

Supplementary Materials

Table S1. Collected measurements of *Parahesperornis alexi* and other hesperornithiform birds. Measurements were collected from the specimens noted using digital calipers, unless otherwise noted.

	<i>Parahesperornis alexi</i>	<i>Parahesperornis alexi</i>	<i>Hesperornis regalis</i>	<i>Hesperornis gracilis</i>	<i>Baptornis advenus</i>	<i>Fumicollis hoffmani</i>	<i>Brodavis varneri</i>	<i>Pasquiaornis tankei</i>	<i>Enaliornis barretti</i>
Frontal	KUVP 2287	KUVP 24090	KUVP 71012	-	-	UNSM 20030	SDSM 68430	RSM P2995.4†	-
Maximum mediolateral width	40.68	-	39.74*	-	-	-	-	28.24*	-
Anterior-posterior length	53.94*	-	68.73*	-	-	-	-	34.78*	-
Premaxilla	KUVP 2287	KUVP 24090	KUVP 71012	-	-	UNSM 20030	SDSM 68430	-	-
Mediolateral width at nares	19.90	-	20.08	-	-	-	-	-	-
Anterior-posterior length	108.80*	-	171.67*	-	-	-	-	-	-
Length, opening of nares to rostral end	53.37	-	84.67	-	-	-	-	-	-
Coracoid	KUVP 2287	KUVP 24090	FHSM VP2069	-	KUVP 2290	UNSM 20030	SDSM 68430	RSM P2988.9†	-
Length	-	55.38	53.88	-	52.93	-	-	50.68	-
Width of sternal end	23.31*	33.51	36.7	-	26.64	-	-	20.59*	-
Humerus	KUVP 2287	KUVP 24090	FHSM VP2293	-	KUVP 2290	UNSM 20030	SDSM 68430	RSM P2077.4†	-
Distal mediolateral width	4.63	-	5.4*	-	6.68	-	-	11.04	-
Maximum preserved shaft width	5.01	-	7.44	-	5.48	-	-	4.90	-
Ilium	KUVP 2287	KUVP 24090	YPM 1476	YPM 1679	SDSM 5314	UNSM 20030	SDSM 68430	RSM P2626.27†	BGS 87936 ⁴
Length	237.63*	246.6	307.47*	-	-	198.04*	-	-	-
Ratio of pre- to post-acetabular length	0.45	0.31	0.39*	-	-	0.32*	-	-	-
Height at acetabulum	27.36	29.71	48.55	-	29.60	16.13	-	-	-
Acetabulum diameter	17.38	18.18	28.26	16.12*	11.85	13.58	16.64	18.15	13.51
Antitrochanter width	11.03	12.77	21.04	17.56	7.90	10.50	-	11.27	-

	<i>Parahesperornis alexi</i>	<i>Parahesperornis alexi</i>	<i>Hesperornis regalis</i>	<i>Hesperornis gracilis</i>	<i>Baptornis advenus</i>	<i>Fumicollis hoffmani</i>	<i>Brodavis varneri</i>	<i>Pasquiaornis tankei</i>	<i>Enaliornis barretti</i>
Femur	KUVP 2287	KUVP 24090	YPM 1200	YPM 1679	KUVP 2290	UNSM 20030	SDSM 68430	RSM P2077.108 ²	BMNH A483
Length	68.8	74.53	97.92	84.06	74.90	71.8	-	64.76	-
Proximal mediolateral width	33.59	24.02	52.98	45.06*	26.56	23.58	-	20.85	-
Midshaft mediolateral width	12.53	13.89	17.98	15.82	13.07	11.73	-	12.13	8.36*
Distal mediolateral width	32.26	33.64	52.81	47.75	24.57	25.24	31.08	21.73	16.02*
Width of fibular trochlea	9.27	9.78	16.5	15.23	9.81	9.19	11.39	8.95	6.80
Tibiotarsus	KUVP 2287	KUVP 24090	YPM 1200	YPM 1679	FMNH 395	UNSM 20030	SDSM 68430	RSM P2957.22†	BMNH A478
Length	212.97	230.94	321.11	-	194.76	193.82	226.64	-	-
Height of cnemial expansion	12.57	14.61	29.62	-	13.58	18.14	19.98	12.00	9.65
Proximal mediolateral width	23.69	21.26	34.83	34.00	16.07	18.70	24.92	16.81	10.97
Midshaft mediolateral width	14.86	15.08	24.64	20.75	10.23	12.49	17.20	11.80	9.21*
Distal mediolateral width	23.38	24.59	26.63	28.79	16.78	18.87	25.34	-	-
Fibula	KUVP 2287	KUVP 24090	YPM PU17193	YPM 1679	KUVP 2290	UNSM 20030	SDSM 68430	RSM P2997.80†	-
Length	130.71	-	200.2	-	-	-	-	-	-
Proximal craniocaudal width	13.07	-	19.28	17.41	13.48	10.68	12.74	8.87	-
Patella	KUVP 2287	KUVP 24090	YPM 1200	YPM 1679	KUVP 2290	UNSM 20030	SDSM 68430	-	-
Length	44.61	56.54	108.54	88.24*	20.51	21.11	-	-	-
Proximal width	22.24	26.72	42.25	30.11	15.26	17.31	-	-	-
Tarsometatarsus	KUVP 2287	FHSM VP17312	YPM 1200	YPM 1679	AMNH 5101	UNSM 20030	SDSM 68430	RSM P2077.63 ³	BMNH A477
Length	100.73	99.93	136.88	126.44	89.9	83.72	96.03	85.60	-
Proximal mediolateral width	21.35	17.35	35.65	29.28	19.11	18.79	25.59	15.29	-
Trochlea IV mediolateral width	10.10	8.66	14.72	13.17	6.77	5.13	6.67	6.05	5.51

Trochlea III mediolateral width	6.51	5.33	8.41	6.58	6.52	5.12	7.48	-	4.10
	<i>Parahesperornis alexi</i>	<i>Parahesperornis alexi</i>	<i>Hesperornis regalis</i>	<i>Hesperornis gracilis</i>	<i>Baptornis advenus</i>	<i>Fumicollis hoffmani</i>	<i>Brodavis varneri</i>	<i>Pasquiaornis tankei</i>	<i>Enaliornis barretti</i>
Digit IV: 1	KUVP 2287	-	YPM 1200	YPM 1679	FMNH 395	UNSM 20030	SDSM 68430	-	-
Length	29.17	-	44.22	40.32	36.55	-	-	-	-
Proximal dorsoplantar depth	13.56	-	22.81	18.38	6.39	-	-	-	-
Proximal mediolateral width	12.02	-	18.70	15.64	8.06	-	-	-	-
Digit III: 1	KUVP 2287	-	YPM 1200	YPM 1478	FMNH 395	UNSM 20030	SDSM 68430	-	-
Length	31.14	-	40.24	34.87	23.73	37.77	-	-	-
Proximal dorsoplantar depth	7.20	-	11.40	13.94*	7.16	11.33	-	-	-
Proximal mediolateral width	12.51	-	16.58	-	4.58	6.01	-	-	-

*approximate; ^tmeasurement taken from photograph using ImageJ; ¹measured from cast YPM 57198; ²measured from cast YPM 5719; ³measured from cast YPM 57194; ⁴measured from cast BMNH A5310.

Table S2. Specimens used for this study. The majority of specimens were examined directly; however, references are listed for specimens not available for examination during this study.

Genus	Species	Specimen Number	Material	Citation (if specimen not studied directly)
<i>Asiaphesperornis</i>	<i>bazhanovi</i>	IZASK 2/KM 97	roughly 14th or 15th cervical vertebra	1
<i>Asiaphesperornis</i>	<i>bazhanovi</i>	IZASK 4/KM 97 ¹	partial dentary	1
<i>Baptornis</i>	<i>advenus</i>	YPM 1465*	distal tarsometatarsus (lectotype)	
<i>Baptornis</i>	<i>advenus</i>	AMNH 5101	cervical and thoracic vertebrae, partial pelvis, distal tibiotarsus, tarsometatarsi, partial phalanx.	
<i>Baptornis</i>	<i>advenus</i>	FMNH 395	caudal fragment of left mandible, 23rd vertebra, partial sacrum & pelvic fragments, pygostyle, femora, tibiotarsi, tarsometatarsus, metatarsal I, 14 phalanges, including 2 unguals	
<i>Baptornis</i>	<i>advenus</i>	KUVP 2290	coracoid, humerus, ulna, radius, partial scapula, 9 vertebrae, partial sacrum, femur, patella, fibulae, partial tibiotarsi, partial tarsometatarsus	

<i>Baptornis</i>	<i>advenus</i>	KUVP 16112	cervical and thoracic vertebra, partial sacrum and pelvis, partial femora, partial tibiotarsi, partial tarsometatarsus, partial phalanges; juvenile	
<i>Brodavis</i>	<i>americanus</i>	RSM P2315.6* (unnumbered cast at KUVP)	tarsometatarsus	
<i>Brodavis</i>	<i>baileyi</i>	UNSM 50665*	tarsometatarsus	
<i>Brodavis</i>	<i>varneri</i>	SDSM 68430*	cervical and thoracic vertebrae, ribs, partial sacrum and pelvis, partial femur, tibiotarsus, fibula, tarsometatarsus	
<i>Canadaga</i>	<i>arctica</i>	NMC 41050*	three cervical vertebrae, probably 15-17	2
<i>Chupkaornis</i>	<i>keraorum</i>	MCM.A773*	cervical and thoracic vertebrae, partial femora, fibula	3
<i>Enaliornis</i>	<i>barretti</i>	BMNH A477*	partial tarsometatarsus	
<i>Enaliornis</i>	<i>barretti</i>	BGS 87933 (cast as BMNH A5306)	partial femur	
<i>Enaliornis</i>	<i>barretti</i>	BGS 87936 (cast as BMNH A5310)	acetabular region of pelvis	
<i>Enaliornis</i>	<i>barretti</i>	BMNH A163	partial femur	
<i>Enaliornis</i>	<i>barretti</i>	BMNH A483	partial femur - juvenile	
<i>Enaliornis</i>	<i>barretti</i>	SMC B 54404	braincase	
<i>Enaliornis</i>	<i>barretti</i>	SMC B 55277	23rd vertebra	
<i>Enaliornis</i>	<i>barretti</i>	SMC B 55306	partial femur	
<i>Enaliornis</i>	<i>barretti</i>	SMC B 55310	partial femur	
<i>Enaliornis</i>	<i>sedgwicki</i>	BMNH A479	partial femur	
<i>Enaliornis</i>	<i>sedgwicki</i>	SMC B 55279	thoracic vertebra	
<i>Enaliornis</i>	<i>sedgwicki</i>	SMC B 55280	thoracic vertebra	
<i>Enaliornis</i>	<i>sedgwicki</i>	SMC B 55287	partial femur - juvenile	
<i>Enaliornis</i>	<i>sedgwicki</i>	SMC B 55289	partial femur	
<i>Enaliornis</i>	<i>sedgwicki</i>	SMC B 55300	partial femur	
<i>Enaliornis</i>	<i>seeleyi</i>	BMNH A478	partial tibiotarsus	
<i>Enaliornis</i>	<i>seeleyi</i>	BMNH A5801	partial femur	
<i>Enaliornis</i>	<i>seeleyi</i>	SMC B 55321	partial tarsometatarsus - juvenile	
<i>Fumicollis</i>	<i>hoffmani</i>	UNSM 20030*	cervical and thoracic vertebrae, pygostyle, rib fragments, partial pelvis, femur, patella, fibula, tibiotarsus, tarsometatarsus, 6 pedal phalanges	
<i>Hesperornis</i>	<i>chowi</i>	YPM PU 17208*	tarsometatarsus	4
<i>Hesperornis</i>	<i>crassipes</i>	YPM 1474*	Nearly complete skeleton	5
<i>Hesperornis</i>	<i>gracilis</i>	YPM 1473*	partial tarsometatarsus, 2 pedal phalanges	

<i>Hesperornis</i>	<i>gracilis</i>	YPM 1478	thoracic vertebrae, partial femur, partial tibiotarsus, tarsometatarsus, 2 pedal phalanges	
<i>Hesperornis</i>	<i>gracilis</i>	YPM 1679	cervical and thoracic vertebrae, partial synsacrum and pelvis, rib fragments, femora, patella, fibula, tibiotarsi, tarsometatarsi, 3 pedal phalanges	
<i>Hesperornis</i>	<i>lumgairi</i>	CFDC B.78.02.07*	tarsometatarsus	
<i>Hesperornis</i>	<i>macdonaldi</i>	LACM 9728*	femur	
<i>Hesperornis</i>	<i>macdonaldi</i>	LACM 9727	femur	
<i>Hesperornis</i>	<i>macdonaldi</i>	CFDC B.81.03.16	femur	6
<i>Hesperornis</i>	<i>mengeli</i>	CFDC B.78.01.08 ²	tarsometatarsus	
<i>Hesperornis</i>	<i>regalis</i>	YPM 1200*	cervical, thoracic, and caudal vertebrae, femora, tibiotarsi, tarsometatarsi, patellae, fibulae, 2 pedal phalanges	
<i>Hesperornis</i>	<i>regalis</i>	BMNH A-720	partial pelvis	
<i>Hesperornis</i>	<i>regalis</i>	FHSMNH 2069	cervical and thoracic vertebrae, rib fragments, coracoids, femora, tibiotarsi, tarsometatarsi, patella, pedal phalanges	
<i>Hesperornis</i>	<i>regalis</i>	FR 2181	femur, tibiotarsus, patella, fibula	
<i>Hesperornis</i>	<i>regalis</i>	YPM 1206	partial skull and lower jaw, cervical and thoracic vertebrae	5
<i>Hesperornis</i>	<i>regalis</i>	YPM 1207	cervical and thoracic vertebrae, partial synsacrum and pelvis, partial coracoid, femora, partial tibiotarsi, partial fibulae, patellae, tarsometatarsi, 2 pedal phalanges	
<i>Hesperornis</i>	<i>regalis</i>	YPM 1476	cervical and thoracic vertebrae, synsacrum and pelvis, partial sternum, femur, patella, tarsometatarsi, tibiotarsi, pedal phalanges	
<i>Hesperornis</i>	<i>regalis</i>	YPM 1477	cervical and thoracic vertebrae, rib fragments, partial coracoid, femora, tibiotarsi, fibulae, patella	
<i>Hesperornis</i>	<i>sp.</i>	FHSMNH 2293	thoracic vertebrae, rib fragments, humerus, scapula, partial femur, patella, partial tibiotarsus	
<i>Hesperornis</i>	<i>sp.</i>	KUVP 71012	partial skull and lower jaw, axis and cervical vertebrae, tarsometatarsus; 11 pedal phalanges	
<i>Hesperornis</i>	<i>sp.</i>	SDSM 5312	cervical and thoracic vertebrae, partial pelvis, femur, patella, tibiotarsus, tarsometatarsus, 4 pedal phalanges	
<i>Hesperornis</i>	<i>sp.</i>	YPM 1499	cervical and thoracic vertebrae, femora, fibulae, patellae, tibiotarsus, tarsometatarsus	
<i>Hesperornis</i>	<i>sp.</i>	YPM PU 17193	femur, fibula, patella, tibiotarsus	

<i>Hesperornis</i>	<i>sp.</i>	YPM PU 18589	cervical and thoracic vertebrae, sternal fragment, clavicle, femur, patellae, tibiotarsus	
<i>Parahesperornis</i>	<i>alexi</i>	KUVP 2287*	partial skull and lower jaw, cervical and thoracic vertebrae, synsacrum and pelvis, coracoid, humerus, sternal fragments, femora, patella, fibula, tibiotarsi, tarsometatarsi, 26 pedal phalanges, skin impressions	
<i>Parahesperornis</i>	<i>alexi</i>	KUVP 24090	cervical, thoracic, and free caudal vertebrae, synsacrum and pelvis, pygostyle, coracoid, scapula, sternal fragments, femora, patellae, fibulae, tibiotarsi	
<i>Parahesperornis</i>	<i>sp.</i>	FHSM VP-17312	tarsometatarsus	
<i>Pasquiaornis</i>	<i>hardiei</i>	RSM P2077.117 (cast as YPM 57191)	partial tarsometatarsus	7
<i>Pasquiaornis</i>	<i>hardiei</i>	RSM P2077.59 (cast as YPM 57199)	partial femur	
<i>Pasquiaornis</i>	<i>hardiei</i>	RSM P2077.60 (cast as YPM 57192)	partial femur	
<i>Pasquiaornis</i>	<i>hardiei</i>	RSM P2487.3 (cast as YPM 57198)	partial humerus	
<i>Pasquiaornis</i>	<i>hardiei</i>	RSM P2831.6	partial dentary	7
<i>Pasquiaornis</i>	<i>hardiei</i>	RSM P2831.8	cervical vertebra	7
<i>Pasquiaornis</i>	<i>hardiei</i>	RSM P2985.9	splenial	7
<i>Pasquiaornis</i>	<i>hardiei</i>	RSM P2989.19	partial mandible	7
<i>Pasquiaornis</i>	<i>hardiei</i>	RSM P2997.18	tarsometatarsus	7
<i>Pasquiaornis</i>	<i>hardiei</i>	RSM P2997.4	femur	7
<i>Pasquiaornis</i>	<i>hardiei</i>	RSM P2997.81	partial tarsometatarsus	7
<i>Pasquiaornis</i>	<i>tankei</i>	RSM P2077.10 (cast as YPM 57197)	partial femur	
<i>Pasquiaornis</i>	<i>tankei</i>	RSM P2077.4 (cast as YPM 57193)	partial humerus	
<i>Pasquiaornis</i>	<i>tankei</i>	RSM P2077.79	partial tarsometatarsus	
<i>Pasquiaornis</i>	<i>tankei</i>	RSM P2077.79	partial tarsometatarsus	7, 8
<i>Pasquiaornis</i>	<i>tankei</i>	RSM P2957.15	thoracic vertebra	7
<i>Pasquiaornis</i>	<i>tankei</i>	RSM P2957.21	partial tibiotarsus	7
<i>Pasquiaornis</i>	<i>tankei</i>	RSM P2957.22	partial tibiotarsus	7
<i>Pasquiaornis</i>	<i>tankei</i>	RSM P2985.1	thoracic vertebra	7
<i>Pasquiaornis</i>	<i>tankei</i>	RSM P2988.11	partial dentary	7
<i>Pasquiaornis</i>	<i>tankei</i>	RSM P2988.12	cervicothoracic vertebra	7
<i>Pasquiaornis</i>	<i>tankei</i>	RSM P2988.25	partial quadrate	7
<i>Pasquiaornis</i>	<i>tankei</i>	RSM P2988.9	coracoid	7

<i>Pasquiaornis</i>	<i>tankei</i>	RSM P2989.21	partial mandible	7
<i>Pasquiaornis</i>	<i>tankei</i>	RSM P2995.1	humerus	7
<i>Pasquiaornis</i>	<i>tankei</i>	RSM P2995.4	partial frontal	7
<i>Pasquiaornis</i>	<i>tankei</i>	RSM P2997.60	partial scapula	7
<i>Potamornis</i>	<i>skutchi</i>	UCMP 73103	partial quadrate	

*type specimen; ¹Incorrect identification; here revised to Aves *incertae sedis*; ²incorrectly reported as BO 780106 in Martin and Lim, 2002.

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