

Small-Mammal Data on Early and Middle Holocene Climates and Biotic Communities in the Bonneville Basin, USA

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Archaeological investigations in Camels Back Cave, western Utah, recovered a series of small-mammal bone assemblages from stratified deposits dating between ca. 12,000 and 500 ¹⁴C yr B.P. The cave's early Holocene fauna includes a number of species adapted to montane or mesic habitats containing grasses and/or sagebrush (e.g., *Lepus townsendii*, *Marmota flaviventris*, *Reithrodontomys megalotis*, and *Brachylagus idahoensis*) which suggest that the region was relatively cool and moist until after 8800 ¹⁴C yr B.P. Between ca. 8600 and 8100 ¹⁴C yr B.P. these mammals became locally extinct, taxonomic diversity declined, and there was an increase in species well-adapted to xeric, low-elevation habitats, including ground squirrels, *Lepus californicus* and *Neotoma lepida*. The early small-mammal record from Camels Back Cave is similar to the 11,300–6000 ¹⁴C yr B.P. mammalian sequence from Homestead Cave, northwestern Utah, and provides corroborative data on Bonneville Basin paleoenvironments and mammalian responses to middle Holocene desertification. © 2002 University of Washington.

Key Words: Small mammals; early Holocene; middle Holocene; Bonneville Basin; environmental change; taxonomic diversity.

INTRODUCTION

In a recent comprehensive study, Madsen (2000) and Madsen *et al.* (2001) examined regional geomorphic data, biotic data from new and previously recovered woodrat middens, and floral and faunal materials from the 11,300–1000 ¹⁴C yr B.P. stratified deposits in Homestead Cave, western Utah, to investigate late Quaternary paleoecology in the Bonneville Basin. Of particular importance here are the analyses of Grayson (1998, 2000a,b)

of the more than 160,000 identified small mammals specimens recovered from Homestead Cave. Among the many enlightening aspects of this research, Grayson found that (1) contrary to some climatic models (e.g., Mock and Bartlein, 1995), northerly parts of the Great Basin during the early Holocene were cool and moist, not warm and moist; (2) the onset of warmer and drier middle Holocene climates is marked by extinctions or dramatic declines of montane mammals in low-elevation contexts (see also Grayson, 1993), and; (3) the distribution of montane mammals in the Great Basin continues to be shaped by complex patterns of colonization and extinction, and some small mammals on “isolated” Great Basin mountains are not as isolated as once thought (see also Grayson and Madsen, 2000; Lawlor, 1998). Approximately 120 km south of Homestead Cave, recent archaeological investigations in Camels Back Cave recovered a series of relatively large and diverse faunal assemblages from stratified deposits dating between >10,000 and 500 ¹⁴C yr B.P. (Schmitt and Madsen, 2002). The mammalian fauna include the first terminal Pleistocene–middle Holocene aggregates from the southern Great Salt Lake Desert and provide exceptional data to compare with the early faunal record from Homestead Cave.

CAMELS BACK CAVE

Camels Back Cave is a small north-facing portal in southern Camels Back Ridge, Tooele County, Utah, at an elevation of 1380 m (Schmitt *et al.*, 1994; Schmitt and Madsen, 2002). The ridge is an isolated limestone island surrounded by alkali flats and low dunes adjacent the southeastern margin of the Great Salt Lake Desert. The region currently supports xerophytic scrub communities containing greasewood (*Sarcobatus vermiculatus*), four-winged saltbush (*Atriplex canescens*), horsebrush

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(*Tetradymia* sp.), salt grass (*Distichlis* sp.), and introduced annuals (notably cheatgrass [*Bromus tectorum*]); neighboring playa margin dunes support some big sagebrush (*Artemisia tridentata*), Indian ricegrass (*Stipa hymenoides*), and rabbitbrush (*Chrysothamnus* sp.). Between 1996 and 1998 we stratigraphically excavated a contiguous 2 × 4-m block of deposits down to Pleistocene Lake Bonneville gravels resting on the bottom of the cave. We identified 33 stratigraphic horizons, 17 of which contained evidence of brief human occupations spanning the last ca. 7500 ¹⁴C years. Although the proportion of accumulated materials vary from one depositional unit to the other, most of the cave's deposits comprise a mixture of aeolian dust, decomposed organic materials, and cemented tufa and limestone spall from the cave ceiling and walls.

The terminal Pleistocene–early middle Holocene deposits in Camels Back Cave are represented by nine stratigraphic horizons controlled by 10 radiocarbon dates (Fig. 1). Although the base of Stratum I is undated, the topographic relationship of the cave to remnant features of Pleistocene Lake Bonneville (e.g., Currey, 1990; Oviatt *et al.*, 1992) and the underlying layer of water-rounded gravels suggest that recovered materials may date to ca. 12,000 ¹⁴C yr B.P. Strata I–II lacked evidence of human occupation and radiocarbon dates of 9560 ± 40 ¹⁴C yr B.P. from the top of Stratum I and 8810 ± 70 ¹⁴C yr B.P. from the middle of Stratum IIa were extracted from a carnivore (cf. *Canis latrans*) scatological dropping and an artiodactyl fecal pellet, respectively. Each of the remaining dates was provided by radiocarbon assay of charcoal from fire hearths constructed by the cave's human inhabitants. Sequential dates from individual stratigraphic

units suggest there has been little or no mixing of deposits of differing ages and that these radiocarbon dates provide accurate proxies for the age of materials within each unit.

Mammal Remains

Faunal materials were collected by sieving the excavated deposits through nested 1/4" (6.4-mm) and 1/8" (3.2-mm) screens. All skeletal materials trapped in the 1/4" screens were identified for most stratigraphic aggregates and 1/8" mesh samples from two 50 × 50-cm units were examined in each layer to more fully investigate the types and frequencies of diminutive mammals.

Of the 13,699 small mammal bones and bone fragments collected from strata I–VIII, 3885 (28%) were identified to at least the genus level (Fig. 1). The identified skeletal remains (Table 1) are dominated by species that currently occupy arid, low-elevation contexts in the Great Basin, especially black-tailed jackrabbit (*Lepus cf. californicus*), Townsend's ground squirrel (*Spermophilus mollis*), kangaroo rat (*Dipodomys* sp.), and desert woodrat (*Neotoma lepida*). There are, however, some taxa that largely occur in boreal habitats on Great Basin mountains and mountain foothills and are not known in the Camels Back Ridge vicinity today. These include the white-tailed jackrabbit (*L. townsendii*), yellow-bellied marmot (*Marmota flaviventris*), and bushy-tailed woodrat (*Neotoma cinerea*) (e.g., Grayson, 1993; Hall, 1946; Brown, 1971). In addition, we identified the remains of small mammals that may inhabit low-elevation contexts but characteristically occupy relatively mesic settings containing grasses and/or sagebrush. Included are the western harvest mouse (*Reithrodontomys megalotis*), who tend to be most abundant in well-watered habitats containing dense grasses (Hall, 1946; Webster and Jones, 1982); sage voles (*Lemmiscus curtatus*), who are characteristically associated with grassland habitats containing stands of *Artemisia tridentata* (Hall, 1946; Carroll and Genoways, 1980); and pygmy rabbits (*Brachylagus idahoensis*), who are tethered to dense stands of *A. tridentata* for food and shelter (e.g., Green and Flinders, 1980; Katzner and Parker, 1997) and occur today in northern Great Basin sagebrush valleys and upland plains far removed from Camels Back Ridge.

Taphonomic analyses of the Camels Back Cave small mammals suggest that the majority of the specimens were accumulated by nonhuman predators and collectors. Regardless the presence of human occupation, many of the small mammal bones exhibit various types and degrees of nonhuman digestive attrition (e.g., Andrews, 1990; Schmitt and Juell, 1994; Hockett, 1995) and it appears that most specimens were deposited in carnivore scatological droppings and egested raptor pellets. While prehistoric human subsistence activities deposited some jackrabbit (*Lepus cf. californicus*) and bighorn sheep (*Ovis canadensis*) bones in the cave, human use of the cave was infrequent and characteristically brief (Schmitt and Madsen, 2002); in most instances these use-episodes represent overnight stays where little food refuse was deposited. This especially is the case for the rodent fauna; marked similarities in taxonomic presences and skeletal part representation and completeness across the cave's

Stratum	N of Taxa ^a	NISP ^a	Age (¹⁴ C yr B.P.)	Lab Nos. (Beta Analytic)
VIII	9	471	6110 ± 90	63481
VII	10	495	6430 ± 60	122775
VI	8	287 ^b	6390 ± 70, 6550 ± 130	122774, 122776
V	8	898	6650 ± 50, 7230 ± 160	122777, 122778
IV	10	443	7350 ± 220	64369
III	8	262	7530 ± 50	118937
IIb	18	278		
IIa	17	553	8810 ± 70	122767
I	14	198	9560 ± 40	144431
Lake Bonneville gravels				
Total NISP = 3885				

^aLagomorpha and Rodentia; see Table 2. NISP = number of identified specimens (e.g., Grayson 1984).

^b1/4" mesh collections only; no 1/8" mesh samples were collected.

FIG. 1. Numbers of small-mammal taxa, numbers of identified specimens, and radiocarbon ages by stratum from the terminal Pleistocene–early middle Holocene deposits in Camels Back Cave.

TABLE 1
Numbers of Identified Small Mammal Specimens by Taxon Recovered from Strata I–VIII (ca. 12,000–6000 ¹⁴C yr B.P.)
at Camels Back Cave

Species	Stratum									Total
	I	IIa	IIb	III	IV	V	VI ^a	VII	VIII	
<i>Brachylagus idahoensis</i>	4	4	—	—	—	—	—	—	—	8
<i>Sylvilagus</i> sp.	46	119	25	4	1	3	3	2	4	207
<i>Lepus</i> cf. <i>californicus</i>	15	67	72	177	274	714	212	352	247	2130
<i>Lepus townsendii</i>	5	19	1	—	—	—	—	—	—	25
<i>Marmota flaviventris</i>	—	2	—	—	—	—	—	—	—	2
<i>Ammospermophilus leucurus</i>	—	—	1	4	4	6	1	—	5	21
<i>Spermophilus</i> sp.	2	25	23	22	26	41	21	36	75	271
<i>Spermophilus mollis</i>	2	2	6	5	9	9	4	3	14	54
<i>Thomomys</i> sp.	3	75	24	7	31	17	15	23	29	224
<i>Thomomys bottae</i>	—	14	4	2	4	4	2	5	8	43
<i>Perognathus</i> sp.	1	1	—	—	—	—	—	—	—	2
<i>Perognathus longimembris</i>	—	2	2	—	3	—	—	1	2	10
<i>Perognathus parvus</i>	3	4	2	—	—	—	—	1	—	10
<i>Microdipodops megacephalus</i>	4	—	—	—	—	—	—	—	—	4
<i>Dipodomys</i> sp.	66	117	74	34	75	93	20	61	77	617
<i>Dipodomys ordii</i>	6	9	5	2	4	4	1	3	2	36
<i>Dipodomys microps</i>	—	5	7	3	3	3	2	1	1	25
<i>Peromyscus</i> sp.	2	3	1	—	—	—	—	—	—	6
<i>Peromyscus crinitus</i>	—	1	—	—	—	—	—	—	—	1
<i>Peromyscus maniculatus</i>	9	11	3	—	4	—	—	2	—	29
<i>Peromyscus truei</i>	—	—	1	—	—	—	—	—	—	1
<i>Neotoma</i> sp.	—	4	1	—	—	—	—	—	1	6
<i>Neotoma cinerea</i>	24	48	5	—	—	—	—	—	—	77
<i>Neotoma lepida</i>	—	16	17	2	5	4	6	5	6	61
<i>Microtus</i> sp.	3	—	1	—	—	—	—	—	—	4
<i>Lemmys curtatus</i>	1	1	1	—	—	—	—	—	—	3
<i>Reithrodontomys megalotis</i>	2	4	—	—	—	—	—	—	—	6
<i>Ondatra zibethicus</i>	—	—	1	—	—	—	—	—	—	1
<i>Erethizon dorsatum</i>	—	—	1	—	—	—	—	—	—	1

^a 1/4" mesh collections only; no 1/8" sample units were collected.

noncultural and cultural-bearing strata suggest that few, if any, specimens were introduced by human foragers (Schmitt and Lupo, 2002).

ASSEMBLAGE COMPOSITION AND COMPARISONS

As part of the Homestead Cave analyses, Grayson (2000a,b) examined the changing abundances of small mammal species adapted to upland and/or mesic habitats and discovered that “the early Holocene strata at Homestead Cave are marked by a wide variety of mammals whose modern habitat requirements and distributions strongly suggest that the Homestead Knoll area was relatively cool and moist at that time” (2000a, p. 84). Included are the remains of *Brachylagus idahoensis*, *Marmota flaviventris*, *Perognathus parvus* (Great Basin pocket mouse), *Lemmys curtatus*, and high relative proportions of *Neotoma cinerea*. The presence of these taxa suggest that the cave vicinity was dominated by grasslands with stands of *Artemisia*, and the ca. 8300 ¹⁴C yr B.P. extinction or near-extinction of these mammals provide testimony to the rapid onset and severity of middle

Holocene desertification (Grayson, 2000b; Madsen *et al.*, 2001; see also Hockett, 2000; Huckleberry *et al.*, 2001).

The Camels Back Cave small mammalian fauna are similar to those at Homestead Cave and strongly support some of Grayson’s previous (1993) and most recent (2000a,b) conclusions. Most notable are the types of small mammals in the cave’s terminal Pleistocene–early Holocene aggregates and their subsequent responses to increasingly arid middle Holocene climates. Table 2 presents seven small mammalian taxa that were identified in both Camels Back and Homestead caves. Three species (*Neotoma cinerea*, *Marmota flaviventris*, and *Lepus townsendii*) predominantly occupy cool and moist montane settings in the modern Great Basin (Brown, 1971; Grayson, 1993) and four (*Brachylagus idahoensis*, *Perognathus parvus*, *Lemmys curtatus*, and *Reithrodontomys megalotis*) largely occur in moist habitats containing a thick grass understory and/or dense stands of *Artemisia*. The relative abundance of these seven mammals recovered from early (>10, 000–6000 ¹⁴C yr B.P.) stratigraphic horizons in Homestead and Camels Back caves is presented in Figure 2. While Homestead Cave provided greater temporal

TABLE 2

Identified Taxa Adapted to Cool and Moist Contexts from Terminal Pleistocene–Early Middle Holocene Deposits in Homestead and Camels Back Caves

Species	Common name
<i>Brachylagus idahoensis</i>	Pygmy rabbit
<i>Lepus townsendii</i>	White-tailed jackrabbit
<i>Marmota flaviventris</i>	Yellow-bellied marmot
<i>Perognathus parvus</i>	Great Basin pocket mouse
<i>Neotoma cinerea</i>	Bushy-tailed woodrat
<i>Lemmys curtatus</i>	Sage vole
<i>Reithrodontomys megalotis</i>	Western harvest mouse

resolution and returned a larger sample of identified specimens, the late Pleistocene–early Holocene small faunas in these two caves are similar, including high relative proportions of *N. cinerea* (Grayson, 2000b, Figure 7; Schmitt and Lupo, 2002). Both sites show conspicuous declines or extinctions of all these taxa between ca. 8600 and 8100 ^{14}C yr B.P. and, at the same time, there were increases in the abundances of *N. lepida*, kangaroo rats (*Dipodomys* sp.), ground squirrels (*Spermophilus mollis* and *Ammospermophilus leucurus*), and other small mammals well-adapted to low-elevation xeric environments.

These changes in the Homestead and Camels Back cave faunas lend support regional paleovegetation and pollen records which demonstrate a decrease in moist grassland–sagebrush habitats at the expense of expanding xerophytic scrub communities about 8000 ^{14}C yr B.P. (e.g., Rhode, 2000; Madsen *et al.*, 2001). In addition, both cave assemblages show an overall decline in small mammal diversity that corresponds with the onset of increasingly arid middle Holocene environs. At Homestead Cave, Grayson (1998, 2000a) examined changes in small mammal taxonomic richness (the number of mammal species present) and found faunal assemblages that accumulated prior to 8300 ^{14}C yr B.P. to be more rich than those that accumulated after this time. A similar relationship between moisture and small mammal richness, or “positive richness-response” (e.g., Grayson, 1998, and references therein) is evident at Camels Back Cave and, once again, the data mirror the early mammalian sequence at Homestead Cave. With or without taking changing sample sizes into account, small mammal richness at Camels Back Cave is greatest in late Pleistocene–early Holocene strata I and II (Fig. 1), and these layers contain larger numbers of species than those that accumulated throughout the remainder of the cave’s depositional history.

Changes in the composition of the Camels Back leporid fauna also correspond with the ca. 8300 ^{14}C yr B.P. shift in regional vegetation and further suggest that there was a rather prominent decrease in perennial shrub cover along Camels Back Ridge. A comparison of the ratio of *Sylvilagus* sp. to both *Sylvilagus* sp. and *Lepus* sp. (Fig. 3) clearly demonstrates that *Sylvilagus* were most abundant during the late Pleistocene and early Holocene and that populations declined considerably just prior to 8000 ^{14}C yr B.P. Although cottontails (*S. nuttallii* and *S. audubonii*) inhabit low-elevation settings in the region, they commonly are associated with dense shrub cover which is used to hide from predators (e.g., Trent and Rangstad, 1974; Chapman, 1975). *Sylvilagus* abundances in the cave’s early strata suggest the area supported a substantial vegetative cover at this time, and the co-occurrence of *Brachylagus idahoensis* suggests that this cover included stands of *Artemisia tridentata*. Conversely, *L. californicus* rely on their ability to run (rather than hide from) predators and are particularly well adapted and common to open xeric habitats (e.g., Dunn *et al.*, 1982; Best, 1996). *Lepus californicus* “replace” *Sylvilagus* and dominate the Camels Back Cave small mammal fauna after ca. 8300 ^{14}C yr B.P. (Table 1; Fig. 3), and it is likely that this increase in *Lepus* was, at least in part, a response to deteriorating sagebrush communities and the

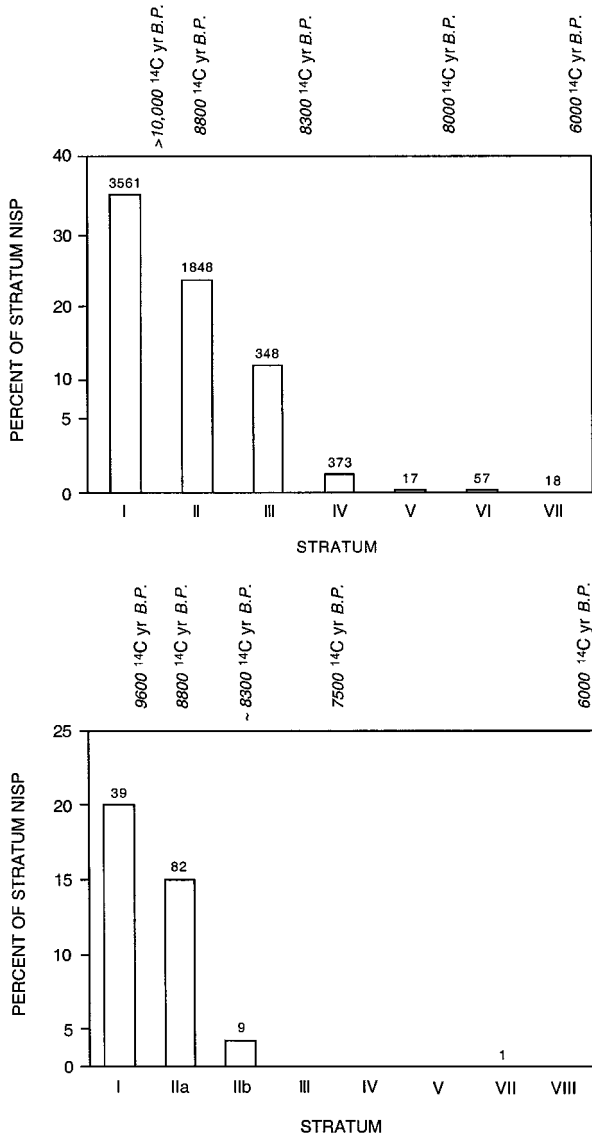


FIG. 2. The relative abundance of seven small mammals well-adapted to cool and moist environs (see Table 2) compared with all identified lagomorphs and rodents in the early deposits at Homestead (top) and Camels Back (bottom) caves. The numbers above the bars provide the total number of these mammal specimens identified in each stratigraphic aggregate.

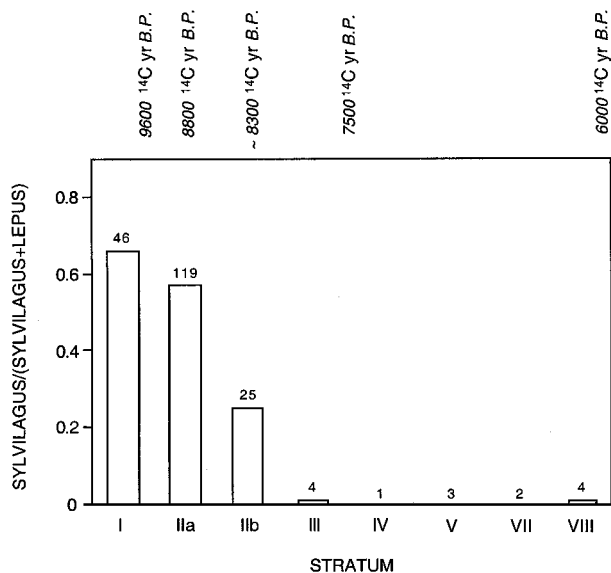


FIG. 3. The ratio of *Sylvilagus* sp. to *Sylvilagus* sp. and *Lepus* sp. in the early deposits at Camels Back Cave. Numbers above the bars provide the number of specimens identified as *Sylvilagus* sp.

expansion of more propitious open desert habitats (see also Grayson, 1988, p. 33).

SUMMARY AND CONCLUSIONS

The early faunal record at Camels Back Cave provides data on early Holocene environments and mammalian responses to middle Holocene desertification in the Bonneville Basin. This record adds to the growing body of data on small mammal histories in the Great Basin and may prove useful in modern wildlife management issues (e.g., Lyman, 1996), especially those concerning the potential impacts of future climatic change on mammal populations in the arid west. The types and variety of early Holocene mammals suggest that the Camels Back Ridge vicinity was cool and moist and supported grasses and stands of *Artemisia* (likely *A. tridentata*), and the extinction of small mammals adapted to mesic contexts just prior to 8000 ¹⁴C yr B.P. attests to the extreme aridity of the middle Holocene. The relative abundances of these early Holocene mammals are less than those at Homestead Cave and it appears that areas surrounding Camels Back Cave were not quite as cool. This is not surprising however, since Homestead Knoll is 120 km to the north and areas immediately south of the cave encompass a more upland setting than southern Camels Back Ridge. Moreover, Homestead Cave is adjacent the Great Salt Lake (e.g., Madsen *et al.*, 2001, Figure 3) and as Pacific storm systems make their way across the area, the "lake-effect" enhancement of these storms has probably always come into play, and it is likely that this lake-edge context has always been wetter and slightly cooler than the southern Great Salt Lake Desert. Regardless of these subtle differences, faunas from both caves strongly suggest that middle Holocene desertification brought forth significant changes in regional plants

and animals, including a rather rapid transition to xerophytic shrub communities dominated by *Sarcobatus vermiculatus* and *Atriplex* sp. and an overall decline in mammalian taxonomic richness. These biotic communities have dominated the Camels Back Cave vicinity for the last ca. 8000 ¹⁴C years and probably were similar to the native desert habitats surrounding Camels Back Ridge today.

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