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Camel fossils from gravel pits near Edmonton and Vauxhall, and a review of the Quaternary
camelid record of Alberta

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Draft

Abstract

Camelid remains are known from several Quaternary palaeontological localities in Alberta, yet most specimens are undescribed in the literature. Specimens reported here comprise a large sample of the known camelid record from the province, and provide further insight into the record of Quaternary megafauna of western Canada. Remains from the Edmonton area include specimens pre- and post-dating the Last Glacial Maximum (LGM), whereas remains from the Vauxhall area are post-LGM. A metapodial fragment of a giant camel originally described as *Titanotylopus* from the Edmonton area is likely from earlier in the Pleistocene or late Pliocene. Camelid remains are not overly abundant in Alberta, but are widely distributed, having been recovered from several sites across the province. A new radiocarbon date of $11,280 \pm 40$ ^{14}C yr BP on a radioulna of *Camelops* cf. *C. hesternus* represents only the fourth direct age assessment of a Quaternary camelid from Alberta. Radiocarbon data may suggest linkages to patterns of extirpation observed in camelid populations from northern Canada, followed by re-colonization following deglaciation.

Key Words: Camelidae, *Camelops*, Pleistocene, biogeography, radiocarbon dating

Introduction

Quaternary vertebrate remains recovered from gravel pit localities are the major source of information concerning Pleistocene megafauna in Alberta (e.g., Churcher 1968; Wilson and Churcher 1978; Churcher and Wilson 1979; Wilson 1983; Burns and Young 1994; Jass et al. 2011). Camelids (family Camelidae) are mentioned as part of the fauna from many of those deposits, but a majority are undescribed in the literature, the notable exception being fossils from the Gallelli Pit locality (Wilson and Churcher 1978). To provide improved understanding of the record of camelids from Alberta, we describe fossils recovered from sand and gravel deposits near Edmonton, including a new radiocarbon date. We also describe remains from the Gertzen Pit, a gravel pit locality situated near Vauxhall in southern Alberta. Finally, we review and summarize the reported geographic and chronologic distribution of camelids in Alberta.

Previously published records of camelids from Alberta include specimens from the early post-Late Glacial Maximum (LGM) found in an archaeological context at Wally's Beach (Kooyman et al. 2012; Waters et al. 2015), with palaeontological records of comparable age from the Bighill Creek Formation along the Bow River in south-central Alberta (Wilson and Churcher 1978; Wilson 1983) and from deposits along the Peace River (Churcher and Wilson 1979). Records from pre- and post-LGM gravel pit localities in the Edmonton area and Vauxhall are mentioned as part of broader faunal assemblages in the literature (Burns 2010; Burns and Young 1994; Jass et al. 2011), but the camelid remains are not described beyond an indication of their presence. Potentially older and/or comparably aged camelids are known from the Medicine Hat-Wellsch Valley sequence of Alberta and Saskatchewan (Stalker et al. 1982).

Direct ages on Quaternary camelids from Alberta is sparse. A single AMS (Accelerator Mass Spectrometry) radiocarbon date on a specimen from a gravel pit near Edmonton produced a non-finite age (Jass and Beaudoin 2014). Bone samples from the Wally's Beach site were analyzed on separate occasions using different techniques (Kooyman et al. 2012; Waters et al. 2015), with recent analyses yielding an average age of $11,440 \pm 25$ ^{14}C yr BP (Waters et al. 2015). A third direct date comes from the Gertzen Pit, with a reported age of $10,708 \pm 100$ ^{14}C yr BP (Burns 2010). All of the records are significant, because they provide some broad indication of the timing when camelids occupied southern portions of western Canada during the late Quaternary. However, they also illustrate the paucity of information available on Quaternary camelids in Alberta and in Canada, generally.

Setting

The geologic and broad chronologic setting for Quaternary fossil remains from the Edmonton area have been previously discussed (e.g., Burns and Young 1994; Jass et al. 2011). However, it is important to re-emphasize that all specimens reported here come from fluvial sand and gravel deposits and were recovered in association with industrial activities. As a result, the stratigraphic context is only coarsely understood for most specimens. Radiocarbon analyses have shown that several individual localities contain remains of disparate age, including specimens that date prior to the Late Glacial Maximum (LGM) and specimens that date after the LGM (Burns and Young 1994; Jass et al. 2011). Despite challenges in understanding the geologic context of fossils, they have proven useful for addressing broad chronological and biological questions (e.g., Burns 2010; Young et al. 1994; Jass et al. 2011).

As with fossils from Edmonton area gravel pits, fossils recovered from the Gertzen Pit have little information in the way of stratigraphic context. Notes on file at the Royal Alberta Museum (RAM) indicate that the remains were collected by gravel pit staff, and that bones appeared to be associated with an upper stratum containing shield clasts. That interpretation is congruent with published radiocarbon data (see Burns 2010) indicating a post-LGM age for at least some remains from the Gertzen Pit.

Materials and Methods

To improve upon the sparse record of Quaternary camelids in Alberta, we evaluated specimens preliminarily identified as camelids in the Quaternary Palaeontology collections at the Royal Alberta Museum. Preliminary identifications represent the cumulative effort of museum staff over many years of fieldwork and collections acquisition. We evaluated 47 total specimens (Edmonton area pits, $n = 12$; Gertzen Pit, $n = 35$). Of those specimens, 42 (Edmonton area pits, $n = 10$; Gertzen Pit, $n = 32$) could be identified as representing some form of camelid. To facilitate comparison with previous publications that distinguish Edmonton area pits, we specify that camelids come from Pit 48 ($n = 5$), Clover Bar ($n = 2$), Riverview ($n = 2$) and Lafarge 1042 ($n = 1$). An additional record from collections housed at the University of Alberta (Edmonton area, Locality 5c of Reimchen 1968) was also evaluated because it appears to have come from comparable depositional settings.

Identification of specimens was based on descriptions in the published literature, as noted in the Systematic Palaeontology section below. For broad comparative purposes, we utilized a specimen (90.5.1) of *Camelus dromedarius* housed in mammalogy collections at the Royal

Alberta Museum. We acknowledge that we invoked a level of geographic and temporal parsimony in our identifications, meaning that we primarily focused on the similarity of specimens to *Camelops* and other late Pleistocene camelids from North America (i.e., *Hemiauchenia*). Measurements on individual specimens follow Driesch (1976), and were taken with Mitutoyo digital calipers to the nearest 0.01 mm. We relied heavily on Baskin and Thomas (2016), Bravo-Cuevas et al. (2012), Harrison (1985), Webb (1965), and Wilson and Churcher (1978) for comparative measurements and morphological evaluation.

Most specimens were incomplete, and morphological characters used to diagnose members of Camelidae (e.g., Honey et al. 1998) were not consistently present. Therefore, we stress that the identifications we present here may be re-evaluated in the future with recognition of additional morphological synapomorphies and/or by other analytical means (e.g., aDNA). Fragmentary specimens that we deemed could not be reasonably evaluated and identified as camelids are excluded from the reporting below.

We sampled one complete radioulna (P94.12.24) from an Edmonton area pit (Clover Bar Sand & Gravel) for radiocarbon dating. The submitted sample came from the mid-shaft of the element and weighed 3.95 g. Pretreatment and AMS dating on bone collagen was conducted by Beta Analytic, Inc.

Geographic data for specimens presented here were compiled from records at the Royal Alberta Museum and the literature (Figure 1). Harington (2003) was especially helpful in finding appropriate records for inclusion. Summary latitude and longitude data are not presented here but are available upon request from researchers.

Reported specimens are housed at the Royal Alberta Museum (RAM) and University of Alberta Laboratory of Palaeontology (UALVP). All specimen numbers indicate RAM specimens unless otherwise noted.

Results

Systematic palaeontology

Mammalia Linnaeus, 1758

Artiodactyla Owen, 1848

Camelidae Gray, 1821

Camelops Leidy, 1854

Camelops cf. *C. hesternus* (Leidy, 1873)

REFERRED SPECIMENS: P94.1.598, right M2; P98.8.131, right M2; P98.8.132, right M3; P94.1.104, upper right molar (position indeterminate); P98.8.119, partial right, edentulous mandible; P98.8.40, left m3; P98.5.180, atlas; P98.8.124, fourth or fifth cervical vertebra; P98.8.42, fifth cervical vertebra; P98.8.128, fifth cervical vertebra; P98.8.44, lumbar vertebra; P98.8.45, lumbar vertebra; P98.8.46, lumbar vertebra; P98.8.43, sacrum; 94.12.66, partial right scapula; P98.8.125, partial right scapula; P98.8.126, partial right scapula; P98.8.38, partial right scapula; P98.8.145, partial right scapula; P98.8.136, partial left scapula; P98.8.146, partial left scapula; P09.7.5, partial left scapula; P98.8.29, proximal portion of right humerus; P98.8.30, distal portion of right humerus; P98.8.31 distal portion of right humerus; P98.8.32 distal portion

of left humerus; P98.8.122 left humerus; P94.12.24, right radioulna; P94.8.92, partial left radioulna; P98.8.34, right metacarpal; P05.10.52, left metacarpal; P98.8.33, innominate; P98.8.37, proximal portion of right tibia; P98.8.143, proximal portion of right tibia; P98.8.141, proximal portion of left tibia; P98.8.36, distal portion of left tibia; P98.8.127, distal portion of right tibia.; P98.8.130, right metatarsal; P98.8.35, distal portion of metapodial.

LOCALITIES: Edmonton Area Pits—P94.1.598, P94.1.104, P98.5.180, P05.10.52 (Pit 48); P94.12.66, P94.12.24 (Clover Bar), P94.8.92 (Riverview), P09.7.5 (Lafarge Pit 1042); Gertzen Pit—P98.8.131, P98.8.132, P98.8.119, P98.8.40, P98.8.124, P98.8.42, P98.8.128, P98.8.44, P98.8.45, P98.8.46, P98.8.43, P98.8.125, P98.8.126, P98.8.145, P98.8.136, P98.8.146, P98.8.29, P98.8.30, P98.8.31, P98.8.32, P98.8.122, P98.8.34, P98.8.33, P98.8.37, P98.8.143, P98.8.141, P98.8.36, P98.8.127, P98.8.130, P98.8.35.

Description: All referred elements retain some morphological characteristics consistent with *Camelops*, based on descriptions by Webb (1965). Rather than re-state all those characteristics, here we describe the specimens and discuss some of the observed features consistent with identification to the genus.

Molars are large, hyposodont, and conform well to previous descriptions and measurements for *Camelops* (Webb 1965; see Table 1; Figure 2a–d). No evidence of “llama buttresses” occurs on the lower molars. We note that some variation occurs in the size of these teeth outside of published data (Webb 1965). However, the size is more consistent with data reported for *Camelops* than the smaller *Hemiauchenia* (see Bravo-Cuevas et al. 2012).

The dentary preserves evidence of a hooked angular process, a morphological feature consistent with camelids (Figure 2e). Although no measurements were possible, the overall size and robustness is consistent with assignment to *Camelops* as opposed to smaller Pleistocene Auchenini (= Lamini).

The single atlas (P98.5.180) is well preserved with minor damage to the posterior side of the left wing and slight erosion of the articulations and spinous processes (Figure 3a). Morphologically, the atlas is consistent with descriptions for *Camelops* (e.g., parallel lateral borders of wings, neural arch higher than *Camelus*, deep ventral alar fossa; Webb 1965). Measurements conform to descriptions in Webb (1965), with the exception of the maximum width (116.19 mm).

Identified cervical vertebrae are relatively complete, with most containing at least the centrum and neural arch (Figure 3b). The cervicals are relatively elongate as compared to *Equus* or *Bison*, and preserve costellar processes consistent with descriptions for *Camelops* (Webb 1965). One specimen (P98.8.128) is a juvenile, as indicated by an unfused centrum. Transverse processes are relatively weathered or damaged.

Lumbar vertebrae show minor wear to the transverse processes, and the distal and proximal articular surfaces (Figure 3d). The spinous process is broken and missing in all specimens. Specimens are larger than comparative specimens of *Bison* and *Equus*, and all specimens have centrum lengths within the range of *Camelops* (P98.8.44 = 83.67 mm; P98.8.45 = 75.54 mm; P98.8.46 = 71.55 mm).

The referred sacrum (P98.8.43) is a juvenile as indicated by the lack of fusion of the centra. No measurements were collected, but the specimen conforms to descriptions of the sacrum in *Camelops* (Webb 1965).

The single innominate (P98.8.33) is well preserved including the right acetabulum, obturator foramen, illia, and ischia (Figure 3e). The pubic symphysis is noticeably thickened and ventrally convex as in *Camelops*. The ischium is short and heavily built, and the ischial tuberosity is large, but not as curved ventrally as in *Camelus* (Webb 1965). In overall size, the specimen is between *Equus* and *Bison*, and compares well with a cast of *Camelops* from the La Brea Tar Pits. Measurements included length of the pubic symphysis (186.45 mm), length of the obturator (107.67 mm) and length of the acetabulum (79.17 mm).

Scapulae are incomplete, typically consisting of the glenoid cavity, coracoid process and proximal portions of the acromion process (Figure 4a). The neck and coracoid process are robust, and the acromion process extends anteriorly towards the glenoid cavity. The anterior extension of the acromion process resembles *Camelus* more than either *Bison* or *Equus*, taxa of comparable size known from late Pleistocene gravels in Alberta. Measurements of the scapulae are small relative to other described specimens of *Camelops* from the literature (Table 2).

Humeri generally conform to published descriptions (Webb 1965; Wilson and Churcher 1978). The most complete specimen (P98.8.122; Figure 4b) preserves a low, rounded deltoid crest as described by Wilson and Churcher (1978). In specimens preserving only the proximal portion of the humerus, the medial tuberosity is much more bulbous and projects further than comparative *Camelus* (Figure 4c–d), and the fossa separating the humeral head is broad and shallow. Distal portions of humeri preserve a large nutrient foramen on the posterolateral surface, and the trochlear surface does not extend deeply into the olecranon fossa (Figure 4e), features consistent with identification of *Camelops* (Webb 1965). Trochlear breadths are lower than published data for other specimens of *Camelops* (Table 3).

Morphology of referred radioulnae conforms to *Camelops* (Webb 1965). The radioulna from Clover Bar (P94.12.24; Figure 4f) is one of the more complete specimens reported here, exhibiting only minor damage to the olecranon process, lateral head, and styloid processes. Measurements provided in Table 4 indicate that the specimen is slightly smaller than reported for other *Camelops* (Webb 1965).

Metacarpals and metatarsals are elongate, with a lack of fusion at the distal end of the shaft creating a splayed appearance to the distal articulations with the phalanges. Such structure is broadly characteristic of camelids. The sagittal ridges are mostly restricted to the ventral-dorsal portion of the distal condyles. Metacarpals reported here are smaller than *Camelops* from the La Brea Tar Pits (Table 5; Figure 4g, h). The single, partial metatarsal reported here (P98.8.130; Figure 5a) had a measured diaphyseal breadth (38.83 mm) that is slightly smaller than the range (40–49 mm) for La Brea *Camelops* (Webb 1965). Measurements reported for metapodials of the relatively gracile *Hemiauchenia* are considerably less than the measurements obtained on specimens from Alberta reported here (Table 5).

Proximal ends of tibiae are poorly preserved. On one specimen (P98.8.141; Figure 5b) the popliteal scar and the position of a nutrient foramen and associated furrow are similar to published descriptions (Webb 1965). Distal portions of tibiae are weathered but preserve the fibular groove and medial malleolus (Figure 5c, d). The only measurement taken of distal portions of tibiae was breadth of the distal end (P98.8.127 = 92.24 mm; P98.8.36 = 90.85 mm)

Discussion: Individual elements exhibit various stages of mineralization, but most elements show little mineral replacement. The morphology of all specimens compares favorably to *Camelops hesternus* as described by Webb (1965) and others (e.g., Wilson and Churcher

1978). We acknowledge that many of the morphological characters utilized in our identification are not diagnostic in the phylogenetic sense. They are consistent with camelids, but assignment to *Camelops* is based on overall morphological similarity to published descriptive data.

Our identification is admittedly heavily reliant on size similarity to specimens of *Camelops* from the La Brea tar pits, as are many other published occurrences of *Camelops*. However, many measurements of the Alberta specimens fall outside the ranges provided by Webb (1965). We interpret differences as representing variation within *Camelops*. Sample sizes for measured elements in our study and in other published studies (i.e., Webb 1965) are low. While we acknowledge the possibility that some other form of camelid may be represented in our sample, the size of the Alberta specimens is more consistent with assignment to *Camelops* than *Hemiauchenia* or other Pleistocene forms (e.g., *Titanotylopus*; see Breyer 1974).

A recent review of the taxonomy of *Camelops* indicates the existence of up to four species in the Pleistocene of North America (Baskin and Thomas 2016). *Camelops minidokae* is smaller and primarily restricted to the Irvingtonian, while two other forms characterized by shorter metapodials are unnamed (Baskin and Thomas 2016). Although there is clearly some deviation from published size ranges (e.g., Webb 1965, Breyer 1974), we interpret the specimens reported here as most likely belonging to *C. hesternus*, the single, large form of *Camelops* occurring in the Irvingtonian and Rancholabrean (Baskin and Thomas 2016). Our reticence to definitively name the specimens as *C. hesternus* is rooted in a general lack of statistical clarity in species boundaries in post-cranial elements of *Camelops*.

We note that recent molecular phylogenetic analyses suggest that *Camelops* is the sister taxon to *Camelus* and is not situated within Auchenini as was previously hypothesized based on morphological grounds (Heintzman et al. 2015). That hypothesis presents an evolutionary

explanation for the absence of some morphological features thought to distinguish *Camelops* from other Auchenini (e.g., the absence of “llama buttresses”). If the molecular hypothesis gains additional support, it suggests extreme levels of morphological convergence in other skeletal features of North American camelid lineages, and the morphological characters previously thought to diagnose *Camelops* within Auchenini would potentially be rendered phylogenetically uninformative. Our focus here is not to resolve that issue, but to point out that additional work to improve our understanding of skeletal variation in Quaternary camelids is needed.

cf. *Camelops* sp.

REFERRED SPECIMENS: P89.13.543, fused right and left maxillary fragments; P94.8.33, partial cervical vertebra; P98.8.129 cervical vertebra; P98.8.144, thoracic vertebra.

LOCALITIES: Edmonton Area Pits—P89.13.543 (Pit 48); P94.8.33 (Riverview Pit); Gertzen Pit—P98.8.129, P98.8.144.

Description: Specimens identified as cf. *Camelops* compare well with other specimens described here or with published descriptions (e.g., Webb 1965). However, the specimens are relatively incomplete, to a degree that we are less certain of taxonomic affinity. Beyond association and broad similarity with specimens more reliably referred to *Camelops*, there is not a strong morphological justification for the identification.

Discussion: Given that no other camelid is yet reported from the localities presented here, it seems most likely that the remains are from *Camelops*. We conservatively refer them to cf. *Camelops* due to a lack of definitive characters. However, we emphasize that the referred fragments and elements appear most consistent with *Camelops*, and descriptions of other taxa (e.g., *Hemiauchenia*: Webb 1974; Dalquest 1980; Bravo-Cuevas et al. 2012) are less consistent with the morphologies we observed.

Camelidae indeterminate (“Giant Camel”)

REFERRED SPECIMENS: UALVP1622, distal condyle of metapodial.

LOCALITIES: Edmonton Area – (Locality 5c of Reimchen 1968)

Description: The specimen is a single, distal condyle from a metapodial (Figure 5e). Although fragmentary, the specimen retains morphology consistent with camelids, with an indication of unfused splaying of the distal portion of the metapodials. The sagittal ridge is restricted to the ventral and dorsal portion of the condyle as in camelids. The greatest distal breadth of the single condyle is 61.89 mm, nearly approaching the distal breadth of both condyles in a specimen we identify as *Camelops* (68.34 mm, P05.10.52; Table 5).

Discussion: The single specimen of camelid that we report from collections at the University of Alberta is an anomaly. No other camelid of similar size is known from collections at the Royal Alberta Museum. The specimen was originally, tentatively identified as *Titanotylopus*

(Reimchen 1968). A second possibility is that the record represents a southern extension of the Yukon giant camel, shown to have identical collagen fingerprints to a mid-Pliocene giant camel from Ellesmere Island (Rybczynski et al. 2013). We are not confident that either identification can be defended solely on a morphological basis, and we prefer a more conservative taxonomic assignment. Nevertheless, the specimen is unique relative to all other reported camels from Alberta.

Radiocarbon dating

AMS radiocarbon dating on bone collagen extracted from a radioulna (P94.12.24) from the Edmonton Area Pits (Clover Bar) indicated a corrected age of $11,280 \pm 40$ ^{14}C yr BP (Beta-394909; $\delta^{13}\text{C} = -19.8$; Cal BP 13205 to 13075). The radiocarbon age is consistent with ranges of ages known from the locality (Jass et al. 2011). A total of four direct radiocarbon dates are now known for Quaternary camelids from Alberta.

Discussion

Very few detailed specimen records of camelids from Alberta are published. The remains reported here represent a significant addition to the published literature on Quaternary megafauna of southwestern Canada. Collectively, these records along with other published records indicate that *Camelops* was fairly widespread in Alberta during the late Pleistocene, particularly in southern portions of the province (Figure 1). Because very few Quaternary vertebrate sites are known in northern and northeastern Alberta, the distribution as shown in Figure 1 may not represent the full geographic extent of camelids within Alberta during portions

of the Pleistocene. Other Quaternary camelids reported from Alberta include *Hemiauchenia*, but that genus is definitively known only from the Wellsch Valley-Medicine Hat sequence in southwestern Saskatchewan and southeastern Alberta (Stalker et al., 1982). Another possible record identified as *Camelops* or *Hemiauchenia* was recovered from the Watino area, in the Peace River region of northwestern Alberta (Churcher and Wilson 1979). The anomalous record of a giant camel other than *Camelops* is notable.

UALVP1622 is a giant camel other than *Camelops*. As such, the record either represents a significant temporal range extension of a giant camel into the late Pleistocene or indicates the presence of older faunal component in sands and gravels of the Edmonton area (Reimchen 1968). *Titanotylopus* is known from the Irvingtonian but is not reported from Rancholabrean deposits (Harrison 1985), and giant camels closely related to *Paracamelus* are known only from the Arctic into Pleistocene time in North America (Rybczynski et al. 2013). We are reluctant to interpret the record as a chronological range extension of either taxon, particularly because no other giant camel specimens are known from among several thousand records of late Quaternary megafauna recovered from the Edmonton area. Reimchen's (1968) description and interpretation of the giant camel locality indicates that UALVP1622 and associated mammoth remains were likely from an older horizon of the so-called Saskatchewan Gravels, informally considered to be gravels occurring above bedrock but below glacial drift. We prefer an interpretation that UALVP1622 comes from geologically older gravels than the rest of the material reported here, despite the fact that it raises significant concerns about the potential for broad chronologic mixing within assemblages of megafauna from fluvial sediments in the Edmonton area. At the least, the record re-emphasizes the importance of direct dating of specimens to come out of sand and gravel pits, where specimens of disparate age may show little variation in preservation.

Even with the additional radiocarbon date provided here, direct ages on *Camelops* from Alberta are rare. Of the four direct ages known, three indicate a post-LGM age and one is non-finite. Therefore, Quaternary *Camelops* from Alberta is presently known from two time bins: Beyond Radiocarbon and Post-LGM. Additional associated radiocarbon ages indicate additional post-LGM records are consistent with assignment to those time bins. For example, a humerus identified as *Camelops* cf. *C. hesternus* was recovered from the Gallelli Pit, near Calgary, Alberta, and was associated with remains of bison dating to $11,300 \pm 290$ ^{14}C yr BP (Wilson and Churcher 1978). Remains of *Camelops* from Bonnycastle Pit, a post-LGM site located southeast of Calgary, are in the process of being formally described (Wilson, pers. comm.; see Wilson 1983 for a preliminary report). Although additional data are needed, the broad temporal bins are suggestive of similarities to temporal patterns observed elsewhere in northern North America (Heintzman et al. 2015).

Camelops may have been extirpated in portions of northern North America well before the LGM (Heintzman et al. 2015; Zazula et al. 2011) and the absence of dated remains preceding the LGM in Alberta suggests a similar pattern may have occurred further to the south into southern Canada, the notable difference being the re-dispersal of southern populations of *Camelops* northward in post-LGM times. Although the data are sparse, the hypothesis is testable with additional radiocarbon dating and aDNA analyses. We predict that remains of *Camelops* from Alberta with direct, non-finite dates are likely to be phylogenetically more similar to northern populations that became extirpated prior to the LGM. Additionally, we predict that post-LGM *Camelops* from Alberta likely represent phylogenetically distinct populations relative to pre-LGM populations from Alberta and northern Canada.

In summary, Quaternary camelids of southern Canada have received sparse attention in the published literature, likely because they are relatively rare when compared to other megafauna (e.g., horse, bison, mammoth). The records of camelids from Edmonton and Vauxhall increase the number of specimens of *Camelops* from Alberta described in the published literature. Radiocarbon data preliminarily indicate two chronologic bins for camelids in the late Pleistocene in Alberta, with pre-LGM populations perhaps being extirpated synchronously with Yukon populations. Additional radiocarbon dating and aDNA analyses offer potential avenues for addressing questions about the timing and nature of biogeographic changes and extinction in Quaternary camelids in southern Canada. In particular, further evaluation and analyses of fossil materials from both the Medicine Hat region and direct radiocarbon dating of the sparse Peace River region would be beneficial.

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Table 1. Occlusal length, occlusal width and crown height (CH) of molars of *Camelops* from Edmonton and Vauxhall, by specimen number. Summary data includes comparison of this report with published data for *Camelops* (Webb 1965; Baskin and Thomas 2016) and *Hemiauchenia* (Bravo-Cuevas et al. 2012). (n) = number of specimens used to calculate summary data. Measurements in mm.

Specimens	Element	Length	Width	CH
P96.17.60	right m3	44.93	24.52	-
P96.8.1	left m3	50.34	24.1	-
P98.8.40	left m3	52.22	19.46	27.67
P98.8.131	right M2	40.05	26.07	47.12
P94.1.598	right M3	-	24.68	74.36
P98.8.132	right M3	46.02	22.01	69.03
Summary Data				
Range (this report)	m3	44.93–52.22 (3)	19.46–24.52 (3)	-
Range (Baskin and Thomas 2016)	m3	51.3–62.5 (8)	18.5–23.2 (8)	-
Range (Webb 1965)	m3	57.3–58.4 (4)	18.5–22.3 (4)	-
Range (<i>Hemiauchenia</i> ; Bravo-Cuevas et al. 2012)	m3	40.0–15.1 (10)	10.6–16.3 (9)	
Range (this report)	M2	40.05 (1)	26.07 (1)	47.12 (1)
Range (Baskin and Thomas 2016)	M2	38.7–42.2 (3)	35.0–36.9 (3)	-
Range (Webb 1965)	M2	39.2–54.5 (4)	28.2–32.8 (4)	-
Range (<i>Hemiauchenia</i> ; Bravo-Cuevas et al. 2012)	M2	21.5–29.0 (8)	14.0–22.0 (7)	19.5 (1)
Range (this report)	M3	-	22.01–24.68 (2)	-
Range (Baskin and Thomas 2016)	M3	51.2–52.6 (3)	33.1–34.8 (3)	
Range (Webb 1965)	M3	45.8–48.5 (3)	26.3–30.3 (3)	
Range (<i>Hemiauchenia</i> ; Bravo-Cuevas et al. 2012)	M3	23.4–29.1 (7)	12.3–21.5 (6)	23.9–24.4 (2)

Table 2. Measurements of scapulae of *Camelops*. GLP = greatest length of the glenoid process, BG = breadth of the glenoid cavity. (n) = number of specimens used to determine ranges. Measurements in mm. * = estimate.

Specimens	GLP	BG
P09.7.5	108.81	58.64
P98.8.125	108.98	59.52
P98.8.126	110.8	57.37
P98.8.145	105.76	53.27*
P98.8.136	113.69	60.67
P98.8.146	96.18	52.46
Summary Data		
Range (this report)	96.18–113.69 (6)	52.46–60.67 (6)
Range (Webb 1965)	122–132 (8)	-

Table 3. Measurements of the humerus of *Camelops*. GL = greatest length of the specimen, Bp = breadth of the proximal end, Bd = breadth of the distal end, BT = breadth across the trochlea, SD = smallest breadth of the diaphysis. (n) = number of specimens used to determine ranges. Measurements in mm. * = estimate.

Specimens	GL	Bp	Bd	BT	SD
P98.2.122	-	-	91.41	82.95	55.78
P98.8.30	-	-	-	-	45.41
P98.8.31	-	-	-	-	49.54
P98.8.32	-	-	86.29	71.86	46.08
Summary Data					
Webb (1965)	441–465 (5)	129–136 (6)	-	94–105 (10)	-
Wilson and Churcher (1978)	-	135* (1)	-	-	-

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Table 4. Measurements of radioulna of *Camelops* from Edmonton and summary data from Webb (1965). GLR = greatest length of the radius, GLU = greatest length of the ulna, LO = length of the olecranon, Bp = breadth of the proximal end, Bd = breadth of the distal end, DPA = depth across the *processus anconaeus*. (n) = number of specimens used to determine ranges. Measurements in mm.

Specimen	GLR	GLU	LO	Bp	Bd	DPA
P94.12.24	557.02	475.65	87.28	86.1	84.53	76.46
Summary Data						
Webb (1965)	615–642 (7)	521–559 (10)	77–84 (8)	92–99 (10)	79–93 (16)	-

Table 5. Measurements of the metacarpal of *Camelops*. Bp = breadth of the proximal end, Bd = breadth of the distal end, GL = greatest length of the specimen, SD = smallest breadth across the diaphysis. (n) = number of specimens used to determine ranges. Measurements in mm. * = estimate. * = estimate.

Specimens	Bp	Bd	GL	SD
P05.10.52	-	68.34	-	44.45
P98.8.34	77.00	-	337.00	44.69
<i>Hemiauchenia</i> (metapodial; Bravo-Cuevas et al. 2012)	39.7	-	330*	25.3
<i>Hemiauchenia</i> (metapodial; Bravo-Cuevas et al. 2012)	-	43.20	-	-
Summary Data				
Webb (1965)	82–92 (3)	-	374–380 (3)	51–57 (3)

FIGURE CAPTIONS

Figure 1. Localities mentioned in the text (A-D) Edmonton area sites: Pit 48, Clover Bar Sand and Gravel, Riverview Pit, and Lafarge Pit 1042 (Burns and Young 1994; this report); (E) Gallelli Pit (Wilson and Churcher 1978); (F) Bonnycastle Pit (Wilson 1983); (G) Empress (Lowdon and Blake 1975); (H) Medicine Hat (Stalker et al. 1982); (I) Gertzen Pit (Burns 2010; this report); (J) Wally's Beach (Kooyman et al. 2012); (K) Watino (Churcher and Wilson 1979).

Figure 2. Cranial and mandibular elements of *Camelops* cf. *C. hesternus*. (a) P94.1.598, right M2, occlusal view; (b) P98.8.132, right M3, occlusal view; (c) P98.8.131, right M2, occlusal view; (d) P98.8.40 left m3, occlusal view; (e) P98.8.119, a partial right, edentulous mandible, lateral view (f) right mandible of *Camelus dromedarius*, lateral view. Arrows point to the angular process.

Figure 3. Vertebrae, sacral and pelvic elements of *Camelops* cf. *C. hesternus*. (a) P98.8.180, atlas, dorsal and ventral view; (b) P98.8.124, fourth of fifth cervical vertebra, lateral view; (c) P98.8.44, lumbar vertebra, lateral and proximal view; (d) P98.8.43, sacrum, dorsal view; (e) P98.8.33, innominate, ventral view.

Figure 4. Forelimb elements of *Camelops* cf. *C. hesternus*. (a) P98.8.125, partial right scapula, anterior view; (b) P98.8.122, left humerus, medial view; (c) P98.8.29, proximal end of right humerus, proximal view; (d) right humerus of *Camelus dromedarius*, proximal view; (e)

P98.8.32, left humerus, medial view; (f) P94.12.24, right radioulna, lateral view; (g) P05.10.52, left metacarpal, anterior view; (h) P98.8.34, right metacarpal, anterior view.

Figure 5. Hind limb elements of *Camelops* cf. *C. hesternus* and Camelidae indeterminate (“Giant Camel”). (a) P98.8.130, right metatarsal, anterior view; (b) P98.8.141 proximal end of left tibia, posterior and anterior view; (c) P98.8.36, distal portion of left tibia, posterior view; (d) P98.8.127, distal portion of right tibia, posterior view; (e) UALVP1622, distal condyle of metapodial, anterior and posterior view, of Camelidae indeterminate (“Giant Camel”). Circle and arrow point to nutrient foramen and associated furrow.

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