsetochelys delairi</i>	61	<i>Patagoniaemys gasparinae</i>
8	<i>manchoukuoensis</i>	35	<i>Echmatemys wyomingensis</i>	62	<i>Peligrochelys walshae</i>
9	<i>Otwayemys cunicularius</i>	36	<i>Eochelone brabantica</i>	63	<i>Platychelys oberndorferi</i>
10	<i>Plastomenus aff. thomassii</i>	37	<i>Erquelinnesia gosseleti</i>	64	<i>Portlandemys macdowellii</i>
11	<i>Sinemys brevispinus</i>	38	<i>Euclastes acutirostris</i>	65	<i>Prochelidella cerrobarcinae</i>
12	<i>Styemys nebrascensis</i>	39	<i>Euclastes platyops</i>	66	<i>Procolpochelys grandaeva</i>
13	<i>Xenochelys Formosa</i>	40	<i>Euclastes wielandi</i>	67	<i>Proterochersis robusta</i>
14	<i>Adocus amtgai</i>	41	<i>Heckerochelys romani</i>	68	<i>Protochelydra zangerli</i>
15	<i>Alienochelys selloumi</i>	42	<i>Helochelydra nopcsai</i>	69	<i>Rhinochelys pulchriceps</i>
16	<i>Allopleuron hoffmanni</i>	43	<i>Hoplochelys crassa</i>	70	<i>Sandownia harrisi</i>
17	<i>Angolachelys mbaxi</i>	44	<i>Hoyasemys jimenezi</i>	71	<i>Shachemys laosiana</i>
18	<i>Argillochelys africana</i>	45	<i>Indochelys spatulata</i>	72	<i>Siamochelys peninsularis</i>
19	<i>Argillochelys cuneiceps</i>	46	<i>Itlochelys rasstrigin</i>	73	<i>Sinemys gamera</i>
20	<i>Ashleychelys palmeri</i>	47	<i>Lophochelys</i>	74	<i>Syllomus aegyptiacus</i>
21	<i>Basilemys variolosa</i>	48	<i>Macroclmemy schmidti</i>	75	<i>Tasbacka aldabergeni</i>
22	<i>Brachyopsemys tingitana</i>	49	<i>Mexichelys coahuilaensis</i>	76	<i>Tasbacka ouledabdounensis</i>
23	<i>Calcarichelys gemma</i>	50	<i>Mongolemys elegans</i>	77	<i>Terlinguachelys fischbecki</i>
24	<i>Carolinochelys wilsoni</i>	51	<i>Mongolochelys efremovi</i>	78	<i>Warkalania carinaminor</i>
25	<i>Chelonoidis gringorum</i>	52	<i>Neurankylus eximius</i>	79	<i>Xinjiangchelys junggarensis</i>
26	<i>Chelosphargis advena</i>	53	<i>Nichollsemys bareri</i>	80	<i>Yaminuechelys maior</i>
27	<i>Chengyuchelys</i>	54	<i>Ninjemy oweni</i>	81	<i>Yehguia ta</i>

82

