

Supplementary Information

Tongue adhesion in the horned frog *Ceratophrys* sp.

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Supplementary table 1: Force, time, and contact area measurements and contact pressure and adhesive stress calculations for each experimental trial

Date	ID	Trial #	F _{imp} [mN]	t _{imp} [ms]	F _{imp} / body weight	F _{adh} [mN]	t _{pull} [ms]	F _{adh} / body weight	J _{adh} [Ns]	A [mm ²]	A _{free} [mm ²]	A _{rel}	σ _{con} [Pa]	σ _{adh} [Pa]
2013_02_26	I	3	1205	46	1.95	-785	884	1.27	-0.290	387	70	0.82	3,117	-2,030
2013_02_26	I	4	2527	44	4.08	-983	248	1.59	-0.181	101	94	0.07	24,923	-9,695
2013_03_01	I	1	1745	34	2.82	-850	211	1.37	-0.157	83	79	0.05	21,020	-10,239
2013_03_01	I	2	1556	41	2.51	-455	1025	0.74	-0.170	330	158	0.52	4,718	-1,381
2013_03_01	I	3	493	36	0.80	-974	499	1.57	-0.423	245	216	0.12	2,012	-3,975
2013_03_01	I	4	2276	31	3.68	-592	969	0.96	-0.176	341	106	0.69	6,676	-1,737
2013_03_05	I	1	556	43	0.90	-512	835	0.83	-0.285	359	110	0.69	1,550	-1,427
2013_03_05	I	2	1928	46	3.11	-804	508	1.30	-0.285	246	178	0.28	7,832	-3,266
2013_03_05	I	3	2641	50	4.27	-690	491	1.12	-0.239	269	224	0.17	9,824	-2,568
2013_03_05	I	4	1897	41	3.06	-462	839	0.75	-0.328	266	176	0.34	7,122	-1,733
2013_03_12	I	1	1891	40	3.06	-766	1069	1.24	-0.380	408	33	0.92	4,638	-1,879
2013_03_15	I	2	1545	48	2.50	-715	649	1.15	-0.298	141	112	0.21	10,947	-5,064
2013_03_12	I	3	1307	29	2.11	-613	1845	0.99	-0.768	455	92	0.80	2,874	-1,348
2013_03_12	I	4	1692	31	2.73	-677	917	1.09	-0.457	186	129	0.31	9,089	-3,636
2013_03_12	I	5	1543	38	2.49	-528	750	0.85	-0.353	153	148	0.03	10,095	-3,453
2013_03_15	I	1	1282	31	2.07	-452	785	0.73	-0.253	290	105	0.64	4,419	-1,557
2013_03_15	I	2	775	34	1.25	-430	837	0.70	-0.276	257	124	0.52	3,019	-1,677
2013_03_15	I	3	2032	60	3.28	-652	486	1.05	-0.257	147	134	0.09	13,784	-4,425
2013_03_15	I	4	1240	34	2.00	-692	906	1.12	-0.317	364	260	0.28	3,406	-1,901
2013_03_15	I	5	473	40	0.76	-536	1218	0.87	-0.382	259	168	0.35	1,830	-2,073
2013_03_19	II	1	1612	18	3.79	-655	3087	1.54	-0.385	348	15	0.96	4,633	-1,881
2013_03_19	II	2	605	55	1.42	-292	1261	0.69	-0.294	248	24	0.90	2,441	-1,177
2013_03_19	II	3	327	51	0.77	-246	1508	0.58	-0.282	130	34	0.74	2,517	-1,894
2013_03_19	II	4	946	59	2.23	-245	1841	0.58	-0.340	106	26	0.76	8,893	-2,301
2013_03_21	II	1	541	33	1.27	-553	3126	1.30	-0.432	276	16	0.94	1,959	-2,004
2013_03_21	II	2	1539	43	3.62	-664	741	1.56	-0.046	85	24	0.72	18,073	-7,802
2013_03_21	II	3	529	28	1.24	-261	2482	0.61	-0.414	325	33	0.90	1,627	-803
2013_03_21	II	4	628	31	1.48	-691	998	1.63	-0.071	242	67	0.72	2,600	-2,860
2013_03_25	II	1	1453	72	3.42	-92	1652	0.22	-0.008	136	0	1.00	10,645	-678
2013_03_25	II	2	297	42	0.70	-566	936	1.33	-0.084	126	4	0.97	2,367	-4,506
2013_03_25	II	3	703	33	1.65	-223	2152	0.52	-0.209	237	8	0.97	2,972	-942
2013_03_25	II	4	269	57	0.63	-512	189	1.20	-0.055	29	28	0.03	9,279	-17,652
2013_03_28	II	1	751	39	1.77	-227	1195	0.53	-0.026	206	0	1.00	3,647	-1,101
2013_03_28	II	2	245	21	0.58	-573	1466	1.35	-0.215	190	46	0.76	1,288	-3,014
2013_04_03	II	1	1182	28	2.78	-522	1197	1.23	-0.118	281	0	1.00	4,213	-1,860
2013_04_03	II	2	515	29	1.21	-599	1486	1.41	-0.226	217	0	1.00	2,369	-2,757
2013_04_08	II	1	435	26	1.02	-364	1017	0.86	-0.211	189	89	0.53	2,302	-1,927
2013_04_08	II	2	383	31	0.90	-469	974	1.10	-0.260	221	72	0.67	1,737	-2,129
2013_04_08	II	3	457	15	1.08	-844	780	1.99	-0.328	171	106	0.38	2,665	-4,925
2013_04_12	II	1	730	42	1.72	-648	786	1.52	-0.121	142	43	0.70	5,149	-4,573
2013_05_27	III	1	614	88	4.94	-94	683	1.76	-0.001	97	15	0.83	6,326	-967
2013_05_27	III	2	414	143	3.33	-163	245	1.31	-0.032	108	10	0.60	3,824	-1,507
2013_05_27	III	3	324	105	2.61	-172	619	1.38	-0.079	55	23	0.37	5,946	-3,149
2013_06_11	III	1	776	35	6.24	-225	1823	1.81	-0.132	124	17	0.77	6,272	-1,818
2013_06_11	III	2	611	29	4.91	-301	918	2.42	-0.155	128	43	0.02	4,770	-2,354
2013_06_11	III	3	544	16	4.38	-93	1351	0.75	-0.110	43	34	0.71	12,699	-2,181
2013_06_14	III	1	538	38	4.32	-131	1790	1.05	-0.036	130	74	1.00	4,130	-1,005
2013_06_14	III	2	579	31	4.66	-289	1006	2.33	-0.073	113	4	0.48	5,110	-2,555
2013_06_18	III	1	806	29	6.49	-104	883	0.84	-0.055	115	55	0.66	6,993	-902
2013_06_18	III	2	459	32	3.70	-229	1218	1.85	-0.137	89	6	0.95	5,165	-2,580
2013_06_18	III	3	458	30	3.69	-259	910	2.08	-0.194	91	88	0.15	5,048	-2,855
2013_06_18	III	4	626	16	5.04	-231	550	1.86	-0.042	82	23	0.01	7,633	-2,819
2013_06_21	III	1	621	27	4.99	-267	2081	2.14	-0.183	120	58	0.90	5,152	-2,213
2013_06_21	III	2	544	30	4.38	-178	376	1.43	-0.034	19	17	0.05	28,641	-9,364
2013_06_21	III	3	535	35	4.30	-123	289	0.99	-0.029	21	29	0.05	25,471	-5,843
2013_06_21	III	4	385	39	3.09	-151	607	1.22	-0.082	31	126	0.03	12,409	-4,882
2013_06_26	III	1	401	36	3.23	-127	2932	1.02	-0.215	142	12	0.86	2,835	-896
2013_06_26	III	2	614	34	4.94	-372	680	2.99	-0.140	72	1	0.42	8,475	-5,136
2013_06_26	III	3	665	40	5.35	-236	685	1.90	-0.118	129	0	0.16	5,171	-1,834
2013_06_26	III	4	488	34	3.93	-390	1308	3.14	-0.208	112	58	0.39	4,376	-3,492
2013_05_27	IV	2	172	26	1.28	-456	462	3.40	-0.050	133	0	0.88	1,297	-3,440
2013_05_27	IV	3	142	20	1.05	-193	250	1.44	-0.047	57	74	0.83	2,498	-3,400
2013_05_27	IV	4	37	55	0.28	-236	743	1.76	-0.119	51	44	0.54	735	-4,647
2013_05_30	IV	1	453	38	3.37	-225	844	1.68	-0.110	142	108	0.48	3,177	-1,581
2013_05_30	IV	2	355	31	2.64	-217	728	1.61	-0.023	174	39	0.98	2,037	-1,245
2013_05_30	IV	3	22	33	0.17	-161	472	1.20	-0.052	56	4	0.02	397	-2,866
2013_06_03	IV	1	502	74	3.74	-139	959	1.04	-0.089	65	77	0.91	7,713	-2,141
2013_06_11	IV	1	273	26	2.03	-264	844	1.97	-0.160	124	81	0.29	2,205	-2,136
2013_06_11	IV	2	720	27	5.36	-342	1515	2.55	-0.226	137	0	0.83	5,259	-2,497
2013_06_11	IV	3	582	33	4.34	-231	279	1.72	-0.033	60	4	0.03	9,705	-3,847
2013_06_11	IV	4	198	23	1.47	-209	1427	1.55	-0.151	110	69	0.84	1,793	-1,889
2013_06_14	IV	1	198	6	1.47	-292	2874	2.17	-0.232	145	50	0.99	1,369	-2,018
2013_06_18	IV	1	597	29	4.44	-339	4251	2.53	-0.281	191	12	1.00	3,116	-1,772
2013_06_18	IV	2	516	31	3.84	-371	626	2.76	-0.094	83	18	0.12	6,184	-4,447
2013_06_18	IV	3	815	34	6.07	-331	1254	2.47	-0.077	151	20	0.71	5,386	-2,190
2013_06_18	IV	4	402	38	3.00	-302	986	2.25	-0.122	117	30	0.07	3,446	-2,591
2013_06_21	IV	1	605	39	4.50	-216	1627	1.61	-0.139	123	20	1.00	4,928	-1,759
2013_06_21	IV	2	711	76	5.30	-163	2021	1.21	-0.217	129	42	0.97	5,498	-1,257
2013_06_21	IV	3	614	33	4.57	-367	1366	2.73	-0.198	128	108	0.46	4,776	-2,857
2013_06_21	IV	4	468	36	3.48	-218	1269	1.63	-0.122	129	68	0.61	3,617	-1,688

Supplementary table 2: Estimation of the error in our experimental setup that occurred in cases in which the tongue hit the glass slide with a slight lateral offset from the center.

Offset error for setup with 100g force transducer

offset from center [cm]	desired force value [mN]	measured force value [mN]	difference [mN]	deviation [%]
0	0.0	-0.7	0.7	
0	196.2	208.2	-12.0	-6.1
1	196.2	197.4	-1.2	-0.6
2	196.2	189.9	6.3	3.2
3	196.2	176.1	20.1	10.2
-1	196.2	209.6	-13.4	-6.8
-2	196.2	213.4	-17.2	-8.7
-3	196.2	214.9	-18.7	-9.6

Offset error for setup with 1,000g force transducer

offset from center [cm]	desired force value [mN]	measured force value [mN]	difference [mN]	deviation [%]
0	0.0	5.8	-5.8	
0	981.0	1,008.5	-27.5	-2.8
1	981.0	1,017.1	-36.1	-3.7
2	981.0	994.0	-13.0	-1.3
3	981.0	986.5	-5.5	-0.6
-1	981.0	932.7	48.3	4.9
-2	981.0	961.8	19.2	2.0
-3	981.0	945.2	35.8	3.6

Supplementary table 3: Test for normal distribution of the raw data for each individual and the overall dataset. P-values for Shapiro-Wilk test for normal distribution. Variables that are not normally distributed ($p > 0.05$) are highlighted in bold face

ID	F_{imp}	F_{adh}	t_{imp}	t_{pull}	J_{adh}	A	A_{rel}	σ_{con}	$\log(\sigma_{con})$	σ_{adh}	$\log(\sigma_{iadh})$
I	0.54	0.31	0.29	0.1	1.80E-03	0.74	0.12	2.30E-03	0.82	5.24E-05	0.02
II	0.01	0.29	0.42	0.07	0.29	0.99	1.30E-03	5.23E-05	0.07	4.00E-06	0.42
III	0.77	0.23	8.47E-06	0.02	0.26	0.05	0.05	1.14E-05	0.01	1.80E-03	0.54
IV	0.5	0.35	4.00E-03	1.30E-03	0.4	0.11	9.20E-03	0.33	0.31	0.09	0.71
overall	7.92E-08	2.00E-04	3.23E-10	2.40E-07	5.76E-05	2.00E-03	1.11E-05	1.67E-10	0.7	4.03E-12	0.08

Supplementary movie 1. Experimental trial recorded at 500 frames per second.

Supplementary movie 2. Regular feeding event of *Ceratophrys* sp. in captivity filmed at 1000 frames per second. Here, the tongue is projected to its full extend while the frog captures a cricket.

Supplementary movie 3. Regular feeding event of *Ceratophrys* sp. in captivity filmed at 1000 frames per second. The tongue is only partially extended while the frog captures an earthworm.