

Supplementary Material

Table S1. Birds' dataset used in this study

Family	Species	Museum code	wing function	body mass (g)
Ichthyornithidae	<i>Ichthyornis dispar</i>	MUZ 689	flight	250.4 ¹
Casuaridae	<i>Casuarius bennetti</i>	LACNHM 107030	reduced	17600*
Tinamidae	<i>Crypturellus tataupa</i>	LACNHM 35338	flight	243.5*
Tinamidae	<i>Nothura maculosa</i>	LACNHM 93093	flight	242
Tinamidae	<i>Tinamus solitarius</i>	LACNHM 101689	flight	1457*
Megapodidae	<i>Megapodius freycinet</i>	UWBM 60327	flight	860
Meleagridae	<i>Meleagris gallopavo</i>	UWBM 59381	flight	3616
Phasianidae	<i>Coturnix coturnix</i>	UWBM 64806	flight	95.5
Phasianidae	<i>Perdix perdix</i>	UWBM 56882	flight	382
Tetraonidae	<i>Lagopus lagopus</i>	UWBM 58894	flight	618
Tetraonidae	<i>Tetrao parvirostris</i>	UWBM 44017	flight	1500
Anatidae	<i>Anas aucklandica</i>	LACNHM 103170	reduced	514.5
Anatidae	<i>Oxyura jamaicensis</i>	UWBM 33103	flight	419.9
Anatidae	<i>Anas platyrhynchos</i>	UWBM 56702	flight	1300
Anatidae	<i>Aythya collaris</i>	UWBM 41671	flight	769
Anatidae	<i>Tadorna tadorna</i>	UWBM 59707	flight	950
Anatidae	<i>Anser albifrons</i>	UWBM 48226	flight	2100
Anatidae	<i>Cygnus olor</i>	UWBM 87398	flight	9100
Anhimidae	<i>Anhima cornuta</i>	LACNHM 86541	flight	3075*
Anhimidae	<i>Chauna chavaria</i>	LACNHM 86067	flight	2620*
Anseranatidae	<i>Anseranas semipalmata</i>	LACNHM 116666	flight	2516.5*
Apodidae	<i>Apus pacificus</i>	UWBM 43829	flight	37.4
Apodidae	<i>Hirundapus caudacutus</i>	UWBM 46916	flight	114
Hemiprocidae	<i>Hemiprocne mystacea</i>	UWBM 60348	flight	57.5
Trochilidae	<i>Archilochus colubris</i>	UWBM 45922	flight	3.5
Caprimulgidae	<i>Caprimulgus carolinensis</i>	UWBM 84731	flight	113
Caprimulgidae	<i>Chordeiles minor</i>	UWBM 59297	flight	65
Aegothelidae	<i>Aegotheles cristatus</i>	UWBM 62800	flight	46.5
Podargidae	<i>Podargus strigoides</i>	UWBM 57500	flight	252
Cuculidae	<i>Centropus milo</i>	UWBM 66047	flight	790
Cuculidae	<i>Coccyzus americanus</i>	UWBM 54994	flight	99.6
Cuculidae	<i>Cuculus canorus</i>	UWBM 56572	flight	105
Cuculidae	<i>Eudynamus scolopacea</i>	UWBM 62904	flight	241
Musophagidae	<i>Corythaixoides concolor</i>	UWBM 53060	flight	253.5*
Musophagidae	<i>Tauraco corythaix</i>	UWBM 52920	flight	310
Columbidae	<i>Columba livia</i>	UWBM 66264	flight	245
Columbidae	<i>Columba rupestris</i>	UWBM 59986	flight	240
Columbidae	<i>Ducula rubricera</i>	UWBM 58730	flight	660
Columbidae	<i>Ptilinopus regina</i>	UWBM 62874	flight	134.7
Columbidae	<i>Raphus cucullatus</i>	NHMUK PVA u/r	reduced	12400 ²
Pteroclididae	<i>Syrrhaptes paradoxus</i>	UWBM 59831	flight	255
Gruidae	<i>Grus canadensis</i>	UWBM 85111	flight	4200
Rallidae	<i>Fulica atra</i>	UWBM 56917	flight	563
Rallidae	<i>Gallicrex cinerea</i>	UWBM 64918	flight	305
Rallidae	<i>Gallirallus owstoni</i>	LACNHM 117230	reduced	220*

Rallidae	<i>Hypotaenidia woodfordi</i>	UWBM 58791	reduced	640
Rallidae	<i>Porphyrio porphyrio</i>	UWBM 82829	flight	1063
Podicipedidae	<i>Aechmophorus clarkii</i>	UWBM 42998	flight	1305
Podicipedidae	<i>Podiceps cristatus</i>	UWBM 46892	flight	995
Podicipedidae	<i>Tachybaptus ruficollis</i>	UWBM 18646	flight	175
Charadriidae	<i>Charadrius dubius</i>	UWBM 56829	flight	38.6
Charadriidae	<i>Pluvialis squatarola</i>	UWBM 38992	flight	188.7
Charadriidae	<i>Vanellus vanellus</i>	UWBM 58086	flight	210
Laridae	<i>Larus argentatus</i>	UWBM 56728	flight	1065
Recurvirostridae	<i>Himantopus himantopus</i>	UWBM 56452	flight	185
Rynchopidae	<i>Rynchops niger</i>	UWBM 45694	flight	342
Scolopacidae	<i>Actitis hypoleucos</i>	UWBM 18832	flight	50
Scolopacidae	<i>Calidris minuta</i>	UWBM 18822	flight	20
Scolopacidae	<i>Limosa limosa</i>	UWBM 47055	flight	197
Scolopacidae	<i>Numenius madagascariensis</i>	UWBM 47056	flight	800
Scolopacidae	<i>Scolopax minor</i>	UWBM 55189	flight	153
Scolopacidae	<i>Tringa glareola</i>	UWBM 56515	flight	87.9
Sternidae	<i>Chlidonias niger</i>	UWBM 56906	flight	62
Sternidae	<i>Thalasseus maximus</i>	UWBM 45715	flight	467
Alcidae	<i>Brachyramphus marmoratus</i>	UWBM 79447	flight/diving	258
Alcidae	<i>Cepphus carbo</i>	UWBM 43859	flight/diving	610
Alcidae	<i>Fratercula cirrhata</i>	UWBM 43839	flight/diving	840
Alcidae	<i>Uria aalge</i>	UWBM 79468	flight/diving	925
Alcidae	<i>Uria lomvia</i>	UWBM 80877	flight/diving	919
Alcidae	<i>Mancalla milleri</i>	LACNHM 2813	diving	460.7 ³
Alcidae	<i>Pinguinus impennis</i>	LACNHM 90052	diving	4750 ⁴
Gaviidae	<i>Gavia adamsii</i>	UWBM 60479	flight	4250
Spheniscidae	<i>Eudyptula minor</i>	UWBM 80409	diving	824.5
Spheniscidae	<i>Pygoscelis adeliae</i>	UWBM 38008	diving	4767
Spheniscidae	<i>Pygoscelis antarctica</i>	UWBM 38043	diving	3178
Spheniscidae	<i>Spheniscus humboldti</i>	UWBM 81776	diving	3290
Diomedidae	<i>Diomedea immutabilis</i>	UWBM 35364	flight	2191
Procellariidae	<i>Fulmarus glacialis</i>	UWBM 38024	flight/diving	585
Procellariidae	<i>Macronectes giganteus</i>	UWBM 38048	flight/diving	4653
Procellariidae	<i>Pterodroma solandri</i>	UWBM 55582	flight	516
Procellariidae	<i>Puffinus pacificus</i>	UWBM 78197	flight/diving	247
Pelecanoididae	<i>Pelecanoides urinatrix</i>	UWBM 60504	flight/diving	132
Ciconiidae	<i>Mycteria americana</i>	UWBM 55850	flight	2287.5
Fregatidae	<i>Fregata minor</i>	UWBM 65825	flight	1500
Pelecanidae	<i>Pelecanus erythrorhynchus</i>	UWBM 59235	flight	7950
Phalacrocoracidae	<i>Nannopterum harrisi</i>	LACNHM 89910	reduced	3250*
Phalacrocoracidae	<i>Phalacrocorax olivaceus</i>	UWBM 45751	flight	910
Sulidae	<i>Morus serrator</i>	UWBM 63012	flight/diving	1330
Sulidae	<i>Sula leucogaster</i>	UWBM 42580	flight/diving	1550
Threskiornitidae	<i>Platalea ajaja</i>	UWBM 45516	flight	1540
Threskiornitidae	<i>Plegadis chihi</i>	UWBM 59279	flight	386
Ardeidae	<i>Ardea cinerea</i>	UWBM 46891	flight	1620
Ardeidae	<i>Egretta sacra</i>	UWBM 42633	flight	569
Ardeidae	<i>Ixobrychus eurhythmus</i>	UWBM 47044	flight	140
Accipitridae	<i>Buteo jamaicensis</i>	UWBM 69579	flight	1304
Accipitridae	<i>Accipiter gentilis</i>	UWBM 80189	flight	768

Accipitridae	<i>Circus aeruginosus</i>	UWBM 56450	flight	540
Accipitridae	<i>Haliaeetus leucocephalus</i>	UWBM 33937	flight	4430
Accipitridae	<i>Haliaeetus indus</i>	UWBM 73850	flight	612
Accipitridae	<i>Aquila chrysaetos</i>	UWBM 59392	flight	3600
Pandionidae	<i>Pandion haliaetus</i>	UWBM 89927	flight	1307
Cathartidae	<i>Cathartes aura</i>	UWBM 76117	flight	1775*
Falconidae	<i>Falco peregrinus</i>	UWBM 78840	flight	1057
Strigidae	<i>Aegolius funereus</i>	UWBM 44737	flight	101.4
Strigidae	<i>Asio otus</i>	UWBM 85097	flight	277
Strigidae	<i>Bubo virginianus</i>	UWBM 84417	flight	1044
Strigidae	<i>Ninox novaeseelandiae</i>	UWBM 62833	flight	335
Strigidae	<i>Nyctea scandiaca</i>	UWBM 79185	flight	1649
Strigidae	<i>Strix occidentalis</i>	UWBM 47929	flight	550
Tytonidae	<i>Tyto alba</i>	UWBM 66222	flight	415.6
Alcedinidae	<i>Alcedo atthis</i>	UWBM 63315	flight	35
Alcedinidae	<i>Dacelo novaeguineae</i>	UWBM 62803	flight	322
Alcedinidae	<i>Megascops alcyon</i>	UWBM 86148	flight	162.9
Alcedinidae	<i>Merops apiaster</i>	UWBM 56655	flight	63.8
Coraciidae	<i>Coracias garrulus</i>	UWBM 56485	flight	162
Upupidae	<i>Upupa epops</i>	UWBM 56497	flight	66.1
Bucerotidae	<i>Rhyticeros plicatus</i>	UWBM 63079	flight	1700
Picidae	<i>Colaptes auratus</i>	UWBM 56373	flight	126
Picidae	<i>Dryocopus martius</i>	UWBM 56955	flight	340
Picidae	<i>Picoides tridactylus</i>	UWBM 56807	flight	70
Ramphastidae	<i>Aulacorhynchus prasinus</i>	UWBM 46781	flight	177
Cacatuidae	<i>Cacatua alba</i>	UWBM 82950	flight	640
Cacatuidae	<i>Eolophus roseicapillus</i>	UWBM 60857	flight	376
Psittacidae	<i>Ara ararauna</i>	UWBM 39897	flight	793.1
Psittacidae	<i>Chalcopsitta cardinalis</i>	UWBM 63146	flight	208
Psittacidae	<i>Psephotus haematonotus</i>	UWBM 57446	flight	57.7
Psittacidae	<i>Trichoglossus haematodus</i>	UWBM 62876	flight	130.5
Alaudidae	<i>Alauda arvensis</i>	UWBM 44371	flight	41.2
Alaudidae	<i>Melanocorypha mongolica</i>	UWBM 57843	flight	58.2
Artamidae	<i>Artamus personatus</i>	UWBM 57691	flight	39.4
Cinclidae	<i>Cinclus mexicanus</i>	UWBM 50254	flight/diving	57
Corvidae	<i>Corvus corone</i>	UWBM 56471	flight	575
Corvidae	<i>Pica pica</i>	UWBM 56913	flight	194
Fringillidae	<i>Carpodacus erythrinus</i>	UWBM 46370	flight	22.6
Fringillidae	<i>Coccothraustes coccothraustes</i>	UWBM 57930	flight	51.1
Icteridae	<i>Sturnella magna</i>	UWBM 45310	flight	98
Hirundinidae	<i>Delychon dasypus</i>	UWBM 51833	flight	20.1
Hirundinidae	<i>Progne subis</i>	UWBM 45892	flight	53
Hirundinidae	<i>Tachycineta bicolor</i>	UWBM 41607	flight	22
Laniidae	<i>Lanius minor</i>	UWBM 56650	flight	40
Motacillidae	<i>Anthus spinoletta</i>	UWBM 57992	flight	22
Motacillidae	<i>Motacilla cinerea</i>	UWBM 44455	flight	16.5
Muscicapidae	<i>Erithacus rubecula</i>	UWBM 44884	flight	18.4
Muscicapidae	<i>Monticola saxatilis</i>	UWBM 57835	flight	47
Muscicapidae	<i>Oenanthe oenanthe</i>	UWBM 44525	flight	27.8
Paridae	<i>Parus major</i>	UWBM 46368	flight	14.9
Prunellidae	<i>Prunella modularis</i>	UWBM 44880	flight	18.1

Sturnidae	<i>Sturnus vulgaris</i>	UWBM 56688	flight	74
Sylviidae	<i>Acrocephalus arundinaceus</i>	UWBM 56679	flight	34.7
Turdidae	<i>Catharus fuscescens</i>	UWBM 45998	flight	30.3
Turdidae	<i>Turdus iliacus</i>	UWBM 56570	flight	57.5
Pittidae	<i>Pitta moluccensis</i>	UWBM 73874	flight	55.5
Tyrannidae	<i>Contopus cooperi</i>	UWBM 36746	flight	29.5
Tyrannidae	<i>Tyrannus tyrannus</i>	UWBM 35764	flight	39

Table S2. Anatomical description of the landmarks of the humerus shown in the figure 3.

Region	Landmark	Type	Description
Proximal epiphysis	1	I	Origin of the deltopectoral crest in the diaphysis
	2	I	Proximal end of the deltopectoral crest intersecting with the <i>caput humeri</i>
	3	II	Most proximal end of the <i>caput humeri</i>
	4	I	Ventral end of the <i>incisura capitis</i>
	5	II	Ventral end of the ventral tubercle
	6	II	Ventral end of the <i>crus dorsale</i> in the <i>fossa neumotricipitalis</i>
	7	II	Proximal end of the <i>fossa neumotricipitalis</i>
	8	II	Dorsal end of the <i>fossa neumotricipitalis</i>
	9	II	Ventral end of the bicipital crest
	10	II	Point of greatest convexity in joint between the bicipital crest and the diaphysis
Diaphysis	11	III	Ventral point in the midshaft of the diaphysis (perpendicular projection from the line between landmarks 10 and 13 at midlength)
	12	III	Dorsal point in the midshaft of the diaphysis (perpendicular projection from the line between landmarks 10 and 13 at midlength)
Distal epiphysis	13	II	Origin of the flexor process in the diaphysis
	14	I	Distal junction between the flexor process and the <i>fossa olecrani</i>
	15	II	Most proximal end of the ventral condyle
	16	I	Junction between ventral and dorsal condyles (<i>incisura intercondylaris</i>)
	17	II	Most proximal end of the dorsal condyle
	18	II	Most dorsal point of the epiphysis
	19	I	Most prominent point of the <i>process supracondylaris dorsalis</i>

Table S3. Summary of multivariate regressions for allometric variation of the humeral shape based on Procrustes coordinates (*Pcoor*) on body mass (M_b) and centroid size (CS) using the subsample that excludes Apodiformes, Sphenisciformes and Alcidae.

	PGLS	adj R ²	p-value
CS		0.030	0.002**
flighted-flightless		0.070	0.003**
CS: flighted-flightless		0.010	0.161
M_b		0.020	0.02*
flighted-flightless		0.068	0.003**
M_b : flighted-flightless		0.012	0.122