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Evidence for prey preference partitioning in the Middle Eocene high-diversity crocodylian assemblage of the Geiseltal-Fossillagerstätte, Germany utilizing skull shape analysis

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Supplementary Material

Table S1. List of specimens for extant crocodylian data set used for geometric morphometric analysis (n = 218). **Institutional Abbreviations: AMNH**, American Museum of Natural History, Herpetological Collections, New York, NY, USA; **CMNH**, Carnegie Museum of Natural History; **ICN**, Herpetological Collections of the Universidad Nacional, Bogotá, Colombia; **UF-H**, University of Florida, Florida Museum of Natural History, Herpetology, Gainesville, FL USA; **UF-VP**, University of Florida, Florida Museum of Natural History, Vertebrate Paleontology, Gainesville, FL USA; **USNM**, Smithsonian United States Natural History Museum, Washington D.C. USA.

Taxon	Collection	Specimen #
Alligator		
A. mississippiensis	UF-H	39618
A. mississippiensis	UF-H	22215
A. mississippiensis	UF-H	34788
A. mississippiensis	UF-H	34886
A. mississippiensis	UF-H	35156
A. mississippiensis	UF-H	37230
A. mississippiensis	UF-H	39106
A. mississippiensis	UF-H	42548
A. mississippiensis	UF-H	42872
A. mississippiensis	UF-H	43151
A. mississippiensis	UF-H	50125
A. mississippiensis	UF-H	61483
A. mississippiensis	UF-H	67824
A. mississippiensis	UF-H	84197
A. mississippiensis	UF-H	109038
A. mississippiensis	UF-H	10941
A. mississippiensis	UF-VP	147700
A. mississippiensis	UF-VP	177250
A. sinensis	UF-H	67829
A. sinensis	UF-H	105540
A. sinensis	AMNH	R-139672
A. sinensis	AMNH	R-139673
A. sinensis	AMNH	R-23898
A. sinensis	AMNH	R-23899
A. sinensis	AMNH	R-23900
A. sinensis	AMNH	R-23901
A. sinensis	AMNH	R-23907

Caiman		
C. crocodilus	CMNH	9997
C. crocodilus	UF-H	19067
C. crocodilus	UF-H	39062
C. crocodilus	UF-H	45439
C. crocodilus	UF-H	80910
C. crocodilus	UF-H	80911
C. crocodilus	UF-H	80912
C. crocodilus	UF-H	80913
C. crocodilus	UF-H	80914
C. crocodilus	UF-H	80915
C. crocodilus	UF-H	80916
C. crocodilus	UF-H	80917
C. crocodilus	UF-H	80918
C. crocodilus	UF-H	80919
C. crocodilus	UF-H	80920
C. crocodilus	UF-H	80921
C. crocodilus	UF-H	80922
C. crocodilus	UF-H	80923
C. crocodilus	UF-H	80924
C. crocodilus	UF-H	80925
C. crocodilus	UF-H	80926
C. crocodilus	UF-H	80927
C. crocodilus	UF-H	80928
C. crocodilus	UF-H	80929
C. crocodilus	UF-H	80930
C. crocodilus	UF-H	80931
C. crocodilus	UF-H	80932
C. crocodilus	UF-H	80933
C. crocodilus	UF-H	80934
C. crocodilus	UF-H	80935
C. crocodilus	UF-H	80936
C. crocodilus	UF-H	80937
C. crocodilus	UF-H	80938
C. crocodilus	UF-H	80939
C. crocodilus	UF-H	80940
C. crocodilus	UF-H	80941
C. crocodilus	UF-H	80942
C. crocodilus	UF-H	80944
C. crocodilus	UF-H	80945
C. crocodilus	UF-H	80946
C. crocodilus	UF-H	80947
C. crocodilus	UF-H	80948
C. crocodilus	UF-H	80949
C. crocodilus	UF-H	80950
C. crocodilus	UF-H	80951
C. crocodilus	UF-H	80952
C. crocodilus	UF-H	80953
C. crocodilus	UF-H	80954
C. crocodilus	UF-H	80959

C. crocodilus	UF-H	154567
C. latirostris	UF-H	62649
C. yacare	UF-H	121231
C. yacare	UF-H	121249
C. yacare	AMNH	R-73622
C. yacare	AMNH	R-97299
C. yacare	AMNH	R-97300
C. yacare	AMNH	R-97303
C. yacare	AMNH	R-97304
C. yacare	AMNH	R-97308
C. yacare	AMNH	R-97309
C. yacare	AMNH	R-97329
C. yacare	AMNH	R-97330
Melanosuchus		
M. niger	UF-H	53600
M. niger	UF-H	62641
M. niger	UF-H	72914
M. niger	AMNH	R-58130
M. niger	AMNH	R-58134
M. niger	AMNH	R-110179
M. niger	AMNH	R-15171
M. niger	AMNH	R-58132
M. niger	AMNH	R-71172
Paleosuchus		
P. palpebrosus	CMNH	113091
P. palpebrosus	UF-H	62509
P. palpebrosus	UF-H	75020
P. palpebrosus	UF-H	75023
P. palpebrosus	UF-H	87980
P. palpebrosus	AMNH	R-137161
P. palpebrosus	AMNH	R-137162
P. palpebrosus	AMNH	R-137170
P. palpebrosus	AMNH	R-93812
P. palpebrosus	AMNH	R-97327
P. palpebrosus	AMNH	R-97328
P. trigonatus	CMNH	113092
P. trigonatus	CMNH	55624
P. trigonatus	CMNH	55625
P. trigonatus	AMNH	R-129259
P. trigonatus	AMNH	R-129260
P. trigonatus	AMNH	R-137174
P. trigonatus	AMNH	R-66391
Crocodylus		
C. acutus	CMNH	145676
C. acutus	CMNH	6450
C. acutus	CMNH	9993
C. acutus	ICN	1850
C. acutus	UF-H	49953
C. acutus	UF-H	54201
C. acutus	UF-H	56429

C. acutus	UF-H	63929
C. acutus	UF-H	115691
C. acutus	UF-H	151167
C. acutus	UF-H	151168
C. intermedius	ICN	1849
C. intermedius	ICN	1851
C. johnstoni	USNM	299810
C. johnstoni	AMNH	R-86540
C. mindorensis	USNM	228407
C. moreletii	UF-H	29160
C. niloticus	UF-H	54812
C. niloticus	UF-H	55787
C. niloticus	UF-H	154251
C. niloticus	AMNH	R-10081
C. niloticus	AMNH	R-23463
C. niloticus	AMNH	R-23464
C. niloticus	AMNH	R-23465
C. niloticus	AMNH	R-23466
C. niloticus	AMNH	R-7134
C. niloticus	AMNH	R-7136
C. niloticus	AMNH	R-127255
C. niloticus	AMNH	R-137239
C. niloticus	AMNH	R-23468
C. niloticus	AMNH	R-23469
C. niloticus	AMNH	R-07852
C. niloticus	AMNH	R-23471
C. niloticus	AMNH	R-24717
C. niloticus	AMNH	R-29291
C. niloticus	AMNH	R-29292
C. novaguinae	UF-H	145927
C. novaguinae	UF-H	149214
C. novaguinae	AMNH	R-64425
C. palustris	AMNH	R-77632
C. palustris	AMNH	R-96134
C. porosus	CMNH	39674
C. porosus	UF-H	71779
C. porosus	UF-H	134586
C. porosus	AMNH	R-32338
C. porosus	AMNH	R-62632
C. porosus	AMNH	R-62633
C. porosus	AMNH	R-66639
C. porosus	AMNH	R-66640
C. porosus	AMNH	R-76853
C. porosus	AMNH	R-24958
C. porosus	AMNH	R-58016
C. porosus	AMNH	R-74958
C. porosus	AMNH	R-15179
C. porosus	AMNH	R-24957
C. porosus	AMNH	R-74957
C. porosus	AMNH	R-06581

C. porosus	AMNH	R-07131
C. porosus	AMNH	R-29949
C. porosus	AMNH	R-58015
C. raninus	AMNH	R-29294
C. rhombifer	UF-VP	225401
C. rhombifer	AMNH	R-154087
C. rhombifer	AMNH	R-57773
C. rhombifer	AMNH	R-75033
C. rhombifer	AMNH	R-77595
C. siamensis	AMNH	R-118712
C. siamensis	AMNH	R-49231
C. siamensis	AMNH	R-72640
Mecistops		
M. cataphractus	UF-H	145926
M. cataphractus	AMNH	R-10075
M. cataphractus	AMNH	R-107634
M. cataphractus	AMNH	R-160902
M. cataphractus	AMNH	R-29300
M. cataphractus	AMNH	R-57772
M. cataphractus	AMNH	R-75424
Osteolaemus		
O. tetraspis	UF-H	33749
O. tetraspis	AMNH	R-10082*
O. tetraspis	AMNH	R-10083
O. tetraspis	AMNH	R-101417
O. tetraspis	AMNH	R-101418
O. tetraspis	AMNH	R-117801
O. tetraspis	AMNH	R-117802
O. tetraspis	AMNH	R-160900
O. tetraspis	AMNH	R-160901
O. tetraspis	AMNH	R-24740
O. tetraspis	AMNH	R-29889
O. tetraspis	AMNH	R-69057
O. tetraspis	AMNH	R-75420
O. tetraspis	AMNH	R-75421
O. tetraspis	AMNH	R-7743
Tomistoma		
T. schlegelii	UF-H	54210
T. schlegelii	UF-H	62020
T. schlegelii	UF-H	84888
T. schlegelii	UF-H	107493
T. schlegelii	USNM	52972
T. schlegelii	AMNH	R-113078
T. schlegelii	AMNH	R-15177
Gavialis		
G. gangeticus	AMNH	R-110145
G. gangeticus	AMNH	R-131377
G. gangeticus	AMNH	R-15176
G. gangeticus	AMNH	R-7138

Table S2. Percent of total variance and correlation statistics generated from the geometric morphometric analysis of all Geiseltal crocodylians. Statistically significant correlations are bolded in red. **Abbreviations**: **RW**, Relative Warp; **ρ**, Pearson's correlation coefficient.

Axis	% of Total Variance	Age		Centroid Size		Taphonomy	
		ρ	p-value	ρ	p-value	ρ	p-value
RW1	12.7000	-0.0962	0.6262	0.2403	0.2181	0.0203	0.9183
RW2	8.8808	-0.0418	0.8329	0.2416	0.2156	0.0366	0.8532
RW3	7.7253	**0.4662**	**0.0124**	**-0.6046**	**0.0007**	0.3269	0.0895
RW4	6.7721	-0.0088	0.9647	-0.2830	0.1445	0.0759	0.7010
RW5	5.9385	-0.2562	0.1883	0.1255	0.5244	-0.3091	0.1095
RW6	5.8992	0.0689	0.7274	0.2011	0.3049	**-0.4492**	**0.0165**
RW7	4.9501	-0.1518	0.4408	0.1783	0.3639	**-0.4533**	**0.0154**
RW8	4.3973	-0.3165	0.1008	0.1534	0.4358	0.0659	0.7389
RW9	4.1082	-0.1620	0.4101	0.0538	0.7856	0.0475	0.8105
RW10	4.2705	-0.0811	0.6815	**0.3795**	**0.0464**	-0.1535	0.4354
RW11	3.8757	0.0020	0.9920	0.0381	0.8474	-0.1420	0.4711
RW12	3.3946	-0.2689	0.1665	0.0729	0.7123	0.0727	0.7133
RW13	3.1647	-0.0577	0.7704	0.1465	0.4570	-0.1390	0.4807
RW14	2.7056	0.0625	0.7522	-0.0215	0.9137	-0.0257	0.8967
RW15	2.2675	-0.0925	0.6395	0.2133	0.2759	0.1456	0.4598
RW16	2.2452	-0.1404	0.4760	0.0186	0.9250	0.1860	0.3433
RW17	2.3901	0.1201	0.5429	-0.2216	0.2571	0.2430	0.2127
RW18	2.0617	0.3046	0.1150	-0.0691	0.7268	0.0732	0.7114
RW19	1.9265	-0.0604	0.7600	0.0921	0.6413	-0.2033	0.2994
RW20	1.8476	0.0070	0.9720	-0.0478	0.8093	0.0925	0.6396
RW21	1.6496	-0.0338	0.8646	-0.1229	0.5331	0.0489	0.8049
RW22	1.5372	0.1756	0.3714	-0.1488	0.4499	0.2381	0.2225
RW23	1.2577	-0.2245	0.2508	0.0145	0.9417	0.1494	0.4481
RW24	1.1142	0.1931	0.3249	-0.0026	0.9896	0.1403	0.4763
RW25	0.9635	0.0550	0.7811	-0.0015	0.9940	-0.0617	0.7551
RW26	1.0731	0.3613	0.0589	0.0147	0.9408	0.0065	0.9737
RW27	0.8833	0.2707	0.1636	-0.0544	0.7833	-0.1795	0.3606

Table S3. Percent of total variance and correlation statistics generated from the geometric morphometric analysis of all *Diplocynodon* specimens (n = 14). Data for this taxon were isolated from the geometric morphometric analysis of all Geiseltal specimens. Statistically significant correlations are bolded in red. **Abbreviations**: **RW**, Relative Warp; **ρ**, Pearson's correlation coefficient.

Axis	% of Total Variance	% of Taxon Variance	Age		Centroid Size		Taphonomy	
			ρ	p-value	ρ	p-value	ρ	p-value
RW1	12.7000	9.9727	0.4371	0.1181	0.2284	0.4323	0.4251	0.1297
RW2	8.8808	9.0088	0.4901	0.0753	0.5065	0.0646	0.2675	0.3552
RW3	7.7253	8.6845	0.1472	0.6157	-0.3243	0.2580	0.1213	0.6795
RW4	6.7721	6.7182	-0.2319	0.4250	-0.0889	0.7626	0.2291	0.4309
RW5	5.9385	6.0218	-0.3449	0.2272	-0.3144	0.2736	-0.2267	0.4357
RW6	5.8992	7.0127	0.0503	0.8645	-0.2764	0.3388	-0.2716	0.3476
RW7	4.9501	4.6091	0.3475	0.2234	0.2731	0.3448	**-0.6344**	**0.0148**
RW8	4.3973	3.8747	-0.5162	0.0588	-0.5053	0.0653	0.1422	0.6276
RW9	4.1082	4.2693	-0.1468	0.6164	-0.0695	0.8135	0.0345	0.9068
RW10	4.2705	3.9047	-0.1109	0.7059	-0.1317	0.6535	**0.5660**	**0.0349**
RW11	3.8757	4.7908	0.3050	0.2890	0.1468	0.6164	-0.3340	0.2432
RW12	3.3946	4.1737	-0.2493	0.3900	-0.3047	0.2895	0.2113	0.4684
RW13	3.1647	3.1212	0.2677	0.3548	-0.0573	0.8459	-0.1979	0.4976
RW14	2.7056	2.2894	0.2291	0.4308	0.1228	0.6759	-0.1122	0.7026
RW15	2.2675	2.7927	-0.0726	0.8052	0.0293	0.9208	0.2068	0.4780
RW16	2.2452	2.4285	-0.0791	0.7881	-0.2580	0.3731	0.0471	0.8729
RW17	2.3901	2.1785	-0.3751	0.1864	-0.5091	0.0630	0.2615	0.3666
RW18	2.0617	1.6429	0.1739	0.5520	0.4972	0.0705	0.3190	0.2663
RW19	1.9265	1.9705	0.1278	0.6632	-0.2189	0.4521	-0.1666	0.5691
RW20	1.8476	1.8413	-0.4850	0.0788	-0.3480	0.2228	0.1177	0.6886
RW21	1.6496	1.7817	-0.4506	0.1058	-0.4624	0.0959	0.0643	0.8270
RW22	1.5372	1.5830	0.1987	0.4958	0.1491	0.6109	0.1969	0.5000
RW23	1.2577	1.1957	-0.0440	0.8812	-0.2688	0.3527	0.2163	0.4576
RW24	1.1142	1.1980	0.2133	0.4641	0.2007	0.4914	0.1298	0.6584
RW25	0.9635	0.8459	0.1332	0.6499	0.0391	0.8943	-0.3889	0.1693
RW26	1.0731	1.0408	0.3144	0.2737	0.2968	0.3029	-0.4649	0.0939
RW27	0.8833	1.0488	0.1624	0.5792	-0.0023	0.9938	-0.3064	0.2867

Table S4. Percent of total variance and correlation statistics generated from the geometric morphometric analysis of all *Asiatosuchus* specimens (n = 7). Data for this taxon were isolated from the geometric morphometric analysis of all Geiseltal specimens. Statistically significant correlations are bolded in red. Since there was no variation within these specimens with respect to taphonomy, this correlation could not be calculated. **Abbreviations**: **RW**, Relative Warp; **ρ**, Pearson's correlation coefficient.

Axis	% of Total Variance	% of Taxon Variance	Age		Centroid Size	
			ρ	p-value	ρ	p-value
RW1	12.7000	4.6718	-0.3930	0.3831	0.2112	0.6494
RW2	8.8808	10.2200	-0.3628	0.4238	0.3932	0.3829
RW3	7.7253	8.4068	0.3520	0.4388	-0.2349	0.6121
RW4	6.7721	5.7994	0.3559	0.4333	-0.4202	0.3479
RW5	5.9385	5.5885	-0.5699	0.1816	0.2439	0.5982
RW6	5.8992	5.2779	**0.9820**	**8.23E-05**	**-0.9153**	**0.0038**
RW7	4.9501	5.9760	-0.2428	0.5999	0.5077	0.2447
RW8	4.3973	5.6409	-0.4733	0.2834	0.4424	0.3202
RW9	4.1082	4.2766	**-0.7670**	**0.04421**	**0.8750**	**0.0099**
RW10	4.2705	5.2939	0.1916	0.6807	0.1827	0.6950
RW11	3.8757	4.1788	-0.0993	0.8323	-0.3370	0.4599
RW12	3.3946	4.0061	-0.2634	0.5682	0.1618	0.7288
RW13	3.1647	2.6916	-0.6616	0.1055	**0.8149**	**0.0256**
RW14	2.7056	3.4046	0.2977	0.5168	-0.4006	0.3732
RW15	2.2675	1.7217	-0.6665	0.102	**0.8271**	**0.0217**
RW16	2.2452	2.7654	-0.4528	0.3076	0.4164	0.3527
RW17	2.3901	2.9509	0.4983	0.255	-0.3036	0.5080
RW18	2.0617	2.1704	0.1108	0.813	-0.2965	0.5184
RW19	1.9265	3.0157	0.0521	0.9117	0.0088	0.9851
RW20	1.8476	2.5377	0.4919	0.2622	-0.0918	0.8448
RW21	1.6496	1.7262	0.0314	0.9467	-0.3658	0.4197
RW22	1.5372	1.7967	-0.0418	0.929	0.0283	0.9520
RW23	1.2577	1.2065	-0.4816	0.2739	0.4580	0.3014
RW24	1.1142	1.3233	0.5401	0.2108	-0.6004	0.1540
RW25	0.9635	1.2748	-0.2867	0.5331	0.1806	0.6983
RW26	1.0731	1.2960	0.3349	0.4628	0.1428	0.7600
RW27	0.8833	0.7819	0.1707	0.7144	-0.2329	0.6152

Table S5. Percent of total variance and correlation statistics generated from the geometric morphometric analysis of all *Boverisuchus* specimens (n = 5). Data for this taxon were isolated from the geometric morphometric analysis of all Geiseltal specimens. Statistically significant correlations are bolded in red. **Abbreviations**: **RW**, Relative Warp; **ρ**, Pearson's correlation coefficient.

Axis	% of Total Variance	% of Taxon Variance	Age		Centroid Size		Taphonomy	
			ρ	p-value	ρ	p-value	ρ	p-value
RW1	12.7000	20.4896	0.4363	0.4627	0.7941	0.1086	-0.2530	0.6813
RW2	8.8808	8.9833	-0.6077	0.2770	0.4783	0.4151	0.0791	0.8994
RW3	7.7253	6.3952	0.3309	0.5865	0.0264	0.9664	-0.5011	0.3898
RW4	6.7721	7.9115	-0.4681	0.4265	-0.7676	0.1297	-0.6573	0.2280
RW5	5.9385	4.4509	0.0167	0.9787	0.6289	0.2557	-0.2956	0.6292
RW6	5.8992	4.7658	0.4032	0.5009	-0.0143	0.9818	-0.7876	0.1137
RW7	4.9501	5.8914	-0.5701	0.3156	0.0488	0.9379	-0.7982	0.1055
RW8	4.3973	4.5034	0.2424	0.6944	-0.0411	0.9477	0.1347	0.8290
RW9	4.1082	2.1979	0.7071	0.1817	-0.0266	0.9662	-0.3835	0.5239
RW10	4.2705	4.3434	0.6078	0.2769	-0.4699	0.4245	-0.3517	0.5616
RW11	3.8757	2.0240	-0.3861	0.5209	0.1614	0.7954	0.8145	0.0932
RW12	3.3946	1.8034	-0.4060	0.4976	-0.1545	0.8041	0.1045	0.8672
RW13	3.1647	3.9851	0.2131	0.7308	-0.4169	0.4850	-0.0768	0.9023
RW14	2.7056	3.6565	-0.0719	0.9085	-0.6928	0.1947	0.3139	0.6070
RW15	2.2675	2.2819	0.6591	0.2264	-0.1111	0.8589	0.6691	0.2168
RW16	2.2452	1.4028	0.3511	0.5623	0.6557	0.2296	0.8439	0.0723
RW17	2.3901	1.5242	0.1297	0.8354	0.5114	0.3785	0.4760	0.4177
RW18	2.0617	3.2426	0.6762	0.2101	0.2424	0.6945	-0.5106	0.3794
RW19	1.9265	1.0899	-0.6521	0.2331	-0.0990	0.8742	-0.2797	0.6485
RW20	1.8476	0.7099	-0.4733	0.4207	-0.1907	0.7587	0.6236	0.2610
RW21	1.6496	1.5903	0.5601	0.3262	0.7991	0.1047	0.3277	0.5904
RW22	1.5372	1.6828	0.3195	0.6002	-0.6418	0.2430	0.2132	0.7306
RW23	1.2577	1.2429	-0.6434	0.2415	0.5561	0.3304	-0.0836	0.8936
RW24	1.1142	1.0031	-0.0604	0.9231	0.8160	0.0921	0.6481	0.2369
RW25	0.9635	0.9943	0.5582	0.3281	-0.3448	0.5698	0.5331	0.3549
RW26	1.0731	1.0474	0.6033	0.2814	0.6657	0.2200	0.6963	0.1915
RW27	0.8833	0.7868	**0.9450**	**0.0154**	-0.1322	0.8321	-0.0148	0.9812

Table S6. Correlation statistics between age, centroid size, and taphonomy within the entire Geiseltal dataset. Statistically significant values are bolded in red. *Allognathosuchus* could not be included due to the low sample size (n = 2). Statistics could not be run for taphonomy of *Asiatosuchus* as there was no variation in preservation. **Abbreviations: ρ**, Pearson's correlation coefficient; **NA**, not applicable.

Group	Comparison	Pearson's Correlation	
		ρ	p-value
All	Age vs. Centroid Size	**-0.5865**	**0.0010**
	Age vs. Taphonomy	0.2446	0.2097
	Centroid Size vs. Taphonomy	**-0.5581**	**0.0020**
Diplocynodon	Age vs. Centroid Size	**0.7900**	**0.0008**
	Age vs. Taphonomy	-0.3303	0.2488
	Centroid Size vs. Taphonomy	-0.1503	0.6080
Asiatosuchus	Age vs. Centroid Size	**-0.8631**	**0.0124**
	Age vs. Taphonomy	NA	NA
	Centroid Size vs. Taphonomy	NA	NA
Boverisuchus	Age vs. Centroid Size	0.0907	0.8847
	Age vs. Taphonomy	0.2182	0.7244
	Centroid Size vs. Taphonomy	0.1766	0.7764

Figure S1. A histogram depicting the percent variance of all 27 relative warps axes of the entire Geiseltal geometric morphometric dataset. Each axis is divided into the proportions contributed by each taxon. Sample sizes: *Boverisuchus* (n=5), *Diplocynodon* (n=14), *Asiatosuchus* (n=7), *Allognathosuchus* (n=2).

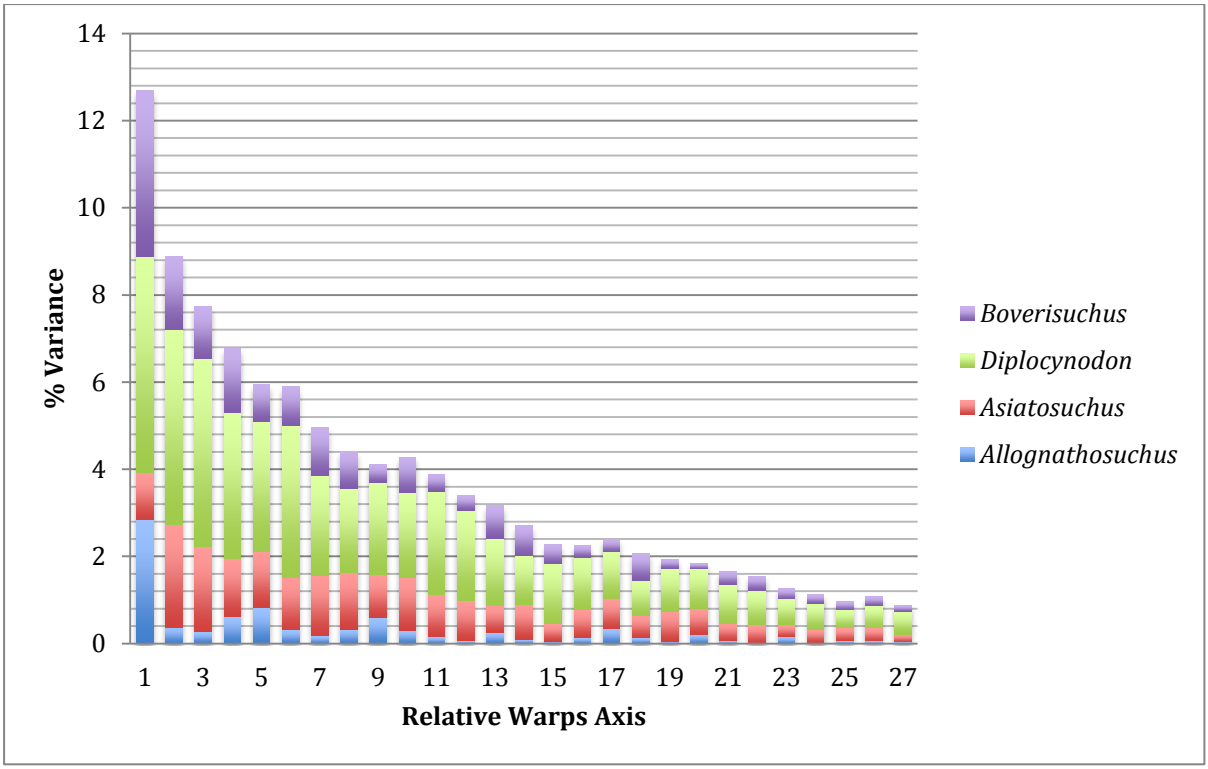

Figure S2. A histogram depicting the percent variance of the entire combined geometric morphometric dataset from all of the 66 relative warps axes. Each axis is divided into the proportions contributed by each group. Sample sizes: Geiseltal (n=28), Gavialidae (n=4), Crocodylidae (n=98), Alligatoridae (n=116).