

Tables

Identification of avian flapping motion from non-volant winged dinosaurs based on
modal effective mass analysis

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Tables A to F

Table A. Parameters of *Caudipteryx zoui* (BPM 0001).

Measurements of the <i>Caudipteryx</i> model		
	Length (mm)	Mass (gram)
Maximum skull length	91	500
Maximum skull width	59	
Total length of cervical vertebrae	176	
Body length	215	2400
Maximum body height	165	
Humerus length	72	1000
Ulna length	62	
Radius length	59	
Manus	91	
Femur length	145	400
Tibia	188	
Fibula	188	
Length of tail	221	700

Table B. Mass and stiffness distribution of *Caudipteryx*.

Mass	Value (Kg)	Stiffness	(N/mm)
m_1	2.400	k_1	1000
m_2	0.500	k_2	200
m_3	0.500	k_3	200
m_4	0.200	k_4	650
m_5	0.200	k_5	650
m_6	0.500	k_6	800
m_7	0.700	k_7	800
Total mass	5		

Table C. Natural frequencies and effective masses of simplified Seven-degree-of-freedom system of *Caudipteryx*.

Natural Frequencies	(Hz)	Effective Mass	(Kg)
f_1	1.9239	$m_{eff, 1}$	4.6546
f_2	3.1831	$m_{eff, 2}$	0
f_3	3.6693	$m_{eff, 3}$	0.1642
f_4	5.7956	$m_{eff, 4}$	0.0107
f_5	7.57	$m_{eff, 5}$	0.0371
f_6	14.456	$m_{eff, 6}$	0
f_7	14.675	$m_{eff, 7}$	0.1334
		Total	5 Kg

Table D. Eight excessive assumed mass distribution in the format of models A, B, ..., I, and model D is the actual one.

Assumed Mass Body (Gram)									
Mass	A	B	C	D	E	F	G	H	I
<i>m</i> ₁	960	1440	1920	2400	2880	3360	3840	4320	4800
<i>m</i> ₂	200	300	400	500	600	700	800	900	1000
<i>m</i> ₃	200	300	400	500	600	700	800	900	1000
<i>m</i> ₄	80	120	160	200	240	280	320	360	400
<i>m</i> ₅	80	120	160	200	240	280	320	360	400
<i>m</i> ₆	200	300	400	500	600	700	800	900	1000
<i>m</i> ₇	280	420	560	700	840	980	1120	1260	1400
Total	2000	3000	4000	5000	6000	7000	8000	9000	10000

Table E. Computer simulation for the first twenty natural frequencies and modal effective mass of *Caudipteryx*.

Eigenvalues Output				Effective Mass Output (gram)		
Mode	Eigen	FREQUENCY		X-Axis	Y-Axis	Z-Axis
Number	Value	(Rad/Time)	(Cycles/Time)			
1	156.25	12.5	1.9894	7.28E-32	1.29E-06	4.83E-30
2	263.83	16.243	2.5851	3.25E-31	1623.33	8.46E-33
3	1322.9	36.371	5.7887	2.80E-30	1554.2	1.30E-30
4	1357	36.838	5.8629	7.77E-31	377.657	1.29E-31
5	3270.3	57.187	9.1015	2.93E-30	1.99E-07	1.14E-28
6	4397.7	66.315	10.554	4.77E-31	0.05959	2.93E-29
7	5631	75.04	11.943	1.66E-30	4.10E-07	9.46E-29
8	7848.7	88.593	14.1	1.08E-28	4.81E-09	1.02E-33
9	11892	109.05	17.356	4.44E-28	117.041	9.09E-28
10	23410	153	24.351	4.22E-30	13.2134	1.05E-28
11	24754	157.33	25.041	1.15E-28	43.6661	6.34E-28
12	33380	182.7	29.078	2.48E-28	2.27E-07	4.62E-27
13	42378	205.86	32.764	4.91E-27	351.593	3.44E-27
14	55747	236.11	37.578	1.34E-25	2.05E-07	1.05E-24
15	71139	266.72	42.45	6.55E-21	5.11E-07	4.55E-22
16	95222	308.58	49.112	7.25E-19	108.981	4.37E-19
17	106000	326.05	51.892	1.17E-17	23.5505	1.35E-17
18	111000	333.47	53.074	1.40E-17	265.408	1.50E-17
19	126000	355.47	56.574	2.71E-17	8.00E-11	8.70E-19
20	143000	377.59	60.096	2.32E-17	4.18081	1.31E-17
Total				7.67E-17	4482.88	4.30E-17

Table F. Computer simulation of the first twenty natural frequencies and modal effective mass in Y-axis for the models A, B, ..., and I.

Modes	A		B		C		D		E		F		G		H		I	
	<i>F</i>	<i>EM</i>	<i>F</i>	<i>EM</i>	<i>F</i>	<i>EM</i>	<i>F</i>	<i>EM</i>	<i>F</i>	<i>EM</i>	<i>F</i>	<i>EM</i>	<i>F</i>	<i>EM</i>	<i>F</i>	<i>EM</i>	<i>F</i>	<i>EM</i>
1	3.15	0.00	2.57	0.00	2.22	0.00	1.99	0.00	1.82	0.00	1.68	0.00	1.57	0.00	1.48	0.00	1.41	0.00
2	4.09	649.38	3.34	974.03	2.89	1298.68	2.59	1623.33	2.36	1947.99	2.18	2272.64	2.04	2597.29	1.93	2921.94	1.83	3246.59
3	9.15	621.27	7.47	932.24	6.47	1243.22	5.79	1554.20	5.28	1865.18	4.89	2176.16	4.58	2487.14	4.31	2798.12	4.09	3109.10
4	9.27	151.47	7.57	226.87	6.56	302.26	5.86	377.66	5.35	453.05	4.96	528.45	4.63	603.84	4.37	679.24	4.15	754.63
5	14.39	0.00	11.75	0.00	10.18	0.00	9.10	0.00	8.31	0.00	7.69	0.00	7.20	0.00	6.78	0.00	6.44	0.00
6	16.69	0.02	13.63	0.04	11.80	0.05	10.55	0.06	9.63	0.07	8.92	0.08	8.34	0.10	7.87	0.11	7.46	0.12
7	18.88	0.00	15.42	0.00	13.35	0.00	11.94	0.00	10.90	0.00	10.09	0.00	9.44	0.00	8.90	0.00	8.45	0.00
8	22.29	0.00	18.20	0.00	15.76	0.00	14.10	0.00	12.87	0.00	11.92	0.00	11.15	0.00	10.51	0.00	9.97	0.00
9	27.44	46.84	22.41	70.24	19.40	93.64	17.36	117.04	15.84	140.44	14.67	163.84	13.72	187.25	12.94	210.65	12.27	234.05
10	38.50	5.28	31.44	7.92	27.23	10.57	24.35	13.21	22.23	15.86	20.58	18.50	19.25	21.15	18.15	23.80	17.22	26.44
11	39.60	17.46	32.33	26.20	28.00	34.93	25.04	43.67	22.86	52.40	21.16	61.14	19.80	69.87	18.66	78.60	17.71	87.34
12	45.97	0.00	37.54	0.00	32.51	0.00	29.08	0.00	26.55	0.00	24.58	0.00	22.99	0.00	21.67	0.00	20.56	0.00
13	51.80	140.64	42.30	210.96	36.63	281.28	32.76	351.59	29.91	421.91	27.69	492.23	25.90	562.55	24.42	632.86	23.17	703.18
14	59.42	0.00	48.52	0.00	42.01	0.00	37.58	0.00	34.30	0.00	31.76	0.00	29.71	0.00	28.01	0.00	26.57	0.00
15	67.12	0.00	54.80	0.00	47.46	0.00	42.45	0.00	38.75	0.00	35.88	0.00	33.56	0.00	31.64	0.00	30.02	0.00
16	77.65	43.64	63.40	65.42	54.91	87.20	49.11	108.98	44.83	130.76	41.51	152.54	38.83	174.32	36.61	196.10	34.73	217.88
17	82.06	9.30	67.00	14.05	58.02	18.80	51.89	23.55	47.37	28.30	43.86	33.05	41.02	37.80	38.68	42.55	36.69	47.29
18	83.92	106.23	68.52	159.29	59.34	212.35	53.07	265.41	48.45	318.47	44.86	371.53	41.96	424.59	39.56	477.64	37.53	530.70
19	89.45	0.00	73.04	0.00	63.25	0.00	56.57	0.00	51.65	0.00	47.81	0.00	44.73	0.00	42.17	0.00	40.00	0.00
20	95.02	1.67	77.58	2.51	67.19	3.34	60.10	4.18	54.86	5.02	50.79	5.86	47.51	6.69	44.79	7.53	42.49	8.37

Models A, B, C, ..., I Modes 1, 2, 3, ..., 20 *f*=Frequency in Hertz EM=Effective Mass (Y-Axis) in Grams