Late Pleistocene and Holocene vertebrates and palaeoenvironments from Charlie Lake Cave, northeast British Columbia

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Received June 3, 1987

Revision accepted February 9, 1988

Excavations outside Charlie Lake Cave, Peace River District, British Columbia, revealed deposits dating from ~10 700 BP to the present. The earliest fauna (10 700 – 10 000 BP) was deposited when the newly deglaciated landscape was largely unforested and included bison (*Bison* sp.), ground squirrel (*Spermophilus* sp.), a large hare (*Lepus* sp.), snowshoe hare (*Lepus americanus*), and a variety of birds, including the Cliff Swallow (*Hirundo pyrrhonota*). By 10 000 BP snowshoe hare (*Lepus americanus*) was the most numerous mammal, indicating the development of forested conditions. By 9000 BP the fauna resembled the modern Peace River fauna prior to European settlement, typical of a largely forested landscape, with wetland areas indicated by aquatic avian species. Subsequent Holocene climatic fluctuations are not evident in the faunal record.

Les excavations en dehors de la caverne du lac Charlie, dans le district de la rivière Peace, en Colombie-Britannique, ont mis à jour des dépôts qui datent d'environ 10 700 ans Av.P. Les dépôts de la faune la plus précoce (10 700 – 10 000 ans Av.P.) se sont accumulés après la déglaciation dans des terrains très peu boisés, et ils renferment des restes de bison (*Bison* sp.), de spermophile (*Spermophilus* sp.), d'un gros lièvre (*Lepus* sp.), d'un lièvre d'Amérique (*Lepus americanus*) et d'une variété d'oiseaux, incluant l'hirondelle à front blanc (*Hirundo pyrrhonota*). Il y a 10 000 ans Av.P., le mammifère en plus grand nombre était le lièvre d'Amérique (*Lepus americanus*), ce qui témoigne de conditions de forêt en voie de développement. Il y a 9000 ans Av.P., la faune ressemblait à celle qui régnait dans le district de la rivière Peace avant la colonisation par les Européens, caractérisée par de grands paysages forestiers avec la présence de marécages telle que révélée par les espèces d'oiseaux aquatiques. Le registre faunique ne fournit pas d'indice de fluctuations climatiques subséquentes à l'Holocène.

[Traduit par la revue]

Can. J. Earth Sci. **25**, 1545–1553 (1988)

Introduction

Most Late Pleistocene and Holocene vertebrate faunas from western Canada are dominated by large mammals. Such faunas are often found in relatively high energy depositional contexts such as river gravels (see summaries in Harington (1978) and Kurtén and Anderson (1980)), in deposits that have resulted in sorting of bones by size (Morlan 1980, pp. 11–12), or in archaeological sites where humans often selected the larger mammals (Driver 1985). Relatively few western Canadian faunas contain smaller mammals or birds in well-dated stratigraphic contexts. Notable exceptions include faunas from mid-Wisconsinan January and Eagle caves (Burns 1980, 1982), and from late Wisconsinan Bluefish Cave (Morlan and Cinq-Mars 1982). Our knowledge of the biogeography and paleoecology of vertebrates in western Canada, unlike other areas of continental North America (Lundelius *et al.* 1983), is mainly confined to large mammals.

This paper lists and interprets the fauna from stratified, dated deposits in a gully outside Charlie Lake Cave near Fort St. John in the Peace River District of British Columbia. The stratigraphic sequence spans the latest Wisconsinan and the Holocene. Remains of fish, amphibians, reptiles, birds, and mammals are well preserved throughout the sequence and record the replacement of the Late Glacial faunal community by the modern community. Reconstruction of paleoenvironments using the fauna can be compared with reconstructions made on the basis of palynological, paleontological, and geomorphological data from the same area.

The Charlie Lake Cave site

The location and stratigraphy of the Charlie Lake Cave site have been described in detail elsewhere (Fladmark *et al.* 1983, 1988). Charlie Lake Cave is an archaeological site (HbRf 39) consisting of a small cave and an external filled gully, excavated by Fladmark in 1983. The site is situated on the south-facing slope of a sandstone escarpment on the north side of Stoddart Creek, which drains Charlie Lake, northwest of Fort St. John, British Columbia (56°16′35″N, 120°56′15″W). At an elevation of about 730 m amsl, the site lies near the top of the escarpment, about 20 m above Stoddart Creek. Bedrock consists of Cretaceous Dunvegan Sandstone, which outcrops along the escarpment and is mantled by glaciolacustrine sediments, weathered sandstone, and reworked slope deposits. The north boundary of the site consists of a small bedrock cliff in which the cave was formed. Downslope from the cliff is a large block of sandstone (the "parapet") that was detached from the cliff some time prior to 10 700 BP. Between the mouth of the cave and the parapet is a deep gully, now filled with sediments. While the cave contains only about 20 cm of deposits above the bedrock floor, the gully contains at least 4 m of fine sediments and sandstone fragments from which artifacts and fauna have been recovered. Thus, the fauna discussed below is not, strictly speaking, a cave fauna, although it was deposited in the immediate vicinity of a cave. The preservation of fauna is probably due to the relatively rapid rate of sedimentation within the gully.

Excavations during 1983 concentrated on the filled gully, where an area of 9.2 m^2 was excavated using standard archaeological techniques. Excavation proceeded by stratigraphic units, with thick layers being subdivided into arbitrary 10 cm levels. All deposits were screened through a 3 mm mesh. Samples of bone and charcoal were obtained throughout the sequence and dated by conventional and advanced mass spectroscopy radiocarbon techniques (Table 1). After completion of excavation, column samples were taken from the sections.

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Stratigraphy

Four major stratigraphic zones (I to IV) have been defined at Charlie Lake (Fig. 1). Some are divided into subzones. Radiocarbon dates have been determined for all zones and most subzones.

Zone I (age unknown) is the lowest encountered at the site, but as bedrock was not reached, other deposits may lie below it. Sediments consist of a coarse sandstone rubble, of relatively unweathered blocks, embedded in a sand–silt–clay matrix, largely derived from weathered bedrock. Floatable organic particles consist mainly of root hairs, which are intrusive. Base-extractable humus is at a low level. No faunal or artifactual specimens were recovered, but excavations did not penetrate far into the zone. This zone is interpreted as the result of a period of rapid bedrock weathering, possibly including collapse of a section of bedrock, resulting in the deposition of large boulder-size clasts.

Zone II (10 700 – 9000 BP) is a pebbly, silty sand, with a high frequency of allochthonous pebbles of quartz, quartzite, chert, shale, and schist, probably derived from redeposition of glaciolacustrine and littoral sediments from the ridge above the site. Organic content remains low. Subzone IIa (10 700 – 10 000 BP) is distinguished from IIb (10 000 – 9000 BP) by a higher frequency of allochthonous pebbles and a greater silt–clay content.

Zone III (9000–4300 BP) is a thick deposit of interbedded humic and sandy layers. Overall, zone III has a higher organic content than zone II and a smaller mean particle size. It is divided into five subzones. IIIa is a medium fine sand, IIIb consists of a major rockfall (readily visible in Fig. 1) and a complex series of sediments around the rocks, while IIIc is characterized by aeolian sand with interbedded organic lenses. IIId consists of a layer of weathered sandstone sand, with a relatively high mean particle size, suggesting increased cryoclastic weathering during this period. IIIe consists of aeolian deposits very similar to those in IIIc but lacking the organic horizons.

Zone IV (4300 BP to Recent) is a relatively homogeneous, thick, highly organic sediment. Granulometric characteristics are similar to those of IIb, suggesting a return to more active weathering after IIIe. No consistent stratigraphic divisions can be recognized, and the zone may have suffered some disturbance from wood rats (*Neotoma* sp.), whose bones are abundant, and whose nesting material probably contributes a significant portion of the organic material. The upper part of the zone has also been disturbed by historic human activity.

A plot of radiocarbon dates against depth below surface (Fig. 2) shows that sedimentation rates have been stable at Charlie Lake Cave, although the overall sedimentation rate slowed after ~7000 BP, resulting in a curvilinear relationship between radiocarbon age and depth. A reduction in sedimentation rates may be the result of increased slope stability above the site. No stratigraphic breaks are evident, and, on the whole, the radiocarbon chronology suggests considerable stratigraphic integrity of the deposits. Below zone IV there is little evidence of disturbance by animals or tree roots.

Two apparently anomalous dates are recorded in Table 1 and Fig. 2. SFU 356 is clearly too old for its stratigraphic position, while SFU 453 is too young. Possible explanations include the following. First, it is posible that some form of disturbance has taken place. While this might account for SFU 356, which is in a stratigraphic zone with some evidence for rodent activity, it cannot account for SFU 453 because rodent burrowing activity was not observed below zone IV. Second, SFU 453, which is based on a charcoal sample, might represent fragments of an intrusive burnt root. Third, the two samples may have been mixed by the laboratory or the excavator. It is worth noting that if one switches the depths, the samples fall into place on Fig. 2.

TABLE 1. Radiocarbon dates

Zone	Date (BP)	Lab No.	Material	Comments
IV	1 400 ± 400	SFU 379	Charcoal	
IV	2 900 ± 400	SFU 358	Charcoal	
IV	4 270 ± 160	SFU 382	Bone	
IV	6 700 ± 290*	SFU 356	Charcoal	
IIIe	4 400 ± 400	SFU 385	Charcoal	
IIIe	4 800 ± 640	SFU 451	Charcoal	
IIId	1 130 ± 240*	SFU 453	Charcoal	
IIIb	7 100 ± 350	SFU 452	Charcoal	Upper IIIb
IIIb	8 400 ± 240	SFU 357	Charcoal	Lower IIIb
IIIa	7 800 ± 800	SFU 370	Charcoal	Under rockfall
IIb	9 760 ± 160	SFU 355	Bone	
IIa–b	9 990 ± 150	RIDDL 393	Bone	IIa–IIb interface
IIa	10 100 ± 210	RIDDL 392	Bone	
IIa	10 380 ± 160	SFU 378	Bone	
IIa	10 450 ± 150	SFU 300	Bone	
IIa	10 770 ± 120	SFU 454	Bone	

*Date is incompatible with the stratigraphic position.

Identified fauna

Identifications were made using comparative collections at the Department of Archaeology at Simon Fraser University, the Department of Ornithology of the Royal Ontario Museum, the Department of Zoology of the Burke Memorial Museum at the University of Washington, the University of British Columbia Museum of Zoology, and the Univesity of Puget Sound Museum of Natural History at Tacoma. A summary of the fauna is presented in Table 2. All specimens recorded in Table 2 were identified to element. For mammal and bird bones, only specimens that could be identified to the ordinal taxonomic level are included. Consequently, many thousands of unidentifiable specimens are omitted from Table 2.

Table 2 lists the number of identified specimens (NISP) for each taxon. There has been considerable discussion regarding the utility of different methods of quantification for vertebrate remains, and it is clear that all methods have drawbacks (Grayson 1979). NISP is at least an unambiguous statement of the frequency of occurrence of a taxon in an assemblage and does not artificially inflate the importance of species represented by very few bones, as happens when minimum number of individuals is calculated (Grayson 1979).

Pisces

Fish were common in all zones, except zone II. Most fish remains await identification, but the presence of fish early in the sequence is unusual, as few Late Pleistocene – early Holocene fish are reported for western Canada. The only specimens that could be identified from zone II were *Catostomus* sp., a species of sucker.

Amphibia and Reptilia

These were identifiable only as frogs and snakes, respectively, the former occuring mainly in the middle half of the sequence and the latter in the upper.

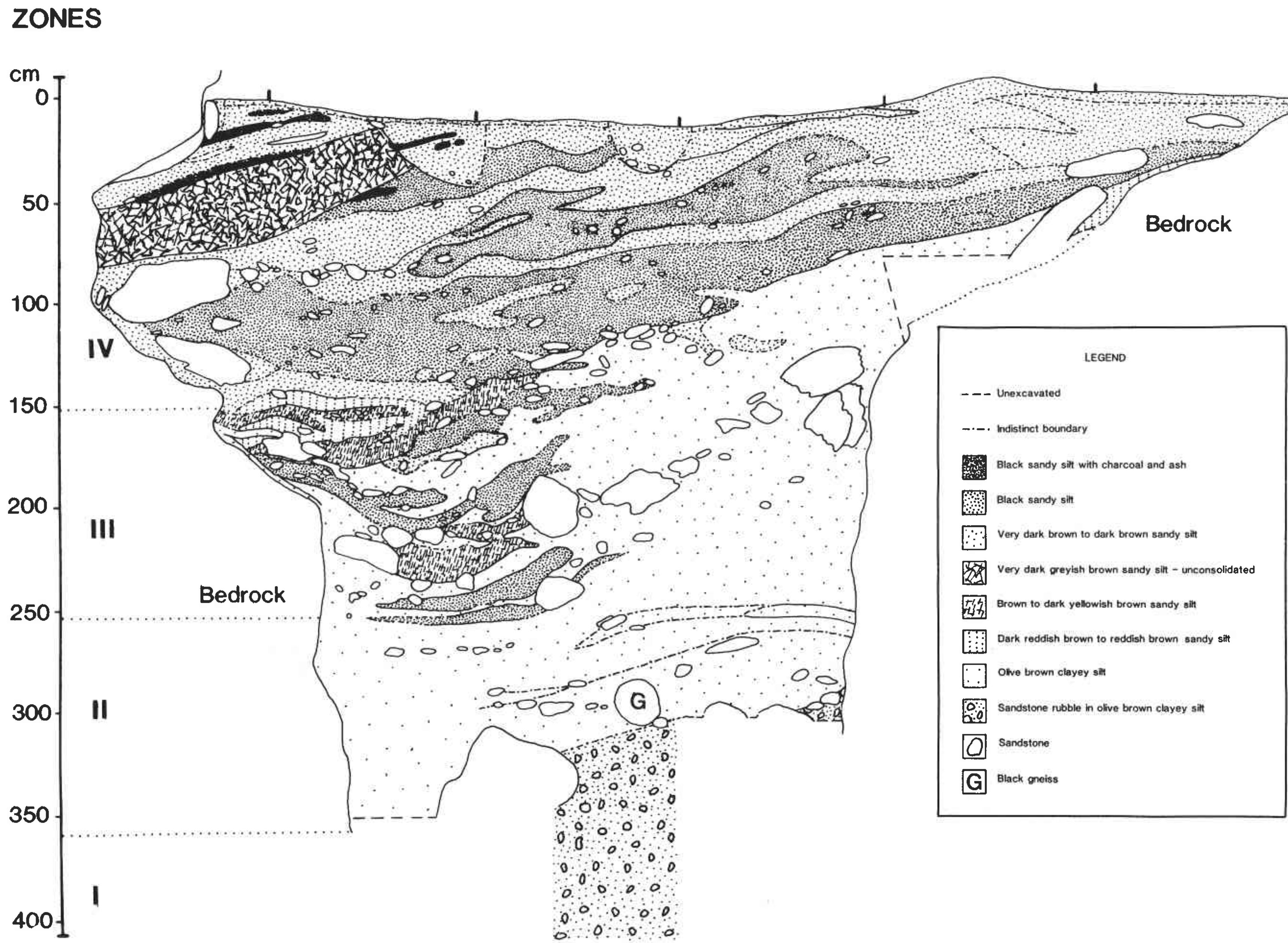

FIG. 1. Stratigraphy of west wall of excavation in gully outside Charlie Lake Cave.

TABLE 2. Charlie Lake Cave fauna identified by zone and subzone

Taxon	Zone								
	IV	IIIe	IIId	IIIc	IIIb	IIIa	IIb	IIa	Total
Pisces (fish)									
Unidentified Pisces	2157	184	359	42	184	186	11	4	3127
Catostomus sp. (sucker)							3		3
Amphibia (amphibians)									
Anura (frogs)	1			1	1	1	2		6
Reptilia (reptiles)									
Serpentes (snakes)	7	1	6	1					15
Aves (birds)									
Aechmophorus occidentalis (Western Grebe)	20			1	2	5	2		30
Podiceps auritus (Horned Grebe)				1	3	3	15		22
Medium-sized Podicipedidae (grebe)	2	2	1	2	9	3	4		23
Phalacrocorax auritus (double-crested cormorant)	1								1
Phalacrocorax sp. (cormorant)	2								2
Cygnini (swans)	1								1
Anserini (geese)	2								2
Anatini (surface-feeding ducks)	36	4	5		2		2	1	50
Anas crecca (green-winged teal)	13		2		1	9	1		26
Anas platyrhynchos (Mallard)	1						1		2
Aythyini (diving ducks)	1	1							2
Bucephela sp. (goldeneye)	1								1
Melanitta fusca (White-winged Scoter)	1								1
Oxyura jamaicensis (Ruddy Duck)	2						1		3
Mergus sp. (large merganser)	1	1	1						3
Lophodytes cucullatus (Hooded Merganser)	1								1
Falconiformes (hawks and falcons)			1						1
Tetraoninae (grouse and ptarmigan)	18	3	4		10	8	13		56
Small Rallidae (Virginia Rail or Sora)							2		2
Fulica americana (Coot)		1					10		11
Charadriiformes (small wader)	2					1		2	5
Larus sp. (small gull)	2			1					3
Ectopistes migratorius (Passenger Pigeon)	5		1		2	1			9
Strigiformes (owls)	3					1			4
Asio flammeus (Short-eared Owl)							8		8
Surnia ulula (Hawk Owl)				5					5
Ceryle alcyon (Belted Kingfisher)		1							1
Passeriformes (perching birds)	18	2	4		1	1	1	11	38
Hirundo rustica (Barn Swallow)	1								1
Hirundo pyrrhonota (Cliff Swallow)						1	3	16	20
Corvus corax (Raven)					1				1
Mammalia (mammals)									
Myotis sp. (bat)	1								1
Lepus americanus (snowshoe hare)	1214	146	195	46	82	124	145	18	1970
Large *Lepus* sp. (hare)								4	4
Eutamias minimus (least chipmunk)	1	1	1	1					4
Eutamias sp. (chipmunk)	7	2		2		4			15
Marmota monax (woodchuck)	21								21
Marmota sp.	86	1	3		2		1		93
Spermophilus sp. (ground squirrel)						7	24	122	153
Tamiasciurus sp. (tree squirrel)	1								1
Castor canadensis (beaver)	33	4	1		2	4			44
Peromyscus sp. (deer mouse)	30		11	1	1	6	2	6	57
Neotoma sp. (wood rat)	103	11	4	1	1				120
Clethrionomys gapperi (Gapper's red-backed vole)	6	1	1		2	11	2		23
Ondatra zibethicus (muskrat)	139	9	14	2	12	21		1	198
Microtus pennsylvanicus (meadow vole)	1								1
Microtus sp. (meadow or long-tailed vole)	16	2	4		1	4	3	2	32
M. xanthognathus (chestnut-cheeked vole)	4		1			6	2		13
Small microtine	73	3	5			11	17	2	111
Large microtine	30	1	1		1	1	2		36
Erethizon dorsatum (porcupine)	3								3
Canis lupus (wolf)	1								1
Canis sp. (wolf or dog)	52	10	8	1	1	1	1		74

TABLE 2 (*concluded*)

Taxon	Zone								
	IV	IIIe	IIId	IIIc	IIIb	IIIa	IIb	IIa	Total
Vulpes vulpes (red fox)	33	2	4	1		1			41
Ursus americanus (black bear)				1					1
Ursus sp. (bear)	4		1						5
Martes americana (American marten)	5								5
M. pennanti (fisher)	8								8
Mustela erminea (ermine)		1							1
M. nivalis (least weasel)	3						2		5
Mustela sp. (weasel)	1								1
M. vison (American mink)	3								3
Gulo gulo (wolverine)	2								2
Mephitis mephitis (striped skunk)	22	1	1						24
Small Mustelidae	42	4	2		2	4	1		55
Felis concolor (mountain lion)	1								1
Lynx lynx (lynx)	7	1				1			9
Felis catus (domestic cat)	5								5
Odocoileus sp. (deer)	3								3
Alces alces (moose)	1								1
Cervus elaphus (wapiti)	5								5
Bison sp. (bison)	2	1	1		14		11	8	37
Large Cervidae (moose or wapiti)	10	2	1			1			14
Medium-sized Artiodactyla	2			1					3
Large Artiodactyla	34	6	3		9	9	6	3	70
Total number	4314	409	646	112	345	436	298	200	6760
Total excluding fish	2157	225	287	70	161	250	287	196	3633

Aves

Many smaller grebes could not be identified to the species level and were grouped as "medium grebes." Some of these specimens were identified as *Podiceps auritus* (Horned Grebe).

Tetraoninae (grouse and ptarmigan) occur frequently in the assemblages. Despite good preservation of many specimens it was not possible to identify them further. Examination of a large series of modern comparative skeletons demonstrated that separation of smaller grouse from ptarmigan could not be undertaken with confidence, and I could not identify any of the Tetraoninae at Charlie Lake to the species level.

A few small Charadriiformes (gulls and waders) were identified, but speciation of this large group on osteological characters was difficult. A number of specimens were clearly small gulls (*Larus* sp.), either *L. pipixcan* (Franklin's Gull) or *L. philadelphia* (Bonaparte's Gull), both of which live in the area today.

A few Columbidae (pigeon) bones were recovered from the site. Currently there are no pigeons present in the area, except *Zenaida macroura* (Mourning Dove) and introduced *Columbia livia* (Rock Dove). However, *Ectopistes migratorius* (Passenger Pigeon) was present in the area in the early historic period (Williams 1979). The Charlie Lake specimens are smaller than modern Rock Doves and are too large to be Mourning Doves. Comparison with specimens of Passenger Pigeons from archaeological sites in Ontario (kindly loaned by H. Savage of the University of Toronto) showed that the Charlie Lake specimens were identical in size and morphology.

Although many Passeriformes were recovered, only three species were identified with confidence. *Hirundo pyrrhonota* (Cliff Swallow) was a notable component of the earlier faunas and was distinguished from other swallows by the morphology of humerus, ulna, and carpometacarpus. One specimen of *Hirundo rustica* (Barn Swallow) was identified. An atlas vertebra of *Corvus corax* (Raven) was also identified.

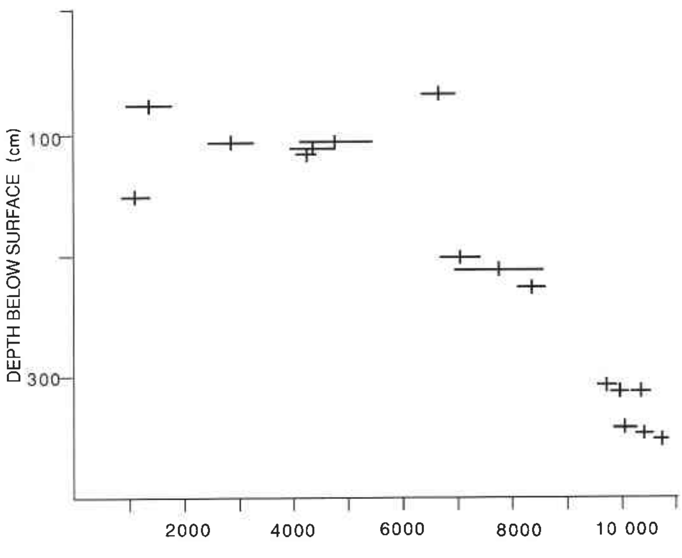

FIG. 2. Radiocarbon dates at 1 SD plotted against depth below surface. See Table 1 for details.

Mammalia

Lagomorphs form the greater part of the assemblage. *Lepus americanus* (snowshoe hare) is very common. However, in zone IIa four specimens of a larger species of *Lepus* were found. Today there are no large species of this genus within hundreds of kilometres of the site. The specimens consist of two scapulae, an ulna, and a metatarsus, none of which exhibit enough distinctive characteristics to allow identification to the species level. Assuming that an extant species is represented, it must be either *L. arcticus* (arctic hare) or one of the jackrabbits, probably *L. townsendii* (white-tailed jackrabbit). Measurements taken on comparative specimens showed overlap in size between *L. arcticus* and *L. townsendii*, although both species were readily distinguished from *L. americanus* on the basis of size. Morphologically, the scapulae from Charlie Lake were more similar to *L. arcticus* based on the angle between the glenoid fossa and the coracoid process and on the shape of the coracoid process, but the size of the comparative sample was small, and specific identification was not justifiable.

The Sciuridae form an important component of the rodent fauna. All chipmunks that were identified are *Eutamias minimus* (least chipmunk), which live on the site today. *Marmota monax* (woodchuck) was identified based on cranial fragments; other *Marmota* sp. specimens in Table 2 are postcranial elements, probably from the same species. No ground squirrels (*Spermophilus*) inhabit the Charlie Lake region today, but they are an abundant component of the lowest fauna. The modern species living closest to Charlie Lake are *S. columbianus* (Columbian ground squirrel) and *S. lateralis* (golden-mantled ground squirrel), which are found about 100 km south in the Rocky Mountains. Comparison with a wide range of modern species shows that either *S. columbianus* or *S. richardsonii* (Richardson's ground squirrel) is present at the site. All other species are either too large (e.g., *S. parryii*, the Arctic ground squirrel) or too small (e.g., *S. lateralis*) or exhibit dental differences (e.g., *S. franklinii*, Franklin's ground squirrel). Modern Columbian and Richardson's ground squirrels exhibit some variation in size, and although size differences may be used to separate bones of the two modern species from a defined region, one cannot develop criteria of absolute size to separate the two species. Hall (1981, p. 388) noted that the maxillary tooth rows diverge anteriorly in *S. richardsonii* whereas they are parallel in *S. columbianus*. A bivariate plot of maxillary tooth row length against palatal width between P3 separated the modern species fairly well. However, the crania from Charlie Lake are fragmentary, and no complete palates are preserved. Alveolar lengths of mandibular and maxillary tooth rows were also measured. In modern specimens of *S. richardsonii* and *S. columbianus* the ranges of these measurements partially overlap. Two Charlie Lake maxillae fell in the area of overlap. Two mandibles fell in the modern range for *S. columbianus* and one in the range of *S. richardsonii*. I am unwilling to make a firm identification on the basis of these data.

The smaller microtines can be identified to species only on dental characteristics. *Clethrionomys gapperi* (Gapper's red-backed vole) has a distinctive dentition. Small *Microtus* specimens were identified as either *M. pennsylvanicus* (meadow vole) or *M. longicaudus* (long-tailed vole) because dentitions were usually incomplete. Only one specimen retained the distinctive upper second molar and was identified as *M. pennsylvanicus*. A number of specimens of a larger *Microtus* were also recovered. Cranial elements were assigned to *M. xanthognathus* (chestnut-cheeked vole) on the basis of dentition. Long bones and edentulous cranial fragments of all microtines except muskrat were assigned to either "large" or "small" categories in Table 2.

Large canids could be either *Canis familiaris* or *C. lupus* (domestic dog or wolf), with one specimen definitely referred to the latter on the basis of mandibular dimensions (Lawrence 1968).

Artiodactyla are relatively rare, considering the prehistoric human use of the site. Many specimens were fragmentary, probably the result of human butchering practices, and many specimens could only be identified as "large artiodactyl" in the size range of *Cervus elaphus* (wapiti), *Alces alces* (moose), or *Bison* sp. (bison). *Bison* could not be identified to species or subspecies, but measurements of postcranial elements from specimens in zone II show that the Charlie Lake specimens were comparable in size to specimens obtained from gravels in the Peace River, Wapiti River, and Smoky River in Alberta. Table 3 presents standardized measurements (following von den Driesch 1976) of Charlie Lake specimens from zone II, Late Pleistocene – early Holocene specimens from north-central Alberta dating to around 10 000 BP, and (for comparison) late Holocene specimens of *Bison b. bison* from the Muhlbach site in central Alberta (Gruhn 1971). The Charlie Lake specimens fit into the range of measurements from the Peace River gravels and are larger than the late Holocene sample.

Origin of the fauna

The precise taphonomic history of the fauna remains to be established. Analysis of the taphonomic histories of small mammals is very difficult because bones display few discrete characters indicative of their postmortem history. When a range of predators is represented at the site, as is the case at Charlie Lake, problems are increased because different predators may treat bones in very similar ways. Although humans were using the site for over 10 000 years (Fladmark *et al.* 1988), the general paucity of artifacts argues for very brief periods of human use of the site. Although deposition of artifacts was sporadic, deposition of fauna was constant, and most of the fauna was not deposited as a result of human use of the site. The presence of human-made cut marks is confined to a few large mammal bones from zone IIa and from upper zone IV (Fladmark *et al.* 1988).

Fauna that did not accumulate as the result of human hunting may have reached the site in a number of ways. Some species certainly lived and died on the site. This includes *Neotoma* sp. (wood rat), *Eutamias minimus* (least chipmunk), and *Marmota monax* (woodchuck). Other species may have been brought to the site as prey items. *Spermophilus* (ground squirrel), *Lepus americanus* (snowshoe hare), and Tetraoninae (grouse or ptarmigan) bones from zones IIa and IIb were often excavated as partially articulated skeletons, suggesting that they had been deposited as dismembered prey items. Other specimens were disarticulated but individual bones were complete, suggesting that they were deposited in owl pellets.

The many carnivore remains, especially in the upper deposits, probably indicate that the site was used as a den, particularly by mustelids such as *Mephitis mephitis* (striped skunk). Carnivores would have brought back the bones of killed and scavenged animals to their dens, they would themselves have died occasionally at the site, and they may also have been preyed upon by larger carnivores. Regardless of the way in which the fauna accumulated, there is no indication of long-distance transportation for any species. All identified specimens are assumed to be members of the local community to be found within a few kilometres of the site.

TABLE 3. Measurements (in mm) of Late Pleistocene – early Holocene *Bison* sp. postcranial elements from the Charlie Lake Cave site and from the Peace River, Wapiti River, and Smoky River gravels of Alberta and of *Bison b. bison* postcranial elements from the late Holocene Muhlbach site, Alberta

Specimen	Measurement	Notes
Humerus BT (breadth of trochlea)		
UCArch 83.78.1	[94]	Lane Pit, Peace River, Alberta
UCArch 79.81.4	[97]	Lane Pit, Peace River, Alberta
UCArch 79.80.77	99.7	Lane Pit, Peace River, Alberta
UCArch 79.80.76	98.6	Paired with above specimen
PRP 1977 W-8	[107]	Watino, Alberta
PRP 1977 W-1	[104]	Watino, Alberta
HbRf 39 #3429	91.8	9990 ± 150 BP (RIDDL 393) zone IIb
HbRf 39 #1849	99.2	10 770 ± 120 (SFU 454) zone IIa
Muhlbach	82.8	Mean value for 20 specimens. Late Holocene
Tibia Bd (breadth of distal end)		
UCArch 77.41.1	83.0	Wapiti Pit, Grand Prairie, Alberta
UCArch 79.81.10	80.7	Lane Pit, Peace River, Alberta
UCArch 79.53.8	83.8	Lane Pit, Peace River, Alberta
UCArch 79.81.9	67.8	Lane Pit, Peace River, Alberta
UCArch 78.71.1 B-40	84.3	Northern Alberta RR Pit, Watino, Alberta. 10 200 ± 100 (GSC 2895) (Jackson and Pawson 1984, Table 11)
UCArch 78.74.1	88.0	Pucci Pit, Watino, Alberta
HbRf 39 #1829	80.7	Zone IIb
Muhlbach	68.1	Mean value of 41 specimens. Late Holocene

NOTE: Measurements in brackets are minimum values on eroded bones.

Palaeoenvironments

Zone IIa (10 700 – 10 000 BP)

The zone IIa fauna, while relatively sparse, gives some evidence for an environment different from the modern Peace River situation. *Lepus americanus*, the most abundant mammal in all subsequent zones, is less common in this zone, and *Spermophilus* dominates the fauna. The latter, together with large *Lepus* and *Bison*, is consistent with an open environment; cliff swallows also favour open habitats (Godfrey 1986, p. 378). The short-eared owl from zone IIb is also found in open habitats (Godfrey 1986, p. 326), and as this specimen was found at the IIa–IIb boundary, it may relate to this earlier, more open environment. On the other hand, *Lepus americanus* probably indicates the presence of some woodland or forest, and I would interpret the zone IIa faunas as occurring in a predominantly open environment with areas of woodland or forest.

As noted above, species identification of the ground squirrels and large hares was not possible, and it is plausible that either "cold" species (mountain-adapted Columbian ground squirrel and arctic hare) or "warm" species (Richardson's ground squirrel and a jackrabbit) are represented. While it is tempting to assume that cold species would be represented in an early postglacial environment, the nature of such environments is poorly known. Guthrie (1982, pp. 315–316) suggested that Pleistocene communities were more diverse, not only because of the presence of extinct species but also because there was a more fine-grained distribution of plant communities, allowing a greater diversity of species. Thus, one finds frequent examples of "northern" species south of their modern range and, less frequently, "southern" species north of their modern range. We may identify the landscape around Charlie Lake as more "open" than today, but it was not necessarily colder.

Further evidence for the faunal community at this period derives mainly from large mammals from Late Wisconsinan and early Holocene deposits in the Peace River, the Wapiti River, and the Smoky River valleys of Alberta. Burns (1986, p. 105) recorded an early Holocene wapiti skeleton dated at 9075 ± 305 BP (S-2614). Another date of 9920 ± 220 BP (AECV 272c) was obtained on the same skeleton (J. Burns, personal communication, 1986). Churcher and Wilson (1979) have identified mammoths, two equids, a camelid, wapiti, musk-ox, and bison. Of these, only bison has been dated directly, with dates of 10 200 ± 100 BP (GSC-2895), 10 200 ± 100 BP (GSC-2902), and 9880 ± 130 BP (GSC-2865) (Jackson and Pawson 1984, Table 11). Churcher and Wilson (1979, p. 75) interpreted the climate as "slightly drier and possibly warmer," producing a prairie or woodland vegetation. The fauna from zone IIa at Charlie Lake provides additional support for their interpretation.

Analysis of pollen from lake sediments approximately 120 km to the southeast of Charlie Lake provides further evidence for the nature of Peace River environments following the ice retreat (White 1983). An initial sedge–herb vegetation (12 000 – 11 700 BP) was replaced by an open deciduous tree – shrub–herb vegetation from ~11 700 to 11 300 BP when the first conifers appeared locally. By 10 700 BP conifers were a dominant feature of the environment. The fauna from Charlie Lake Zone IIa is consistent with the deciduous tree – shrub–herb environment described by White. The slightly later dates from Charlie Lake may be due either to minor discrepancies in dating or to a lag in the establishment of coniferous forest.

MacDonald (1987) has described pollen from two sites: Lone Fox Lake and Yesterday Lake, Alberta, about 100 km northeast of Charlie Lake. From 11 000 to 9000 BP vegetation was changing rapidly and does not have a modern analogue. Deciduous trees, such as *Populus* and *Betula glandulosa*, willow, juniper, herbs, and grasses colonized the deglaciated landscape. MacDonald also recorded the presence of *Typha* (cattail) pollen prior to 10 000 BP, indicative of a relatively warm climate. At about 10 000 BP, coniferous forest, dominated by *Picea*, was established in the region, although the species composition was somewhat different from that of modern boreal forests (MacDonald 1987, p. 314).

Thus, both the fauna from Charlie Lake and the pollen from Lone Fox and Yesterday lakes suggest the establishment of forested conditions at about 10 000 BP in the Peace River area. At Charlie Lake the disappearance of the ground squirrels shortly after 10 000 BP, with a concomitant increase in snowshoe hare, is the most obvious marker of this change.

Analysis of glacial and periglacial deposits in the region (Mathews 1978, 1980; St-Onge 1972) shows that after the retreat of Laurentide ice a series of glacial lakes was established in the Peace River valley and covered the location of Charlie Lake Cave. The Clayhurst stage of Glacial Lake Peace had an elevation similar to that of the cave, and a small beach remnant just below the site may represent a Clayhurst beach (W. Mathews, personal communication, 1983). The absence of *in situ* glaciolacustrine sediments in the gully suggests that glacial lakes were at an elevation below the site by 10 700 BP, consistent with the suggestion that the Clayhurst stage terminated prior to 10 000 BP (Mathews 1980, p. 19). Although the geological data do not offer specific information about the biotic environment, an open landscape is to be expected in areas from which ice and meltwater lakes have retreated.

Zone IIb (10 000 − 9000 BP)

Zone IIb records the establishment of an essentially modern fauna, although, because of small sample size, it seems impoverished when compared with the fauna of later zones. Ground squirrels persist in small numbers into the early part of the zone but disappear soon after. Snowshoe hare dominate the fauna. As this species is clearly associated with forested conditions today (Banfield 1974, p. 83), it would appear that forests were present in this area of the Peace River District from ~10 000 BP to the present. The appearance of *Clethrionomys gapperi* and *Microtus xanthognathus* also supports the interpretation of a forested environment. The former is generally found in "forested and brushy areas" (Banfield 1974, p. 180), and the latter, although less well known, appears to be associated primarily with boreal forest (Banfield 1974, p. 220).

The avian fauna from IIb occurs mainly in the upper part of the subzone and reflects an aquatic environment. *Aechmophorus occidentalis* (Western Grebe), *Podiceps auritus* (Horned Grebe), *Oxyura jamaicensis* (Ruddy Duck), and *Fulica americana* (Coot) are characteristic birds of boreal forest marshes (Erskine 1977). In addition, the small rail indicates a marsh-edge habitat. Grouse are the most common upland birds, and most grouse species are also associated with forested environments.

The IIb fauna indicates two major components of the environment in the early Holocene. Forested conditions were established over the local uplands, as indicated by a high frequency of snowshoe hare and grouse. Although bison can exist within coniferous forests, their continued presence in the site suggests that some areas of the Peace River remained as grassland. The avian fauna, together with evidence for fish and frogs, points to local aquatic conditions. This is consistent with the continued drainage of the local glacial lakes and the likelihood of immature drainage patterns in the deglaciated landscape.

Subsequent zones

After the end of zone IIb, there is little evidence for faunal change. With the exception of Passenger Pigeon and bison (both extirpated from the area by man in the nineteenth century), all recorded species in zones III and IV can be found within a few kilometres of the site today. The notable increase in species diversity in zone IV is mainly due to a larger sample, but other factors may be involved. As the gully between the cliff and the parapet filled with sediment, the cave became more accessible as a den site for a variety of animals, including a range of carnivores and the wood rats. The bones of these species, and of the carnivores' prey, contribute to the diversity of zone IV.

Conclusions

The fauna from Charlie Lake Cave spans the latest glacial episode to modern times. Deposition of faunal material began soon after Glacial Lake Peace had retreated from the site, some time before 10 700 BP. At this time the landscape was open, probably with scattered patches of forest. The sparse faunal remains are unfortunately difficult to identify to species but record the presence of ground squirrel, large hare, and bison, all indicating an open environment. Snowshoe hare inhabited forest patches, and Cliff Swallows fed over open water and marshes. By about 10 000 BP forests were established over most of the area, and a typical forest fauna was present, including numerous snowshoe hare and a wide range of aquatic birds, indicating extensive local marsh development. By 9000 BP the fauna was modern, and there were no major subsequent changes in the fauna, except for nineteenth century extinctions. Palynological, geological, and paleontological data from other sites in the Peace River area confirm that a diverse and productive habitat was established in the region following deglaciation and drainage of proglacial lakes. The early vegetational and faunal community probably survived for less than 1000 years in this area of the Peace River District before its replacement by boreal forest with a vertebrate community similar to that of today.

Acknowledgments

Knut Fladmark kindly offered me the chance to study this fauna and provided much information about the site and its stratigraphy. I am grateful to the following people for allowing access to comparative collections: Richard Cannings, Ellen Kretzman, Sievert Rohwer, Howard Savage, Terri Smith, and Chris Wood. Advice on species identification was provided by James Burns, Michael C. Wilson, Richard Harington, and John White. Howard Savage kindly made a permanent loan of passenger pigeon specimens to Simon Fraser University (SFU). Michael Wilson allowed me to study bison specimens from Alberta, and Ruth Gruhn and Jean Hourston-Wright allowed access to bison bones from the Muhlbach site. I am grateful to James Burns and Richard Harington for their comments on an earlier version of this paper, and to two anonymous reviewers. Preparation of illustrations was by Carol Fairhurst and the Instructional Media Centre SFU. This research was supported by Social Sciences and Humanities Research Council grants to Knut Fladmark and the author.

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