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Description of the first definitive *Corythosaurus* (Dinosauria, Hadrosauridae) specimens from the Judith River Formation in Montana, USA and their paleobiogeographical significance

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ABSTRACT

The late Campanian Judith River Formation in northern Montana, USA has long been recognized as a dinosaur-bearing rock unit.~~ , eversince the first North American dinosaur discovery from this unit. .~~Despite the long ~~study~~ history of research in this formation, most of the vertebrate fossils are represented by fragmentary remains, making precise taxonomic identifications difficult. Contrary to this, the partially contemporaneous Dinosaur Park Formation, Alberta, Canada is known for its tremendous fossil preservation, permitting rigorous studies of dinosaur diversity, evolution, and biostratigraphy. Hadrosaurids comprise one of the most abundant dinosaur clades in the Dinosaur Park Formation, but taxonomic affinities of hadrosaurid specimens remain poorly understood in the Judith River Formation. *Corythosaurus* is the most common hadrosaurid in the Dinosaur Park Formation and, to date,~~,~~ ~~and~~ has been restricted to this formation~~ to date~~. This study reports the first definitive *Corythosaurus* specimens from the Judith River Formation, which were discovered on two private ranches in northern Montana. The attribution of the most complete skeleton to *Corythosaurus* is indicated by~~ the combination of the following characters~~: wide crest-snout angle, presence of premaxilla-nasal fontanelle, dorsoventrally expanded nasal, laterally exposed ophthalmic canal of the laterosphenoid, and tall neural spines. A second specimen preserves a large~~ly~~ ilium that can be positively identified as *Corythosaurus* based on its associated skull, which is now in ~~a~~ private ~~hand~~hands~~ due to its association with a largely complete articulated skull~~. The specimens were recovered from the Coal Ridge Member of the Judith River Formation, which is approximately time equivalent to the Dinosaur Park Formation. Thus, the discovery of *Corythosaurus* in the Judith River Formation extends the biogeographic range of this genus and establishes a framework for future interformational biostratigraphic studies of Late Cretaceous dinosaur faunas in North America. Further discoveries of the shared dinosaur taxa between these two formations are expected to ~~construct~~ establish ~~the~~ an interformational biostratigraphic framework.

Keywords: Late Cretaceous, Hadrosaur, Dinosaur, Judith River Formation

INTRODUCTION

Outcrops of the late Campanian Judith River Formation (JRF) exposed in northern Montana, USA, have produced abundant vertebrate fossils. Since the discovery of the first dinosaur in North America by Ferdinand Vandeveer Hayden in 1854 (Leidy, 1856), rigorous effort has been put into collecting vertebrate fossils from the JRF. As a result of this, several relatively complete skeletal specimens have been collected and described (Dodson, 1986; Prieto-Márquez, 2005; Murphy et al., 2006; Prieto-Marquez, 2007; Freedman, 2015; Mallon et al., 2016; Arbour and Evans, 2017) and have contributed to understanding dinosaur evolution of the Late Cretaceous of North America. Nonetheless, ~~the majority of~~most of the dinosaur remains from the JRF are represented by isolated or partial material~~s~~, hindering detailed taxonomic evaluations. This pattern of fossil occurrences in the JRF is strikingly different~~s~~ from those in the partially contemporaneous Dinosaur Park Formation (DPF) of southern Alberta, where a plethora of dinosaur remains have been discovered with various taphonomic modes, including numerous complete skulls and skeletons (Eberth and Currie, 2005). Due to the excellent preservation and rich fossil occurrences, the dinosaur faunas of the DPF have been well-studied, and the ~~the dinosaur~~ biostratigraphy of dinosaurs has been established at the species level (Ryan and Evans, 2005; Mallon et al., 2012; Cullen et al., 2021), unlike the situation in the JRF.

Lambeosaurine hadrosaurids are ~~one of the dinosaur groups that are~~ well-known from the DPF, but ~~its~~their presence remains ambiguous in the JRF. Currently, at least five valid lambeosaurine taxa are known from the DPF: ~~(~~*Corythosaurus casuarius*, *C.~~orythosaurus~~ intermedius*, *Lambeosaurus lambei*, *~~Lambeosaurus~~ L. magnicristatus*, and *Parasaurolophus walkeri*~~)~~. *Corythosaurus* is represented by over 25 relatively complete skulls and skeletons (Currie and Russell, 2005) and is the most abundant genus among the five lambeosaurine taxa (Ryan and Evans, 2005). Although abundant in the DPF in the Dinosaur Park area, Alberta, Canada, there is no definitive record of this genus from other time equivalent strata such as the JRF. Here, we report the first well-preserved lambeosaurine skeleton identifiable to *Corythosaurus*, collected from the JRF, northern Montana, USA. We also report a second, less complete specimen with a complex provenance that can~~ be~~ also be positively assigned to this genus based on an articulated skull now lost to a private collection~~ also from the JRF of Montana~~. Both specimens contribute significantly toward a more comprehensive understanding of the dinosaur fauna of this formation and the paleobiogeography~~ical~~ ~~significance~~of Campanian dinosaurs in North America.

Institutional abbreviations

AMNH, American Museum of Natural History, New York; CMN, Canadian Museum of Nature, Ottawa, Canada; MOR, Museum of the Rockies, Montana, USA; NMMNH, New Mexico Museum of Natural History & Science, New Mexico, USA; OUSM-FV, Okayama University of Science, Museum of Dinosaur Research, fossil vertebrate collection, Japan; ROM, Royal Ontario Museum, Toronto, Canada; TMP, Royal Tyrrell Museum of Palaeontology, Drumheller, Canada; UALVP, University of Alberta Laboratory for Vertebrate Paleontology, Alberta, Canada; USNM, United States National Museum, Smithsonian Institution, Washington, DC, USA.

MATERIAL AND METHODS

OUSM-FV-001, discovered and excavated from private land in Montana by the commercial company Phoenix Fossils in 1990, was legally purchased by the Hayashibara Museum of Natural Sciences in 1991. When the museum closed ~~down~~ in 2015 ~~subsequent to~~after the bankruptcy of its parent company, OUSM-FV-001 was transferred to the Okayama University of Science Museum. The pathological jugal and the basisphenoid of OUSM-FV-001 were scanned using X-ray CT Latheta (LCT-200) at the Okayama University of Science. The images were acquired at a voltage of 80kV and a current of 0.5 mA. Both the pixel sizes and interslice thicknesses are 120 and 120 um resulting in voxel sizes of 120 um (Supplemental Data S1). Photogrammetric models of the partial nasals and the partial left premaxilla were made using Agisoft Metashape Professional (Supplemental Data S2-S4). Selected measurements of OUSM-FV-001 are provided as Supplemental Data S5.

ROM 77978 was also discovered and legally collected from a private ranch in Hill County, Montana in 2015. The articulated skull and lower jaws were mounted and sold into a private collection. Prior to the sale, the original skull was inspected firsthand by DCE on January 29, 2016. The collector was not interested in obtaining the associated postcranial elements, which were subsequently acquired by the Royal Ontario Museum and accessioned as ROM 77978~~,~~ and described here. Photographs, CT scans, and a high-resolution surface scan together with a 3D print of the skull are also reposited at the ROM. As part of the acquisition of ROM 77978, the landowner agreed to allow scientific access to the field site in order for the ROM to gather detailed contextual sedimentological and stratigraphic information and document the host paleoenvironment. DCE and FF visited the quarry where ROM 77978 was collected on August 10, 2017, along with the person who discovered and collected the specimen.

Systematic paleontology

Dinosauria Owen, 1842

Ornithischia Seeley, 1887

Lambeosaurinae Parks, 1923

Lambeosaurini Sullivan et al., 2011

Corythosaurus Brown, 1914

Corythosaurus sp.

Referred Specimen

OUSM-FV-001, a partial disarticulated skeleton including: partial left and right premaxillae, a complete left and posterior two-thirds of the right maxillae, partial nasals around the prefrontal-nasal fontanelle, a nearly complete left jugal and a partial right jugal, posteromedial portions of both quadrates, partial right squamosal, partial left postorbital, a left frontal, a right laterosphenoid, a left exoccipital ~~other than~~missing the paroccipital process, the main body of the basisphenoid, both dentaries, both surangulars, both angulars, right splenial, partial axial elements, a nearly complete right scapula, blade of the left scapula, both coracoids, nearly complete right sternum, a complete left humerus, nearly complete ulnae, nearly complete ~~radiae~~radii, both ~~manus~~ mani missing a few phalanges, a nearly complete right ilium, both pubes with incomplete anterior and posterior processes, nearly complete left ischium, nearly complete left femur, both tibiae missing the distal ends, nearly complete fibulae, a complete right astragalus, and both pedes missing a few phalanges (Fig. 1C).

Locality and horizon

OUSM-FV-001 was discovered on a private ranch approximately 8 km north of Winifred, Montana (Fig. 1). The locality data ~~is~~ are cataloged in the OUSM collection database and is available upon request. The specific locality data was initially unavailable since the private company that sold this specimen provided only a rough quarry location (within a 4 x 4 km range) and has since ceased operation. Recently, the authors noted that the location of a historical quarry on property now leased by Triebold Paleontology, Inc. nicknamed “Japanese dig” by local ranchers fell exactly within this area. According to recollections of those ranchers as well as ~~from~~ dates found on beverage cans ~~found a~~in~~t~~ the quarry~~ by one author~~, a 1990 date for that excavation matches information provided with OUSM-FV-001. Together with the fact that a nearly complete lambeosaurine skeleton is extremely rare from the Judith River Formation, we tentatively consider that OUSM-FV-001 was collected from this quarry. The OUSM-FV-001 quarry is located near the reference section of the Judith River Formation (Rogers et al., 2016). Since the quarry is positioned no lower than the top 50 m of the badlands, and the Coal Ridge Member occupies the upper ~ 90m of the formation, the horizon yielding the quarry likely belongs to the Coal Ridge Member. The quarry is located approximately 8.5 km NNE of the *Spiclypeus shipporum* holotype locality (Mallon et al., 2016), and is also several hundred meters away from the “Ava” centrosaur quarry, which was collected by Triebold Paleontology, Inc.

Description of OUSM-FV-001

Premaxilla. The anterior right premaxilla and a small portion of the left premaxilla are preserved (Fig. 2C-F). The oral margin of the right premaxilla is slightly ~~lost~~ damaged but has a gently rounded outline. Posteriorly, the posterodorsal process is laterally everted to form a ridge that dorsally defines the external naris. Although incomplete, the dorsal process of the left premaxilla is gently ~~curved~~concave unlike in *Parasaurolophus* which is straight or convex. The posterodorsal end of the dorsal process is curved posterodorsally (Fig. 2D; Data S4), suggesting a wide crest-snout angle as in *Corythosaurus* and *Hypacrosaurus*, rather than *Lambeosaurus* in which the dorsal process is recurved anteriorly to form an acute crest-snout angle less than 120 degrees (e.g., ROM 794, TMP 66.04.01)~~and forms a crest-snout angle of approximately 150 degrees along its dorsal margin (Fig. 2D). The angle is markedly wider than that of *Lambeosaurus,* in which the crest-snout angle is generally less than 120 degrees in large specimens (e.g., ROM 794, TMP 66.04.01)~~. ~~Instead, the wide crest-snout angle of OUSM-FV-001 resembles that of *Corythosaurus* and *Hypacrosaurus*.~~ Internal to the curvature, a septum intercepts the dorsal half of the nasal passage to form an S-loop, as in other members of Lambeosaurini (Evans et al., 2009). The posterodorsal process of the left premaxilla is medially flat to contact its counterpart and dorsally grooved, possibly due to postmortem deformation.

Maxilla. A complete left maxilla and the posterior two-thirds of the right maxilla are mounted for display (Fig. 2A, B, G). Although the anterior process of the maxilla is dorsally covered by the reconstructed premaxilla, a part of the premaxillary shelf exposed at the anterior end is angled at approximately 15 degrees relative to the ventral margin. The lateral exposure of the dorsal process of the maxilla is located approximately at the midline of the maxilla. It is dorsoventrally tall and tapers to a point dorsally. Ventral to the dorsal process, the lateral surface of the left maxilla bears two large and two small foramina, whereas the right maxilla bears one large and four small foramina. A well-developed ectopterygoid ridge emerges posterodorsal to the most posterior foramen, where the maxilla and the ventral margin of the anterior process of the jugal contact. The ectopterygoid ridge occupies approximately 40% of the maxilla length. It is oriented nearly parallel to the alveolar margin of the posterior maxilla, and is approximately 1.5 times as wide as the height of the maxilla anterior to the pterygoid process. The alveolar margin of the maxilla is shallowly concave. It should be noted that the alveolar margin of the left maxilla is slightly swollen at around the midpoint of the maxilla. The swollen area has a rugose surface that resembles the lesion identified on a *Parasaurolophus* maxilla (Bertozzo et al., 2020). Medially, the gently arched row of alveolar foramina ~~are~~ is located dorsal to the midline of the maxilla. At the posterodorsal end of the maxilla, a small~~,~~ triangular pterygoid process projects dorsomedially.

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The left maxilla bears approximately 38 tooth positions within the 298 mm long dental battery. Although the labial-most tooth is not preserved in most of the tooth positions, the remaining positions suggest that the majority of the tooth row had two functional teeth in life. All ~~of the~~ preserved maxillary teeth have a prominent primary ridge and lack other ridges. The primary ridge is straight or slightly curved and positioned at the midline of each tooth. The mesial and the distal margins of the ~~coronal~~ apical half of each tooth have mammilliform denticles.

Nasal. The posterior regions of both nasals are preserved (Fig. 2H-K). Both nasals retain the posterior margin of the premaxilla-nasal fontanelle (PNF), unlike in

Hypacrosaurus in which the PNF is closed early in ontogeny (Brink et al., 2014). The nasal is thick around the PNF and becomes thinner distal to the PNF, forming a medially concave space for the lateral diverticulum (Evans et al., 2009). Since the broken posterior end is still mediolaterally thick, the nasal is likely to extend further posteriorly in life. The elongation of the dorsoventrally high nasal posterior to the PNF differs from the nasal of *Corythosaurus intermedius,* in which the cranial crest is anteroposteriorly shorter than ~~*Corythosaurus*~~ *C. casuarius* and forms a rod-like structure at the posteroventral end of the crest (e.g., ROM 776, 777, 845, UALVP 13). Although the nasal is incomplete, the preserved region is much taller than the strip-like nasal of *Lambeosaurus* (e.g., ROM 1218). The lateral surface of the nasal is generally flat except for the concavity dorsal to the posteroventral margin of the crest. The lateral and the ventral surfaces meet at an acute angle, forming a sharp ridge. Ventrally, the nasal bears a shallow concavity for the prefrontal contact (Fig. 2I, Data S3) as in *C*~~*orythosaurus*~~*. intermedius* (e.g., ROM 776). The ventral surface of the crest, posterior to the prefrontal contact, is smooth and shallowly ~~concave~~convex (Data S2, 3)~~, as in *Corythosaurus casuarius* (e.g., AMNH FARB 5240).~~ .

Jugal. A nearly complete left jugal and a partial right jugal are mounted (Fig 2A, B, Fig. 3A). The anterior process of the jugal is expanded dorsoventrally as in other lambeosaurines (Evans, 2010). The medial palatine process is inclined posterodorsally, resulting in ~~the~~ a posteriorly located dorsal apex of the anterior process relative to the ventral apex. The ventral margin of the jugal forms a posteriorly skewed deep arch, although this region may be slightly eroded. The ventral flange of the jugal posterior to the ventral arch is trapezoidal unlike the pointed ventral flange of *Hypacrosaurus* *altispinus* (Evans, 2010). The anterodorsal and posteroventral margins of the posterior process are oriented nearly parallel to each other.

In addition to the mounted ~~two~~ jugals, a posterior process of another hadrosaurid jugal is present (Fig. 3B, C). The length along the ventral margin of the infratemporal fenestra is nearly 1.5 times as long as the other two jugals, whereas the posterior constriction of the third jugal is only half as wide as the other two. While the differences may indicate the third jugal belongs to a different hadrosaurid taxon, these anomalies are more likely pathological. The lateral and medial surfaces of the anterior region are more porous than the posterior region, and the anterior fracture surface is rugose and bears multiple small cavities which may suggest resorption (Supplemental Data S1).

Quadrate. The posteromedial portions of both quadrates are preserved (Fig 2A, B, Fig. 3D, E). The quadrate is gently bowed posteriorly as in ~~*Corythosaurus*~~ *C. casuarius* (e.g., AMNH FARB 5240) and ~~*Lambeosaurus*~~ *L. lambei* (e.g., ROM 1218), at approximately 144 degrees. Dorsally, a faint squamosal buttress is present on the posterior margin of the quadrate. The posterolateral spur is located at about one-third the height of the quadrate. The posterior surface of the pterygoid wing is slightly excavated to contact the posteroventral ramus of the pterygoid. The ventral end of the quadrate is much wider mediolaterally than the anteroposterior length of the lateral condyle, which is typical in hadrosaurids (Prieto-Márquez, 2010). The lateral and the medial condyles form a deep groove on the posterior surface of the quadrate as in *C.*~~*orythosaurus*~~ *intermedius* (e.g., ROM 777) and *Hypacrosaurus stebingeri* (e.g., MOR 549). The medial condyle appears to be elevated compared to the lateral condyle, although the medial condyle is slightly damaged.

Squamosal. The main body of the right squamosal is preserved (Fig. 3F). The lateral surface of the postorbital process of the squamosal bears a contact surface for the squamosal process of the postorbital. The contact surface extends dorsal to the apex of the quadrate cotylus of the squamosal. The contact surface for the postorbital suggests that the squamosal process of the postorbital is bifurcated, unlike in ~~*Hypacrosaurus*~~ *H. altispinus* (Evans, 2010). The preserved portion of the precotyloid process is shorter than the anteroposterior width of the quadrate cotylus. In posterior view, the medial process of the squamosal is dorsoventrally expanded as in other lambeosaurines (Evans, 2010).

Postorbital. The left postorbital is partially preserved (Fig. 3G). Although the anteromedial process is partly missing, the base of the anteromedial process is deeply depressed, as in derived lambeosaurines such as ~~*Corythosaurus*~~ *C. casuarius* (Brown, 1914). Posterolateral to the depression, the dorsal surface of the base of the squamosal process forms a mediolaterally compressed protuberance as in some *Corythosaurus* (e.g., CMN 34825, ROM 776) and *Lambeosaurus* (ROM 1218) specimens. Although the squamosal process is incomplete, it makes a gentle curvature with the main body of the postorbital, unlike in *Velafrons* in which the squamosal process elevates abruptly (Gates et al., 2007). Ventrally, the jugal process of the postorbital and the anteromedial process form the semicircular posterodorsal margin of the orbit. The orbital margin has a rugose texture. The anteromedial surface of the jugal process is shallowly concave.

Frontal. The left frontal is nearly complete except for the posteromedial region (Fig. 3H-J). The anterior region of the frontal forms the anteroposteriorly striated contact surface for the nasal. The contact surface occupies the anterior half of the frontal and is deeper laterally than medially. The contact surface for the nasal is angled at approximately 20 degrees relative to the skull table. The anteromedial end of the nasal contact surface does not reach the skull midline and forms a deep median cleft unlike in *Parasaurolophus* (Evans et al., 2007). The posterolateral margin of the nasal sutural surface is slightly everted to support the supracranial crest, unlike in large parasaurolophines in which the nasal contact surface extends above the skull table (Evans et al., 2007). Posteriorly, the skull table is slightly elevated to form a median dome as in other lambeosaurines (Ostrom, 1961), although the region is partially missing. Ventrally, the frontal bears three depressions: the olfactory depression, the orbital depression, and the cerebral fossa. The cerebral fossa is the deepest among the three depressions. Its posterodorsal surface shows vascular valleculae.

Laterosphenoid. A right laterosphenoid is missing its dorsolateral process (Fig. ~~3K~~4A). The sulcus for the ophthalmic ramus (CN V_1) is laterally fully open and forms a horizontal groove as in *Corythosaurus* and *Hypacrosaurus*, but differs from *Lambeosaurus* in which CN V_1 is laterally covered by the laterosphenoid (Ostrom, 1961; Evans and Reisz, 2007). In lateral view, ~~Relative to the ophthalmic sulcus, t~~the dorsal margin of the laterosphenoid where it contacts the parietal is nearly parallel or only slightly divergent from the line of the ophthalmic sulcus, resulting in a dorsoventrally short laterosphenoid ~~where it contacts the parietal~~. This is consistent with the laterosphenoids of ~~*Corythosaurus*~~ *C. casuarius* (ROM 1933), ~~*Corythosaurus*~~ *C. intermedius* (ROM 776), and ~~*Hypacrosaurus*~~ *H. stebingeri* (MOR 549). In contrast, it ~~but~~ differs from the laterosphenoid of *Parasaurolophus tubicen* (NMMNH P25100),~~;~~ in which the dorsolateral process is dorsally directed; therefore, the dorsal margin is strongly divergent from the ophthalmic sulcus. ~~The~~ In dorsal view, the dorsolateral process ~~margin~~ of the laterosphenoid strongly curves laterally as in *Prosaurolophus* *maximus* (Horner, 1992), small *Edmontosaurus annectens*, and small ~~*Hypacrosaurus*~~ *H. stebingeri* (Takasaki et al., 2020).

Exoccipital. The left exoccipital is nearly complete other than its paroccipital process (Fig. ~~3L, M~~4B, C). The occipital plate of the exoccipital is pierced by the openings for the glossopharyngeal nerve (CN IX), the vagus nerve (CN X), and the hypoglossal nerve (CN XII) (Ostrom, 1961; Evans et al., 2009). While CN IX and X are associated close together laterally, they are well-separated medially. Dorsally, the exoccipital has a horizontal shelf as the contact surface for the supraoccipital. The horizontal shelf is slightly wider than its anteroposterior length. The laterodorsal margin of the supraoccipital contact is medially overhung, indicating that the exoccipital "locked" into the supraoccipital in articulation. Dorsolateral to the horizontal shelf, a squamosal boss is present on the lateral half of the exoccipital unlike the indeterminate lambeosaurine from the Prince Creek Formation, Alaska, in which the exoccipitals do not participate in forming a squamosal boss (Takasaki et al., 2019).

Basisphenoid. The posterodorsal surface of the basisphenoid and the cultriform process are missing (Fig. ~~3~~ 4 ~~N~~D-~~P~~F). On the lateral surface of the long and massive basipterygoid process, two ridges run proximodistally, emerging from the anteroventral and posterodorsal margins of the foramen for the internal carotid artery at base of the basipterygoid process. The alar process is bifurcated as in *Amurosaurus riabinini* (Godefroit et al., 2004) and borders the anteroventral margin of the foramen for the carotid artery. Posterodorsally, the basisphenoid is enlarged to form the sphenooccipital tubera with the basioccipital. The basipterygoid processes meet at approximately 90 degrees in anterior or posterior views. A part of a small median protuberance is present at the base of the basipterygoid processes as in derived lambeosaurines (Gates and

Sampson, 2007), although it is partly broken. ~~Right lateral ~~T~~to t~~he median protuberance is deeply incised on the right lateral side~~,~~ and the surface surrounding the incision is porous and slightly elevated, which may be pathological.

Mandible. Both dentaries are nearly complete, although most of the anterior and the medial regions are reconstructed (Fig. ~~3Q~~4G-~~T~~J). Anteriorly, the dentary is curved ventrally, starting approximately from the level of the anteriormost reconstructed tooth, at an angle of 159 degrees relative to the posterior half of the dentary. The symphyseal process is markedly curved medially to contact the counterpart as in typical lambeosaurines. The mediolateral width of the symphyseal process is slightly less than twice the non-symphyseal anterior dentary mediolateral width. Posterior to the symphyseal process, the edentulous diastema is shallowly sloped anteroventrally relative to the main body of the dentary. The lateral surface of the main body of the dentary is pierced by at least ten randomly ~~-~~distributed foramina. Posteriorly, the coronoid process is inclined anterodorsally at approximately 80 degrees relative to the alveolar margin. The coronoid process is separated from the main body of the main dentary body by a wide lateral shelf, typical for hadrosaurids. The dorsal apex of the coronoid process is expanded anteroposteriorly, and its posterior surface is deeply grooved to contact the anterodorsal process of the surangular.

A fragmentary bone is cataloged as the left lateral process of the predentary, but its detail is unavailable since it is embedded within the mounted skull (Fig. ~~3Q~~4G). Both surangulars are preserved, although ~~its~~their medial and anterior regions are also embedded within the ~~plaster~~reconstruction. The surangular is dorsoventrally flat at the level of the glenoid. The posterior process of the surangular is strongly curved dorsally and tapers into a point. Ventral to the surangular, the angular is visible in lateral view, although this configuration is likely to be an artifact of misplacement upon mounting the specimen. The right splenial is mediolaterally thin and becomes taller anteriorly, although the anterior end is missing.

Vertebrae. Eleven post-axial cervical, 17 dorsal, and 34 caudal vertebrae are cataloged as containing original bone (Fig. 45), although most retain only either the centrum or neural spine. The preserved vertebrae exhibit general conditions of Hadrosauridae. Centra of the cervical vertebrae are opisthocoelous and slightly concave lateroventrally. The articular facets of the prezygapophyses are subcircular in the anterior cervicals and become mediolaterally wide and elliptical posteriorly. The postzygapophyses are acutely divergent from each other in the anterior cervicals, while the angle becomes wider in the posterior cervicals. Dorsally, the neural spine is small and becomes slightly more prominent in the posterior cervical vertebrae. All of the preserved dorsal centra are amphiplatyan. The best-preserved dorsal centrum is a middle dorsal centrum cataloged as “D-4”. Although the neural spine corresponding to this centrum is missing, a neural spine of a posterior dorsal vertebra (cataloged as “D-16”) is 2.3 times longer than the height of the middle dorsal centrum (“D-4”). Since dorsal centra of hadrosaurids become higher posteriorly, the ratio between neural spine length and centrum of the OUS specimen is likely to be much less than 2.3. The short neural spine differs from *Hypacrosaurus*, which has a long neural spine relative to the centrum (Lull and Wright, 1942; Evans, 2010). The neural spine of the posterior dorsal vertebra is long and gracile, being 5.5 times higher than its anteroposterior width. Centra of the caudal vertebrae are amphiplatyan and are much higher and wider than its length~~s~~ in the anterior caudal vertebrae, while they become elongated posteriorly. The transverse processes lie nearly horizontally, unlike the acutely angled transverse processes of the dorsal vertebrae.

Pectoral girdle. The right scapula is nearly complete other than the glenoid and the distal end of the scapular blade (Fig. ~~5A~~6A). The acromion of the scapula is oriented laterally, forming a flat dorsal surface of the anterior end of the scapula. Posterior to the acromion, a poorly developed deltoid ridge is present along the lateral surface of the scapular blade. The scapula curves ventrally at the neck, although the curvature is less prominent than *Brachylophosaurus canadensis* (Prieto-Marquez, 2007) and *Gryposaurus latidens* (AMNH FARB 5465). The posterior end of the scapular blade is at least 1.5 times as high as the neck, although ~~the~~ further detail is unavailable due to ~~the~~ poor preservation. Both coracoids are nearly complete, exhibiting a slightly shorter contact surface for the scapula compared to the length of the glenoid (Fig. ~~5B~~6B). The anterodorsal margin of the coracoid is concave and ventrally continues to a well-developed biceps tubercle. Distally, the ventral hook of the coracoid is 0.64 times as high as its width. The medioventral margin of the coracoid is rugose for cartilage contact. The right sternum is also nearly complete, except that the medial portion of the proximal plate is missing (Fig. ~~5C~~6C). The sternum is "hatchet" shaped, as is~~n~~ typical for hadrosaurids. The proximal plate of the sternum is thickest along the anterolateral and the posterolateral margins, while the proximal plate is thin medially. The proximal plate of the sternum is shorter than the distal process. The distal process is nearly straight and slightly expanded ~~in the distal end~~distally.

Forelimb. The left humerus is complete (Fig. ~~5D~~6D). The deltopectoral crest is half as wide as its length and reaches approximately 60% of the humerus length. The anterior and the ventral margins of the deltopectoral crest meet at approximately 103 degrees. The ulna and radius are at least 1.2 times as long as the humerus, although the ulna is missing a small portion of the distal midshaft, and the radius is missing its proximal end (Fig. ~~5E~~6E, F). The ulna is slender, being more than 10 times longer than its anteroposterior width as in other members of Lambeosaurini. The right manus is missing only the phalanges II-2, III-1, IV-2, IV-3, and V-3 (Fig. ~~5G~~6G). The manus shows general hadrosaurid features. Metacarpals II-IV are long and slender, with the metacarpal III approximately eight times as long as its width. The manual phalanges are stout other than II-1, which is mediolaterally flat and elongated. The ungual phalanges II-4 and III-4 are hoof-shaped. It may be worth noting that the ungual phalanx II-4 is notably smaller than the ungual phalanx III-4 unlike some hadrosaurids (Brown, 1912; Parks, 1922; Suzuki et al., 2004).

Pelvic girdle. The right ilium is missing the distal half of the preacetabular process, the distal end of the postacetabular process, the supracetabular process, the acetabular margin, and the ischial peduncle (Fig. ~~6A~~7A). The preacetabular process is curved downward at its base relative to the dorsal margin of the main plate. A small ridge develops along the ventral margin of the base of the preacetabular process. Posterior to the acetabulum, the ischial peduncle is composed of two protuberances. The postacetabular process is oriented posterodorsally. It is mediolaterally compressed in the dorsal half, whereas the ventral half is expanded to form the brevis shelf that is facing medioventrally. Medially, the sacral ridge is positioned along the dorsal rim of the ilium. The left pubis is missing most of its prepubic and postpubic processes (Fig. ~~6B~~7B). A faint ridge is present on the lateral surfaces of the iliac and the ischial peduncles along the acetabulum. The left ischium is missing its pubic process and the distal end (Fig. ~~6C~~7C). The proximal tip of the iliac peduncle is deflected posteriorly. The short obturator process is located close to the base of the pubic peduncle. Although the distal end of the ischium is missing, the ischial shaft is distally divergent, suggesting the presence of the ischial boot.

Hindlimb. The left femur is nearly complete, although it is mediolaterally compressed (Fig. ~~6D~~7D). Proximally, the lesser trochanter is small and fused to the greater trochanter. Although the distal end of the femur is posteriorly curved, the curvature is likely due to postmortem distortion. The fourth trochanter is proximally skewed and subtriangular in lateral view with a smooth apex. The fourth trochanter is positioned slightly distal to the midpoint of the femur. The left tibia is missing its distal end (Fig. ~~6E~~7E). The cnemial crest of the tibia is much more developed than the medial condyle and distally extends over the midpoint of the tibia. The left fibula is complete, and both the proximal and the distal ends are expanded anteriorly (Fig. ~~6F~~7F). The anterodorsal process of the astragalus is medially ~~skewed~~offset, and its anterior surface is shallowly excavated (Fig. ~~6G~~7G). No calcaneum is preserved. Although both pedes are missing several pedal phalanges, they show general hadrosaurid features (Fig. ~~6G~~7G). Metatarsal III is approximately six times as long as its width. The pedal phalanges III-2, III-3, IV-2, and IV-3 are disc-like and more than three times as wide as their lengths. The ungual phalanges are hoof-shaped and have a flat ventral surface.

Corythosaurus sp.

Referred Specimen

ROM 77978 includes the angular, left ilium, several mid-caudal vertebrae, and associated fragments of ossified tendons. An incomplete articulated skull and lower jaws preserved from the orbits forward was also associated with this material, but is currently in private hands.

Locality and Horizon

ROM 77978 was excavated from strata of the upper Judith River Formation (Coal Ridge Member) approximately 9 kilometers to the East of the town of Havre, Hill County, Montana~~;~~. The quarry is located in badlands along the Little Boxelder Creek, on the west arm of a north-south oriented coulee system and on the east side of a large dry island, approximately 3 km upstream from its merger with the Milk River (~~Supplemental~~ Fig. ~~S1~~8). Detailed locality data is on file at the Royal Ontario Museum. The quarry itself is located in a shallow saddle low in the local section, approximately 10 m from the valley floor and about 10 m below prairie level of the dry island. The partially disarticulated but closely associated specimen occurred at the base of a coarse-grained channel sandstone unit approximately 60 cm in thickness~~ specimen~~. The host stratum is in the fourth ~~finding~~ fining upward sequence in the immediate section where the quarry is located. The paleochannel is estimated to have been about 1.8 m in depth, and paleochannel flow direction was approximately to the north.

The general area is largely undocumented from a stratigraphic perspective, with the closest published measured sections on the north side of the Milk River at Havre (Eberth and Hamblin, 1993; Arbour and Evans, 2017). However, continuous bedrock exposures along Little Boxelder Creek to the exposures at the Milk River allow identification of key surfaces and marker beds useful to infer the stratigraphic occurrence of ROM 77978; In ascending order (~~see Supplemental~~ Fig. ~~S1~~8): 1. a sharp lithological contact marking the onset of light-colored, Inclined Heterolithic Strata-dominated, channelized sandstones on top of a thick, paleosol-dominated interval, and 2. a laterally extensive, coaly-lignite rich interval. Observations carried out north of Havre (i.e. at the *Zuul crurivastator* quarry, Arbour and Evans, 2017; FF pers.obs.) suggest the sand-dominated deposits ~~as~~ are part of the Coal Ridge Member of the Judith River Formation (Rogers et al., 2016), and the coaly interval at the top of the Coal Ridge Member as the palaeoenvironomental equivalent of the Lethbridge coal zone (Eberth and Hamblin, 1993) ~~occurring at the top of the Coal Ridge Member~~. Furthermore, the overall thickness of strata in the ~~the area~~ ROM 77978 area is approximately 45 meters, allowing comparison with the measured composite section of Eberth and Hamblin (1993) to the north of Havre, where they inferred the top of the sequence to represent the southernmost occurrence of the Dinosaur Park Formation (Belly River Group), including the base of the Lethbridge Coal Zone.

Based on comparisons ~~to~~ with the more complete stratigraphic sequence exposed on the east side the coulee system, the ROM 77978 host stratum is located approximately 40 meters below the base of the coaly deposits, and by extrapolation approximately 10-20 meters lower than the interval that hosted the skeleton of *~~Zuul~~ Z. crurivastator* (Arbour and Evans, 2017; FF pers.obs.). Therefore ROM 77978 is from approximately the middle of the Coal Ridge Member of the Judith River Formation (Rogers et al., 2016). ROM 77978 is therefore chronostratigraphically correlative with the uppermost beds of the Oldman Formation in southern Alberta and the lower Dinosaur Park Formation in Dinosaur Provincial Park (Belly River Group; see Eberth and Hamblin, 1993; Eberth, 2005; Freedman Fowler and Horner, 2015; Arbour and

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Evans, 2017; Fowler, 2017), thus to be considered, from a stratigraphic perspective, representative of the *Corythosaurus*-dominated zone of Ryan and Evans (2005) and Mallon et al. (2012).

Description of ROM 77978

Skull. Since the skull is in private hands, it will not be described in detail. However, inspection of the original fossil before reconstruction by DCE, and the reposited CT scans, surface scans, and 3D print in the ROM collection reveals key morphological features that allow it to be identified as *Corythosaurus* (~~Supplemental~~ Fig ~~S2~~9). These include a cranial crest that extends supraorbitally and prescribes a partial ~~hemispherical~~ semicircular outline in lateral view with its apex positioned above the orbits. The preserved region of the crest is comprised of the premaxilla anteriorly and nasal bones posteriorly with a prominent premaxilla-nasal fontanelle occurring between these bones in the central region of the crest; below the PNF, the sinuous dorsal margin of the posterolateral process of the premaxilla formed by a caudal lobe that extends further dorsally than the rostral lobe, is diagnostic of *Corythosaurus* (Evans et al., 2005). The wide crest-snout angle is approximately 142 degrees, which is within the range of *Corythosaurus* (Evans, 2010). Since the caudal region of the crest is not preserved, and therefore the relative size and the shape of the caudal margin of the crest are not known, ROM 77978 cannot be positively assigned to the specific level. The morphology of the external narial opening, the shape of both the rostral process and free ventral flange of the jugal, shape of the maxilla, and degree of deflection of the edentulous rostral region of the dentaries are all within the range of variation of the sample of *Corythosaurus* from the ~~Dinosaur Park Formation~~DPF (e.g., Ostrom, 1961; DCE pers.obs.; Evans, 2010)

Mandible. ROM 77978 includes an almost complete left angular (Fig. ~~7A~~10A-D), which is missing only the posteriormost region where it forms the base of the retroarticular process. It is a thin, splint-like bone with contact surfaces for the dentary anteriorly and laterally, the splenial medially, and the surangular posteriorly. The exterior surface is smooth, and it is rugose internally at its posterior terminus, where it contacts the surangular in an interdigitating joint. As preserved, the splenial has a maximum length of 198 mm, with a maximum mediolateral width at the contact with the surangular of 27 mm.

Vertebrae. Two relatively complete distal caudal vertebrae (Fig. ~~7E~~10E-J) are typically hadrosaurid in morphology, with subhexagonal centrum faces, prominent chevron facets ventrally, and highly raked neural spines. The vertebral bodies of both vertebrae lack facets or protrusions for caudal ribs, and the zygapophyses are present but poorly developed. Based on comparisons with a mounted skeleton of ~~*Corythosaurus*~~ *C. intermedius* (ROM 845), the largest caudal vertebra is approximately from ~~approximately~~ caudal position 45, and the smaller vertebra is from position number 51. The largest vertebra has a centrum length of 45mm, with an anterior width of 57 mm and height of 47 mm. The incomplete, highly raked neural spine is 64 mm in length. The left prezygapophysis is preserved and projects anteriorly from the neural arch, and there are faint facets that represent postzygapophyses on the posterior base of the neural spine. The smaller vertebra has a centrum length of 39.8 mm, anterior width of 47 mm and height 41 mm. The incomplete highly raked neural spine is 63 mm as preserved.

Pelvic girdle. The almost complete right ilium is only missing the distal half of the strongly downcurved preacetabular process (Fig. 10-K, L). It has a total length of 855 mm in length as preserved, with a depth above the acetabulum of 198 mm. The acetabular margin (175 mm in length) is a shallowly incised arch in the ventral margin of the bone between the pubic and ischiac peduncle. The postacetabular process is elongate, with a length of 270 mm and a dorsoventral height of 128 at its midpoint in lateral view; the elongate postacetabular process (L/H ratio of 2.1) falls within the expected range of Lambeosaurinae, and not Saurolphinae (Brett-Surman and Wagner, 2007). The dorsal margin of the ilium is strongly sigmoidal with a sharp dorsal curvature over the supracetabular crest and a ventrally deflected preacetabular process, as is characteristic of Lambeosaurinae (Horner et al., 2004; Brett-Surman and Wagner, 2007). The prominent supracetabular crest extends ventrally on the lateral surface of the body to a point approximately halfway between the dorsal margin and the base of the ischiac peduncle. The morphology the ilium in ROM 77978 is almost identical to the type series of AMNH 5240 and AMNH 5338 and compares well to OUSM-FV-001, with a strongly sigmoidal dorsal margin, robust suprailiac crest, and elongate postacetabular process that falls into ilium type four of Brett-Surman and Wagner (2007).

DISCUSSION

Taxonomic assignments

Hadrosaurid remains have long been recognized from the Judith River Formation, ever since the discovery of "*Trachodon mirabilis*" (Leidy, 1856). Since then, ~~three~~ two hadrosaurine taxa, *Brachylophosaurus canadensis* ~~(Sternberg, 1953; Prieto-~~

~~Márquez, 2005; Murphy et al., 2006; Prieto-Marquez, 2007),~~ (Sternberg, 1953; Horner, 1988; Prieto-Márquez, 2005; Murphy et al., 2006; Prieto-Marquez, 2007) ~~*Brachylophosaurus goodwini* (Horner, 1988),~~ and *Probrachylophosaurus bergi* (Freedman Fowler and Horner, 2015), have been described from the McClelland Ferry Member of the Judith River Formation. On the other hand, lambeosaurines from the formation are poorly understood, although their presence has been suggested by several poorly preserved specimens. A maxilla and a squamosal (USNM 5457) collected from Dog Creek (~10 km northwest of OUSM-FV-001 quarry) were originally reported as "*Hadrosaurus paucidens*" (Marsh, 1889), and later renamed as "*Lambeosaurus paucidens*" (Ostrom, 1964). While the bones clearly belong to Lambeosaurinae, ~~further~~ their taxonomic status is now considered ambiguous due to their incompleteness (Prieto-Márquez et al., 2006). Another such specimen, an isolated tooth (AMNH FARB 8527) from the Clambank Hollow Quarry (~25 km northwest of OUSM-FV-001 quarry) originally identified as "*Procheneosaurus altidens*" (Sahni, 1972) obviously lacks diagnostic features useful for identifying it to a specific genus. Another incomplete specimen (pelvic and limb bones, AMNH FARB 3971) from near Cow Island, Montana (~ 40 km northeast of the OUSM-FV-001 quarry) was reported as "*Pteropelyx grallipes*" (Cope, 1889). Although this specimen was once treated as a senior synonym of *Corythosaurus* (Brett-Surman, 1989), it was later considered a nomen dubium (Horner et al., 2004). In addition to these dubious specimens, an ischium of an indeterminate lambeosaurine is also known from a multitaxic bonebed from the Careless Creek Quarry (Fiorillo, 1989; Prieto-Márquez and Gutarra, 2016). Furthermore, lambeosaurine egg clutches and embryonic remains *in ovo* have been described from the Judith River Formation (Horner, 1999), but their incompleteness and embryonic nature obscure their taxonomic status. As such, while lambeosaurine material has continuously been reported from the Judith River Formation, ~~their~~ its taxonomic status remains ambiguous, largely due to the lack of taxonomically identifiable elements. The new lambeosaurine skeleton OUSM-FV-001 described in this study is therefore valuable in its reasonably well-preserved status, including part of the cranial crest, which makes genus-level taxonomic identification possible and contributes to a better understanding of the Judith River dinosaur fauna.

OUSM-FV-001 is markedly different from the members of Parasaurolophini in the angled dorsal margin of the posterodorsal process of the premaxilla (Fig. 2D), although it is missing most of its cranial crest. The frontal also differs from Parasaurolophini in the absence of the posteriorly elongated nasal platform of the frontal and the long interfrontal suture relative to the frontal width (Evans et al., 2007). Instead, the presence of the PNF (Fig. 2H-K), the S-loop internal to the posterodorsal process of the premaxilla (Fig. 2E, F), and the dorsoventrally tall nasal suggest an affinity with Lambeosaurini. Among Lambeosaurini, OUSM-FV-001 differs from *Hypacrosaurus* in the absence of tall dorsal neural spines, which is a diagnostic character of *Hypacrosaurus* (Lull and Wright, 1942; Evans, 2010). The presence of a PNF also differs from *Hypacrosaurus* because the PNF of *Hypacrosaurus* closes at an early stage of ontogeny (Horner and Currie, 1994; Brink et al., 2014). Additionally, OUSM-FV-001 differs from ~~*Hypacrosaus*~~ *H. altispinus* in the trapezoidal ventral margin of the ventral flange of the jugal and the bifurcated squamosal process of the postorbital (Evans, 2010). OUSM-FV-001 also differs from *Lambeosaurus* in the wide crest-snout angle and the laterally exposed ophthalmic canal of the laterosphenoid, both of which are diagnostic characters of *Lambeosaurus* (Evans and Reisz, 2007). OUSM-FV-001 further differs from *Lambeosaurus* in the dorsoventrally tall nasal, which does not form the caudal process of the crest. OUSM-FV-001 differs from another member of Lambeosaurini, *Magnapaulia* (Prieto-Márquez et al., 2012) in the well-separated prezygapophyses of the proximal caudal vertebrae. OUSM-FV-001 also differs from the immature lambeosaurine *Velafrons* (Gates et al., 2007) in having the gently curved squamosal process of the postorbital (Fig. 3G). Although the incompleteness of OUSM-FV-001 hinders comparisons with the diagnostic characters of the Asian Lambeosaurini, the dentary of OUSM-FV-001 differs from those of *Amurosaurus* (Godefroit et al., 2004; Bolotsky et al., 2014) and *Sahaliyania* (Godefroit et al., 2008) in the absence of the strong ventral deflection of the anterior half of the dentary (Fig. ~~3Q~~4G-~~T~~I). OUSM-FV-001 also differs from another Asian ~~Lambeosaurini~~ lambeosaurine *Olorotitan* (Godefroit et al., 2012) in the relatively short ~~diastema~~ edentulous region of the dentary. Although the diagnostic character of *Corythosaurus* (i.e., large, bifurcated nasal; Evans et al., 2005) cannot be confirmed on OUSM-FV-001 due to incompleteness of the nasal, the unique set of characters listed above strongly suggests that OUSM-FV-001 is *Corythosaurus*. Whether OUSM-FV-001 is ~~*Corythosaurus*~~ *C. casuarius*, ~~*Corythosaurus*~~ *C. intermedius*, or a distinct species cannot be determined at this point; thus, OUSM-FV-001 is referred to *Corythosaurus* sp..

ROM 77978, although less complete, also contributes important new information on the distribution of *Corythosaurus*. The identification of ROM 77978 is more straightforward but is scientifically hindered because the associated articulated skull is currently in private hands (~~Supplemental~~ Fig. ~~S2~~9), although CT scans, surface scans, and photographs are reposited at the ROM. The skull clearly exhibits a number of diagnostic hallmarks of *Corythosaurus*, including a rounded, helmet-like supracranial crest with its apex positioned above the orbits, a prominent premaxilla-nasal fontanelle between the premaxilla and nasal bones in the central region of the crest, and most importantly a sinuous dorsal margin of the posterolateral premaxillary process formed by a caudal lobe that extends further dorsally than the rostral lobe. The shape of the lateral process of ROM 77978 differs from that of *~~Hypacrosaurus~~ H. stebingeri,* which is dorsally arched (Brink et al., 2014). The wide crest-snout angle is approximately 142 degrees, which is within the range of *Corythosaurus* (Evans, 2010) and similar to *H. stebingeri* (Brink et al., 2014), but outside that of most other lambeosaurines (*Lambeosaurus*, *Parasaurolophus* and *~~Hypacrosaurus~~ H. altispinus*) known from northern Laramidia during the Campanian-Maastrichtian (Evans, 2010). The caudal region of the nasal is not preserved, and therefore the skull cannot be positively assigned to either of the two known species of *Corythosaurus*, *C. casuarius* or *C. intermedius*. Fortunately, the almost complete, well-preserved ilium of ROM 77978 (Fig. ~~7K~~10K, L) exhibits a distinctive suite of morphologies that allow its taxonomic identification to the tribe Lambeosaurini, which is consistent with the identification of the skull as *Corythosaurus*. The ilium of ROM 77978 is almost identical to the holotype of *Corythosaurus* (AMNH 5240) and compares well to the plesiotype AMNH 5338 as well as OUSM-FV-001~~;~~. It has a strongly sigmoidal dorsal margin, large, pendant suprailiac crest, and elongate postacetabular process and can clearly be categorized as ilium type four of Brett-Surman and Wagner (2007). Recognizing that the~~ir~~ five hadrosaurid ilium morphotypes that ~~in~~ form a morphocline ~~and~~ are not strictly taxonomically 'useful', *Corythosaurus* is used to exemplify the~~ir~~ fourth morphotype (Brett-Surman and Wagner 2007). Although the ilia of the Lambeosaurini *Corythosaurus, ~~Hypacrosaurus~~ H. stebingeri,* and *Lambeosaurus* for example cannot be reliably distinguished from each other, the ilium in the ROM collections serves minimally as a detailed stratigraphic record of Lambeosaurini in Montana, which based on the reposited data for the skull can reasonably be identified as *Corythosaurus* sp..

The taxonomic assignment of OUSM-FV-001 and ROM 77978 to *Corythosaurus* sp. in this study demonstrates that it is the first hadrosaurid specimen in the Coal Ridge Member identified below the subfamily level, and the first time a genus of lambeosaurine has been positively identified in the Judith River Formation as a whole.

Paleobiogeographical significance

OUSM-FV-001 and ROM 77978 are notable for being the first *Corythosaurus* specimens from outside the DPF and for extending the biogeographic range of *Corythosaurus* ~ 350 km southward. The late Campanian vertebrate assemblage represented in the DPF is the most diverse terrestrial fauna of the Late Cretaceous, including over 50 dinosaurian taxa (Currie and Koppelhus, 2005). Hadrosaurids are the most abundant in the dinosaur fauna of the DPF (Dodson, 1983; Brinkman, 1990; Cullen and Evans, 2016), and *Corythosaurus* is the most common hadrosaurid genus in the formation (Ryan and Evans, 2005). Despite its abundance in the DPF, the geographical occurrence of *Corythosaurus* ~~is~~ has been restricted to the Dinosaur Provincial Park area in Alberta, Canada, with one exception from Hilda, Alberta, approximately 80 km east of the park (Evans, 2002; Ryan and Evans, 2005). Although there are some ambiguities in the locality and stratigraphical data, the horizon yielding OUSM-FV-001 is ~~supposed~~ likely to be within the Coal Ridge Member of the JRF, which is approximately time equivalent to the DPF (Rogers et al., 2016; Fowler, 2017).

ROM 77978 can be definitively traced to the middle of the Coal Ridge Member of the JRF. Thus, OUSM-FV-001 and ROM 77978 are therefore at least penecontemporaneous to the *Corythosaurus* population from the DPF and likely represent an extension of its biogeographical range rather than a temporal habitat shift. The shared occurrence of *Corythosaurus* in the Coal Ridge Member of the JRF and the DPF is congruent with previous knowledge ~~on~~ of the paleoenvironment and the vertebrate fauna of these strata. The Coal Ridge Member of the JRF and the DPF are within a continuous clastic wedge, and both are interpreted to represent a wet and humid coastal plain environment along the Western Interior Seaway (Eberth and Hamblin, 1993; Eberth, 2005; Rogers et al., 2016). Although there is only one shared dinosaur species (*Mercuriceratops gemini*, Ryan et al., 2014) between the two strata, plus some theropod teeth assigned to *Dromaeosaurus albertensis*, *Troodon formosus*, and *Zapsalis abradens* (Mallon et al., 2016), the terrestrial and freshwater fauna of the JRF and the DPF resemble each other as a whole compared to other Campanian formations in North America (Gates et al., 2010). Based on the limited biogeographical extent of *Corythosaurus* and other late Campanian megaherbivorous dinosaurs, it has been suggested that they have specific habitat preferences and/or limited environmental tolerances (Lehman, 2001). The extension of the *Corythosaurus* biogeographical distribution revealed in this study does not readily disagree with this idea because of the paleoenvironmental similarities of these two strata~~,~~. ~~but~~ A~~a~~dditional specimens and further taxonomic studies of megaherbivorous dinosaurs as well as the construction of a rigorous temporal framework of the time equivalent beds~~ yet~~ deposited in different environmental conditions, such as the more xeric Two Medicine Formation (Rogers, 1990), are necessary to test this hypothesis.

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Even though our study demonstrates the paleobiogeographical extension of *Corythosaurus*, the ~~*Corythosaurus*~~ remains of the genus in the JRF are still overwhelmingly outnumbered by those in the DPF, which is potentially driven by the limited temporal occurrence of *Corythosaurus* in the fossil record. Due to its rich fossil record and intense research history, the stratigraphic distribution of dinosaur taxa in the DPF is well understood (Ryan and Evans, 2005; Mallon et al., 2012; Cullen et al., 2021), and *Corythosaurus* is only ~~discovered in~~known from the lower part of the Dinosaur Park Formation (*Centrosaurus*-*Corythosaurus* faunal zone [Ryan and Evans, 2005], or the megaherbivore assemblage zone 1 [MAZ-1, Mallon et al., 2012]). If such a tight stratigraphic distribution of megaherbivorous dinosaurs is also present in the JRF, it is implied that the horizon directly comparable to the lower half of the DPF is exposed in the outcrop around the OUSM-FV-001 and ROM 77978 localities, and so would have high potential for new discoveries of dinosaurs known from these faunal zones of the DPF. The faunal zones defined within the Dinosaur Park Formation at Dinosaur Provincial Park have been shown to extend across a large regional area of southern Alberta~~-~~ (Evans et al., 2014)~~(Evans, 2002)~~, and some ornithischian taxa such as *Centrosaurus apertus* have been shown to occur in time equivalent portions of the upper muddy unit of the Oldman Formation (Chiba et al., 2015), which is both lithostratigraphically and chronostratigraphically correlative to the Coal Ridge Member of the JRF. We therefore predict that many dinosaur taxa currently known only from the Dinosaur Park Formation will be discovered in the upper Judith River Formation, which will further elucidate paleobiogeographic and ~~32~~biostratigraphic comparisons across the Western Interior Basin.

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Foremost, it is with great pleasure that we contribute this work on dinosaurs from the Judith River Formation of Montana to a volume dedicated to the career of Peter Dodson. Peter’s early work on correlative rocks in southern Alberta and Montana have served as an inspiration for many of us who have followed.

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968