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SUPPLEMENTARY DATA

Morphometric analysis of the forelimb and pectoral girdle of the Cretaceous ornithomimid dinosaur
Oryctodromeus cubicularis and implications for digging

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CORACOID ANALYSES

The coracoid was originally included in all analyses. Due to a lack of morphologically significant results due to small sample sizes and a lack of a point of comparison of adaptations for digging in mammals, passages regarding the coracoid have been limited to this supplement.

MATERIALS AND METHODS

Traditional Morphometric Analysis

A total of 22 coracoids from 12 genera of ornithischian dinosaurs were measured and photographed for the traditional and geometric morphometric analyses (Fig. S1; Table 1S). For the traditional morphometric analysis eight measurements were taken on the coracoid of each specimen (Table S2; Fig. S1).

Geometric Morphometric Analysis

In total, 19 coracoids from 11 distinct genera were used in the geometric morphometric analysis. In the coracoid, there are eight landmarks and six semilandmarks (Table S3, Fig. S2). Three of the landmarks are corresponding structures (points 1, 2, and 3), the remaining five are inflection points. The six semilandmarks are used to describe the anterodorsal curve of the coracoid, and are evenly spaced between the dorsal end of the scapulocoracoid suture (1) and the ventralmost point of the sterna process (6).

RESULTS

Traditional Morphometric Analysis

The measurements of the coracoid specimens are listed in Table S4. In the coracoid, PC1 describes 74.3% of the variation in the data, whereas PC2 describes 12.7% of the variation. All other principal components are insignificant.

Coracoid—In the traditional morphometric analysis of the coracoid, the first three principal components explain 75.1% of the variation in morphology (PC1 explains 42.1%, PC2 explains 18.7% and PC3 explains 14.3%). PC1 and PC2 exhibit only slight phylogenetic separation (Fig. 3S).

PC1 is explained primarily by coracoid maximum height (CH_r), coracoid minimum height (CMH_r), and scapulocoracoid articulation length ($SCAL_r$), all as ratios with coracoid length. As with PC1 of the scapula, PC1 of the coracoid is explained by the dorsoventral expansion relative to the coracoid length. Negative PC1 scores indicate a more strongly dorsoventrally expanded coracoid relative to the length, whereas positive PC1 scores indicate a dorsoventrally compressed coracoid relative to the length. PC1 scores appear to have a potentially phylogenetic and strongly locomotor signature, with bipedal groups such as basal ornithopods and basal ornithischians having tall coracoids relative to their anteroposterior length (negative PC1 scores), and more quadrupedal groups such as iguanodontians and marginocephalians with relatively shorter coracoids relative to their anteroposterior length (positive PC1 scores). However small sample sizes of the groups make it difficult to make any inference, as it is unclear if the full range of morphospace for the taxa is displayed. The two *Oryctodromeus* coracoids examined have highly disparate PC1 scores, which is likely due to individual variation or taphonomic effects—*Oryctodromeus* specimen MOR1642 is more

dorsoventrally compressed relative to the coracoid length and relative to the more positively scoring specimen of *Oryctodromeus*, MOR1636a. PC1 is not correlated with size ($R^2 = 0.116$).

PC2 is explained by the distance of the coracoid foramen from the scapulocoracoid suture (CFPe_r) as well as the size of the sternal process of the coracoid relative to the coracoid length (SPH_r). Positive values indicate the coracoid has a small sternal process with the coracoid foramen close to the scapulocoracoid suture whereas negative values indicates the presence of a more pronounced sternal process and coracoid foramen further from the scapulocoracoid suture. *Camptosaurus* specimens (UMNH VP16422, YPM 1800, YPM 1877), and *Stormbergia* have high PC2 values, whereas *Haya griva*, one specimen of *Hypsilophodon*, *Protoceratops*, and *Corythosaurus* have low PC2 values. There is no evidence of a linear correlation between PC2 scores and size ($R^2 = 0.211$).

PC3 explains the variation in coracoid morphology due to the position of the coracoid foramen (CFPe_r and CFPa_r) and length of the scapulocoracoid suture (SCAL_r) relative to the length of the coracoid versus the size of the sternal process (SPH_r) and the width of the indentation between the sternal process and the coracoidal glenoid (CIW_r). A positive score indicates a pronounced sternal process, and typically a coracoid foramen located close to a relatively short scapulocoracoid suture. Of course, an extremely pronounced singular trait can overshadow others, such as in *Protoceratops* (CM 9185), which has a strongly positive PC3 score, due to the large sternal process with a wide indentation between the glenoid and sternal process, despite the fact that the coracoid foramen is not located very close to the scapulocoracoid suture relative to other taxa. A negative PC3 score indicates a coracoid foramen far from the ventral scapulocoracoid suture, and a relatively small sternal process positioned close to the glenoid. Despite its pronounced sternal process, *Oryctodromeus* (MOR 1636a) has a strongly negative PC3 value due to the position of the coracoid foramen distal to the relatively longer scapulocoracoid suture. The other specimen of *Oryctodromeus* (MOR 1642) has only a slightly negative score due to the position of the coracoid foramen proximal to a relatively shorter scapulocoracoid articulation. There appears to be no phylogenetic signal in PC3 as iguanodontians, basal ornithomorphs, and marginocephalians all span the range of PC3 scores, and size is not correlated with PC3 scores ($R^2 = 0.0113$).

Geometric Morphometrics

Coracoid—In the geometric morphometric analysis of the coracoid, the first four relative warp axes are significant, explaining a cumulative 79.60% of the shape variation. RW1 describes 38.18% of the variation in shape, RW2 describes 19.29% of the variation, RW3 describes 11.79% of the variation, and RW4 describes 10.35% of the variation. 93.32% of the variation remains unexplained when centroid size of each element has been regressed against the relative warp scores, indicating that coracoid morphology is not correlated with element, and presumably, body size. No clear trends are evident in the geometric morphometric analysis of the coracoid (Fig. S4) that may perhaps be influenced by the small sample size overall and the limited sample sizes of some groups, such as marginocephalians, basal ornithomorphs, and *Oryctodromeus*, which each have two samples. The absence of hadrosaurid coracoid specimens also makes inferences about trends in phylogeny and locomotion difficult.

RW1 is explained by size of the coracoid indentation and sternal process, where a more positive score indicates a larger sternal process with a deep coracoid indentation, and a negative score indicates a shorter sternal process with shallow coracoid indentation (Fig. S4A). Marginocephalians exhibit a large discrepancy in RW1 scores, as *Protoceratops* (CM 9185) has

a positive RW1 score, indicating a large sternal process, whereas *Psittacosaurus* (UofC LHVP2) has a strongly negative RW1 score, indicating a small sternal process. All other taxa represented in this study exhibited moderate to large sternal processes, yielding slightly negative to positive RW1 scores. There is no phylogenetic or locomotor trend evident in RW1 scores.

RW2 describes variation in shape due to the dorsoventral expansion of the coracoid (Fig. 4SA). Positive values indicate a tall coracoid relative to the anteroposterior length, and negative values indicate a relatively shorter coracoid relative to the anteroposterior length. Marginocephalians exhibit strongly negative RW2 scores, indicating short coracoids relative to the anteroposterior length. Basal ornithopods, basal ornithischians, and iguanodontians all exhibit large variation in RW2 scores, indicating that outside of marginocephalians, coracoid morphology does not strictly trend with phylogeny or locomotion.

RW3 describes the proximity of the coracoid foramen to the scapulocoracoid articulation (Fig. S4B). Negative scores indicate the foramen sits close to the scapulocoracoid articulation, whereas positive scores indicate that a larger distance separates the coracoid foramen from the scapulocoracoid articulation. Basal ornithopods have positive RW3 scores, indicating a foramen further removed from the scapulocoracoid suture, whereas iguanodontians and basal ornithischians have a larger range of RW3 scores, ranging from slightly positive to strongly negative. Marginocephalians have RW3 scores close to zero, indicating a moderate coracoid foramen position relative to the scapulocoracoid articulation. With the absence of hadrosaurids, it is difficult to determine whether there is any association between RW3 and phylogeny or locomotion.

RW4 is explained by a shift in the position of the coracoid foramen anteroventrally (Fig. S4B). Positive scores RW4 produce a coracoid with the foramen positioned more ventrally, and distal from the scapulocoracoid articulation, whereas negative RW4 scores describe a coracoid with the foramen position at a more dorsal position (but still ventral to the midpoint of the coracoid), and positioned proximal to the scapulocoracoid articulation. Basal ornithischians and *Oryctodromeus* have positive RW scores, whereas other basal ornithopods and marginocephalians have RW4 scores close to zero. Iguanodontians have scores ranging from positive to strongly negative. Unlike in the humerus and scapula, the geometric morphometric analysis of the coracoid does not follow any phylogenetic, size, or locomotor trend.

The CVA (Fig 5S) indicated that there were three significant canonical variates in explaining the morphology of the coracoid (CV1, $p = 0.00048$; CV2, $p = 0.0046$; CV3, $p = 0.031$). CV1 explains the position of the coracoid foramen and the width of the indentation between the coracoidal glenoid and the sternal process. Positive values indicate a wider indentation and a more anteriorly placed coracoid foramen. CV2 describes the size of the sternal process and the depth of the indentation, with positive values indicating a smaller sternal process and a shallower indentation between the glenoid and sternal process. CV3 describes the size of the coracoid indentation and the height of the scapulocoracoid articulation, with positive values indicating a narrower indentation between the glenoid and sternal process and a taller scapulocoracoid articulation. CV1 may potentially trend with phylogeny with iguanodontians having negative CV1 scores and basal ornithopods having positive CV1 scores, however the small sample sizes, as well as the lack of hadrosaurid specimens makes it difficult to ascertain. Iguanodontians span the range of CV2 scores, however basal ornithopods have negative CV2 scores, *Oryctodromeus* has scores near zero, and marginocephalians and basal ornithischians have positive CV2 scores. CV3 does not separate out into morphologically disparate groups. The

only coracoid specimen that is misclassified in an a posteriori test of the groupings is one iguanodontian that is misclassified as a basal ornithischian.

DISCUSSION

Morphological Trends

Coracoid—Coracoid morphology appears to have been relatively conservative throughout the phylogeny of Ornithopoda, suggesting that its function remained similar throughout ornithopod phylogeny and may not have been seriously impacted by the transition from bipedal to quadrupedal or functional specialization. Because there is only one hadrosaurid specimen in the PCA and none included in the RWA, it is not possible to determine if any stronger phylogenetic or locomotor trend in ornithopod coracoids is evident. The CVA of the coracoid shows that when between-group variance is maximized, there is a rough separation of basal ornithopods from iguanodontians, indicating a weak relationship with phylogeny. Overall the analyses indicate that the variation in coracoid shape is primarily controlled by the dorsoventral height of the coracoid relative to its anteroposterior length, the size of the sternal process, and the position of the coracoid foramen relative to the scapulocoracoid articulation (Figs. S3–5). Marginocephalians fall out separately from basal ornithischians and all ornithopod groups in the RWA (Fig. S4), primarily due to the morphology of the sternal process. Specimens of *Oryctodromeus* fall within the range the scores of other basal ornithopods and the shape does not appear to represent any specialization relative to other ornithopods. Our study did not address coracoid size as independently measured relative to body mass or femur length. Further study with a larger sample size, additional hadrosaur material, and with sufficient associated material to assess the size of the coracoid relative to other forelimb elements or overall body size, might potentially produce more informative results.

Morphological Specialization of *Oryctodromeus*—The examined coracoids of *Oryctodromeus* exhibit a large range of scores in the morphometric analyses, but still score within the range of other basal ornithopods. Due to the use of only two specimens in the RWA and CVA, no clear morphospace can be defined for *Oryctodromeus*, which hinders any potential interpretation of any specialization for *Oryctodromeus*. With what little resolution is available, the coracoid of *Oryctodromeus* does not appear specialized relative to other ornithopods.

Implications for Digging

Because the coracoid lacks a functional analog in mammals, inference about osteological adaptations of the coracoid for digging would lack support. Within the EPB, the coracoid acts as the origin of the coracobrachialis brevis muscle (Maidment and Barrett, 2011), and the insertion of the sternocoracoideus or costocoracoideus superficialis muscle, respectively (Dilkes, 2000). However neither of these muscles plays a significant role in digging. The coracoid of *Oryctodromeus* does not appear to be specialized relative to other ornithopods, and the coracoid remains morphologically conservative in *Oryctodromeus* as well as throughout ornithopod phylogeny.

RAW MEASUREMENT DATA

Measurement data for the humeri and scapulae are provided in Tables S5 and S6.

REGARDING JUVENILE SPECIMENS

The known juvenile specimens included in these analyses are listed in the table below. Without histological data on certain specimens, it is difficult to say their ontogenetic stage, so there may be subadult or juvenile specimens in the analyses not included on the list below. However these specimens were either described as juvenile in the literature (Scheetz, 1999), identified as such on specimen labels, or were considerably smaller than other individuals of the genus examined. The number of elements examined for each analysis is indicated in the table. The juvenile specimen of *Oryctodromeus* (MOR 1632b) was not included in any analyses due to incompleteness.

Humerus				
Specimen	Taxon	Group	Traditional	Geometric
MOR 294	<i>Orodromeus makelai</i>	Basal Ornithopod	1	1
MOR 548	Lambeosaur	Hadrosauridae	7	4
YPM-PU 22400	<i>Maiasaura peeblesorum</i>	Hadrosauridae	2	
YPM-PU 23444	<i>Maiasaura peeblesorum</i>	Hadrosauridae	1	
FMNH PR2263	<i>Tenontosaurus tilletti</i>	Iguanodontia	1	
Scapula				
Specimen	Taxon	Group	Traditional	Geometric
MOR 294	<i>Orodromeus makelai</i>	Basal Ornithopod	1	1
MOR 548	Lambeosaur	Hadrosauridae	3	2

SUPPLEMENTARY TABLES

TABLE S1. Coracoid specimens and group assignments used for the traditional and geometric morphometric analyses. An 'x' indicates the inclusion of one specimen in an analysis, numerals indicate the inclusion of multiple elements associated with one specimen number.

Specimen	Taxon	Group	Traditional			Geometric		
			H	S	C	H	S	C
BYU 631-163	<i>Othnielosaurus consors</i>	Basal Ornithischia	x	x	x	x	x	x
NHMUK R11000	<i>Stormbergia dangershoeki</i>	Basal Ornithischia		x	x		x	x
MOR 1642	<i>Oryctodromeus cubicularis</i>	Basal Ornithopoda	3	x	x	2	x	
MOR 1636a	<i>Oryctodromeus cubicularis</i>	Basal Ornithopoda	x	2	x	x	2	x
IMNH 44951	<i>Oryctodromeus cubicularis</i>	Basal Ornithopoda	x			x		x
MOR 623	<i>Orodromeus makelai</i>	Basal Ornithopoda	x	x	x	x	x	x
NHMUK R192	<i>Hypsilophodon foxii</i>	Basal Ornithopoda	x	x	x		x	
NHMUK R196	<i>Hypsilophodon foxii</i>	Basal Ornithopoda	2	2	2	2	x	x
FMNH IGM 100/2015	<i>Haya griva</i>	Basal Ornithopoda	x	x	x	x	x	
CM 9461	<i>Corythosaurus casuarius</i>	Hadrosauridae	x	x	x	x	x	
UMNH VP16567	<i>Camptosaurus sp.</i>	Iguanodontia		x	x		x	x
CM 11337	<i>Camptosaurus aphanoecetes</i>	Iguanodontia	2	2	2	x	2	2
YPM 1877	<i>Camptosaurus dispar</i>	Iguanodontia	x	x	x	x	x	x
YPM 1800	<i>Camptosaurus dispar</i>	Iguanodontia	2	2	2	x	x	2
YPM 5478	<i>Tenontosaurus tilletti</i>	Iguanodontia			x			x
YPM 5456	<i>Tenontosaurus tilletti</i>	Iguanodontia	2	2	x	2	2	x
CM3392/21786	<i>Dryosaurus altus</i>	Iguanodontia	2	2	2	x	x	2
CM 9185	<i>Protoceratops andrewsi</i>	Marginocephalia	x	x	x	x	x	x
UofC LHPV2	<i>Psittacosaurus gobiensis</i>	Marginocephalia	2	2	x	x	2	x

TABLE S2. The abbreviations and descriptions of the measurements used in the traditional morphometric analysis of coracoid. Refer to Figure S1 for illustrations of these measurements.

Measurement	Abbr.	Description
Scapulocoracoid articulation length	SCAL	The length of the suture between the scapula and the coracoid (included in analyses of both the scapula and coracoid)
Coracoid length	CL	The maximum length of the coracoid perpendicular to the scapulocoracoid suture
Coracoid height	CH	The height of the coracoid from the dorsal-most edge to the tip of the coracoidal glenoid
Coracoid minimum height	CMH	The height of the coracoid from the dorsal-most edge to the indentation posterior to sternal process
Coracoid indentation width	CIW	The width from the edge of the coracoid glenoid to the ventral-most part of the sternal process
Sternal process height	SPH	The length of the ventral expansion of the sternal process relative to the indentation posterior to it
Coracoid foramen-perpendicular	CFPe	The distance perpendicular to the scapulocoracoid suture to the coracoid foramen
coracoid foramen-parallel	CFPa	The distance from the ventral-most scapulocoracoid suture to the coracoid foramen, parallel to the suture

TABLE S3. Descriptions of the landmark positions on the coracoid used in the geometric morphometric analysis. Refer to Figure S2 for illustrations of these landmarks.

Landmark	Description
1	Dorsal end of the scapulocoracoid suture
2	Ventral edge of the scapulocoracoid suture
3	Ventral edge of the coracoidal glenoid
4	Posterior coracoid indentation
5	Anterior coracoid indentation
6	Ventral-most point of sternal process
7	Dorsal-most edge of the coracoid foramen
8	Ventral-most edge of the coracoid foramen

TABLE S4. Measurements used in the traditional morphometric analysis of the scapula.
Abbreviations described in Table 1 in the manuscript.

ID#	CL	CH	CMH	CIW	SPH	CFPe	CFPa	SCAL
MOR 1636a	58.77	82.54	68.87	21.83	16.27	14.34	23.36	70.45
MOR 1642	63.19	70.78	60.27	26.57	15.75	11	12.99	52.14
MOR 623	45.57	53.73	41.44	24.8	8.37	10.44	12.25	33.92
BYU 631-163	40.69	48.65	35.2	18.3	8.03	11.25	6.67	38.26
UMNH VP16422	100.9	134.8	116	47.93	13.37	9.33	10.81	62.29
YPM 1877	118.9	140.3	116.1	37.09	28.3	16	6.13	88.61
YPM 5478	42.85	49.56	41.69	17.69	8.9	10.35	6.23	31.66
YPM 5456	170	135.5	117.9	74.47	40.76	48.19	23.17	92.85
YPM 1800	116	107	82	40	17	15	4	66
YPM 1800	102	122	106	41	19	11	4	79
CM3392/21786	48.68	52.21	41.11	24.13	7.47	3.75	11.57	36.02
CM3392/21786	52.88	53.11	44.79	27.03	16.04	4.3	9.4	38.4
NHMUK R192	39.35	54.36	37.97	22.81	13.51	5.8	10.36	27.34
NHMUK R196	29.94	42.65	35.99	19.85	9.84	9.42	3.14	31.2
NHMUK R196	32.83	43.21	35.01	16.93	6.93	8.78	6.09	31.94
NHMUK R11000	48.11	70.36	59.96	24.89	4.38	11.15	7.99	57.79
CM 11337	67.77	87.17	66.95	34.23	23.57	11.99	1.82	58.19
CM 11337	65.88	84.74	69.75	30.56	18.36	12.98	3.44	58.28
CM 9185	59.16	53.54	52.62	28.25	22.01	14.55	0.01	32.46
CM 9461	120.3	97.45	71.7	41.95	30.14	35.74	12.69	69.38

TABLE S5. Measurements used in the traditional morphometric analysis of the humerus.
Abbreviations described in Table 1 in the manuscript.

ID#	HL	DPL	DPW	HHW	HPW	HSW	HSP	HDW	RCW	UCW
MOR 1642	157.66	56.7	4.74	17.52	39.15	14.98	15.44	23.51	18.05	15.52
MOR 1642	160.87	60	4.82	20.99	33.26	15.54	14.35	21.05	18.47	13.25
MOR 1636a	157.5	57.08	5.51	23.05	43.02	15.35	15.72	25.83	20.05	20.26
MOR 1642	168.81	66.8	4.44	17	38.39	14.17	14.99	25.7	17.81	15.9
MOR 623	92.89	32.46	3.38	9.17	24.27	7.37	10.76	11.94	13.26	12.8
BYU 631-163	104.27	32.67	3.59	13.32	25.93	11.44	9.23	18.8	15.05	13.07
BYU 16719	98.64	42.28	4.06	13.15	26.36	10.97	9.86	21.09	11.35	10.13
BYU 5215	200	75.94	9.76	19.89	56.08	20.64	17.42	35.33	19.15	18.58
BYU 17945	248	71.11	15.12	31.77	75.82	30.85	21.35	54.49	26.8	28.21
IMNH 44951	132.58	51.09	5.43	15.01	38.82	13.25	13.04	24.47	14.18	12.69
DBDP-42	298	121.9	14.17	31.56	80.23	32.4	29.46	54.68	28.2	35.59
DBJP-119	306	105.98	9.34	31.95	89.29	39.37	27.62	60.22	37.33	39.29
DBDP-163b	265	101.13	17.7	22.23	72.45	29.18	24.89	49.39	34.3	26.43
UMNH VP20208	334	127.62	9.95	43.22	74.98	24.18	43.3	42.72	48.1	49.8
MOR 548	107.51	47.41	4.77	14.13	34.16	14.93	12.73	29.93	16.08	15.21
MOR 548	114.18	54.2	6.04	15.62	38.51	15.26	16.41	30.17	15.86	16.16
MOR 548	115.07	47.5	6.6	19.94	39.13	17.31	15.94	32.52	13.95	18.26
MOR 548	118.69	50.93	7.01	11.95	39.94	16.46	16.19	29.78	11.4	10.04
MOR 548	128.86	57.61	6.4	14.93	43.59	18.09	18.21	34.83	15.52	18.05
MOR 548	120.14	53.57	4.92	14.11	39.93	14.97	17.18	25.82	15.42	18.04
MOR 548	123.57	60.12	5.48	15	38.95	16.65	17.99	29.91	19.69	17.48
MOR 547	239	110.26	10.51	21.29	51.43	24.74	26.53	34.52	29.65	34.97
MOR 547	245	113.61	8.28	31.1	55.47	25.43	25.62	45.44	32.17	36.63
MOR 404	70.14	22.61	4.36	11.53	21.23	6.58	6.35	14.35	10.3	9.87
MOR 294	63.64	19.7	3.57	8.84	18.69	6.31	7.45	11.98	9.27	9.75

MOR 473	104.44	39.96	3.66	14.47	30.06	10.85	10.2	20.34	15.93	15.47
MOR 478	570	254	26.26	49.17	140.13	57.9	43.51	87.65	70.15	79.91
MOR 607	283	143.77	8.95	42.99	64.68	25.31	46.04	50.3	37.05	46.05
HC-164	198	60.47	6.91	26.27	59.49	22.01	18.25	36.57	27.16	24.38
MOR 311	611	308	29.83	89.19	178	77.05	61.87	131.89	88.49	97.5
MOR 1071	355	170	20.85	44.93	100.07	38.96	45.24	76.8	43.85	48.41
MOR 1071	354	174	21.07	49.77	91.93	37.89	44.47	74.75	45.45	51.66
MOR 1071	381	170	21.4	55.97	97.47	39.84	52.67	84.09	47.32	57.82
MOR 1071	563	265	31.05	57.3	154	73.21	50.06	122.88	75.33	83.05
MOR 2558	462	177	30.85	61.84	173	71.85	41.39	138.03	75.99	73.72
YPM 1876	187	74.84	11.77	29.93	56.52	19.31	20.5	43.36	25.12	25.44
YPM 6794	236	116.08	21.96	47.72	84.02	36.33	30.52	67.08	39.3	38.82
YPM 7331	229	85.78	17.94	31.7	73.55	28.96	25.77	56.31	31.35	31.98

ID#	HL	DPL	DPW	HHW	HPW	HSW	HSP	HDW	RCW	UCW
YPM 1877	339	129	20.27	53.88	108.83	29.55	27.77	85.01	48.49	44.86
YPM 5456	440	182	29.04	87.2	145.61	52.23	57.6	123.07	71.7	74.35
YPM-PU 16514	200	81.17	5.21	26.57	61.9	27.23	23.45	49.95	28.49	26.79
YPM 5456	447	178	23.44	69.26	153.97	56.96	52.71	116.05	66.6	73.81
YPM-PU 23255	537	246	27.16	50.37	157	65.61	52.91	116.5	75.85	78.78
YPM-PU 22400	81.36	35.46	4.25	10.85	20.74	9.48	8.89	18.29	9.71	9.4
YPM 3454	359	183	20.29	45.04	93.4	47.36	44.32	84.79	46.94	58.94
YPM-PU 23444	107.2	47.86	7.74	14.27	31.64	15.64	17.5	27.67	14.06	17.25
YPM-PU 22400	75.29	35.42	2.98	8.19	16.44	7.97	7.25	17.19	8.51	9.7
YPM 1800	288	118	17	52	83	36	28	69	38	39
YPM 1800	291	116	18	51	85	30	32	63	39	40
CM 3392	194	66.96	21.24	14.16	49.39	20.76	18.87	48.18	16.54	15.92

CM 9900	291	116.05	23.91	32.52	87.2	27.89	25.62	58.22	34.72	29.94
CM 21786	178	57.5	13.49	20.83	41.1	17.47	15.3	34.31	20.52	18.52
CM 30745	275	147.26	14.44	46.16	65.29	35.37	31.2	61.65	34.38	41.6
CM 1066	634	310	32.02	72.87	164	64.93	79.63	140.82	77.5	90.84
CM3392/21786	187.69	71.27	16.03	28.07	56.89	19.59	20.02	42.42	24.46	25.84
CM3392/21786	188.4	70.64	13.04	32.2	57.57	20.78	17.94	44.34	24.52	24.77
NHMUK R192	145.17	52.76	9.84	15.15	38.47	16.23	12.38	30.03	16.47	17.61
NHMUK R194	105.93	34.3	5.32	10.32	26.47	10.76	9.55	19.2	14.75	12.05
NHMUK R196	105.41	37.46	7.14	12.67	28.17	11.41	8.57	23.58	8.73	13.44
NHMUK R196	105.38	39.68	5.62	26.76	16.27	10.22	11.07	23.09	16.3	15.33
NHMUK R5830	74.56	25.03	3.34	8.79	17.81	5.34	7.01	13.09	8.73	8.5
NHMUK RU B.17	65.84	21.93	3.63	6.4	19.24	6.8	6.86	15.19	7.88	5.25
NHMUK R3640	602	299	42.81	87.54	174	81.63	71.14	135.86	79.17	99.17
CM 11337	223	90.26	12.56	32.15	69.57	25.66	22.2	50.69	28.08	28.52
CM 11337	224	88.71	16.67	33.94	68.39	27.45	23.17	49.72	27.43	28.25
CM 9185	157.67	69.43	3.79	20.27	45.94	20.08	15.05	46.98	16.5	18.81
CM 9461	414	211	19.91	51.23	123.65	50.03	57.5	103.5	60.54	60.49

TABLE S6. Measurements used in the traditional morphometric analysis of the scapula.
Abbreviations described in Table 1 in the manuscript.

ID#	SL	SAW	BL	MBW	SSL	SCAL	PBW	SAL	IAL
MOR1636	154.11	82.42	115.9	30.81	60.12	70.38	88.32	108.67	129.04
MOR1636	142.32	87.06	105.39	30.4	62.73	73.78	93.18	102.13	120.2
MOR 1642	145.82	77.11	99.99	29.38	59.02	56.66	80.31	99.87	120.94
MOR 294	66.17	28.51	54.46	10.64	23.56	21.44	26	55.99	59.13
MOR 623	93.14	43.48	60.79	14.73	33.13	33.61	38.61	69.86	75.68
MOR 547 W-25-2	365	52	240	38	88	48	84	361	330
BYU 631-163	87.81	48.51	67.54	14.15	40.8	38.26	44.09	86.37	83.24

ID	SL	SAW	BL	MBW	SSL	SCAL	PBW	SAL	IAL
BYU 17948	292	91.32	230	44.51	62.71	64.4	83.08	280	283
BYU 17945	324	105.55	251	52.57	65.12	83.45	128.98	278	294
BYU 12192	1020	280	830	140	215	150	230	1030	970
DBDP-185	314	96.87	244	47.25	64.11	81.32	89.08	287	280
UMNH VP20644	171	82.13	132.02	35.27	54.22	60.22	115.34	150.47	154.1
UMNH VP20208	455	139.75	361	60.99	84.76	87.66	131.61	419	409
UMNH VP16567	502	183	391	85.62	104.26	92.74	184	446	455
MOR 584	204	59.72	151.68	26.76	47.76	28.87	58.49	205	188
MOR 584	218	58.65	171	25.83	50.23	29.02	58.65	214	205
MOR 584	173	52.52	126.74	21.69	40.88	26.7	57.08	173	153
MOR 682	319	129.25	262	60.71	100.97	108.24	127.54	290	273
MOR 1071	767	170	595	115.02	250	102.07	185	732	694
YPM 6794	291	138.68	223	53.98	67.72	105.83	83.92	258	277
YPM 8611	483	169	397	70.44	77.12	135.75	178	433	466
YPM 1877	435	155	339	75.11	100.83	128.11	165	378	416

YPM 56454	208	71.71	162	29.13	46.58	61.99	65.08	191	187
YPM 5456	526	134.02	367	92.51	134.72	92.82	179	460	420
YPM 4546	508	162	398	95.94	105.48	97.34	179	448	409
YPM-PU 22503	764	169	592	112.86	245	96.91	188	706	658
YPM 1800	387	125	314	55	78	70	140	350	340
YPM 1800	388	130	317	54	76	73	134	355	334
CM3392/21786	178.16	55.32	149.54	31.44	40.08	34.34	81.43	153.37	161.95
CM3392/21786	178.77	51.98	151.41	27.37	34.88	36.02	72.23	159.18	169.3
NHMUK R192	134.38	53.81	109.97	21.98	42.32	30.2	49.86	135.28	128.8
NHMUK R196	93.96	39.33	77.81	14.82	33.62	34.74	45.66	77.25	82.41
NHMUK R196	91.34	40.99	69.76	15.03	30.49	31.94	46.14	68.35	71.87
NHMUK RU B.17	72.15	12.53	60.72	9.37	12.28	11.46	23.07	65.57	64.73
NHMUK R11000	162	74.3	130	19.79	63.03	56.36	64.06	151	157
NHMUK R2519	629	212	466	103.5	120	136.72	121.98	608	565
NHMUK R2196	546	160	449	64.22	97	67.64	82.03	540	520
NHMUK R966	857	344	643	134.95	221	201	242	816	758
NHMUK R4743	740	236	635	113.37	84	198	144.26	710	660
CM 11337	310	102.05	231	45.17	85.14	64.09	100.99	280	279
CM 11337	297	102.09	224	44.3	84.71	53.15	105.98	270	269
CM 9185	179.47	56.62	138.88	23.34	49.11	33.97	49.94	178.28	181.2
CM 9461	567	144.49	434	80.56	149.74	76.94	151.6	579	536

SUPPLEMENTARY FIGURES

FIGURE S1. The measurements used in the traditional morphometric analysis of the coracoid in lateral view. Measurements are described in more detail in Table S2.

FIGURE S2. Landmark and semilandmark locations for the geometric morphometric analysis of the coracoid in lateral view, described in more detail in Table S3. Landmarks are signified by circles and are described in the text by their corresponding numbers, semilandmarks are signified by squares.

FIGURE S3. PCA results for the traditional morphometric analysis of the coracoid and scapula. PCA results for the coracoid; **A**, PC1 vs. PC2; **B**, PC2 vs. PC3. *Oryctodromeus* specimens show a broad range of scores, given the small sample size. MOR 1636a has a strongly negative PC1 and PC3 score, while MOR 1642 scores near zero in all three principal components.

FIGURE S4. Relative warp analysis results for the coracoid; **A**, the first two relative warp axes of the analysis of the coracoid; **B**, the third and fourth relative warp axes of the analysis of the coracoid.

Canonical variates of the coracoid, CV1 v. CV2

FIGURE S5. The first two canonical variates from the CVA of the coracoid. The results for the coracoid indicate that iguanodontians have negative scores and basal ornithopods, including *Oryctodromeus* have positive scores, however a phylogenetic signal is difficult to ascertain due to the small sample size.

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