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FOSSIL SHREWS (INSECTIVORA: SORICIDAE) FROM THE LATE PLEISTOCENE OF COLORADO

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ABSTRACT—Five species of shrews (Insectivora: Soricidae), *Sorex* cf. *S. cinereus, Sorex* cf. *S. preblei, S. nanus, S. monticolus,* and *S. palustris* are reported from Cement Creek and Haystack caves, Gunnison Co., Colorado. Deposits in Cement Creek Cave date from 43,330 B.P., prior to the peak Wisconsin glaciation (20,000 to 18,000 B.P.), to the late Holocene. This cave contains a higher diversity of shrews with all 5 species represented, especially *S. monticolus* which is most abundant. Haystack Cave has deposits that date primarily from 19,990 to 12,910 B.P. Two taxa of shrews were recovered from this site, including 1 that might represent an undescribed extinct species of *Sorex.* All other species identified from these caves, except *Sorex* cf. *S. preblei,* currently occur in the Upper Gunnison Basin and indicate that primarily a mixed sagebrush steppe and subalpine forest environment existed near these caves during the late Pleistocene.

RESUMEN—Se registran cinco especies de musgaños (Insectívora: Soricidae), *Sorex* cf. *S. cinereus, Sorex* cf. *S. preblei, S. nanus, S. monticolus,* y *S. palustris* en cuevas de Cement Creek y Haystack, condado de Gunnison, Colorado. Depósitos en la cueva de Cement Creek fechan desde 43,330 B. P., antes del pico de la glaciación Wisconsin (20,000 a 18,000 B.P.), hasta el fin del Holoceno. Esta cueva contiene las 5 especies de musgaños, especialmente *S. monticolus,* que es más abundante. La cueva de Haystack tiene depósitos que fechan principalmente desde 19,990 a 12,910 B.P. Se encontraron 2 taxa de musgaños en este sitio, incluso uno que quizás representa 1 especie extinta de *Sorex* no descrita. Todas las otras especies identificadas en estas cuevas, excepto *Sorex* cf. *S. preblei,* actualmente ocurren en la cuenca superior de Gunnison e indican que existía principalmente un ambiente de estepa artemisa mixta y bosque subalpino cerca de estas cuevas durante el Pleistoceno tardío.

Fossiliferous cave deposits are relatively rare in the southern Rocky Mountains of Colorado, primarily due to the lack of deep caves with dry deposits conducive to the preservation of vertebrate remains. Excavations at 2 caves in the Upper Gunnison Basin, Gunnison Co., Colorado in 1998 provided rich collections of fossil vertebrates dating to the late Pleistocene and Holocene. Included in these collections are numerous partial and complete mandibles of shrews (Insectivora: Soricidae). These specimens are identified and described herein with a discussion on their paleoecological and biogeographical significance. Descriptions of the 2 caves and the stratigraphic context of the fossils are provided.

MATERIALS AND METHODS—All specimens were identified by use of the collections at the National Museum of Natural History (USNM), Smithsonian Institution, Washington, D.C. Measurements follow those described and illustrated by Carraway (1995) and were completed with a low-power stereomicroscope and eyepiece scale to the nearest 0.1 mm. Accelerator mass sprectrometry (AMS) radiocarbon analyses were completed at Beta Analytic Inc., Miami, Florida and are reported in conventional dates in years before present (B.P.). All fossil specimens from Cement Creek Cave are housed at the Denver Museum of Nature and Science (DMNH), Colorado and are catalogued with DMNH numbers. Specimens from Haystack Cave (Site No. 5GN189) are housed at the BLM Anasazi Heritage Center, Dolores, Colorado and are catalogued by site, level, and specimen number.

Haystack Cave—This cave is located on the west-facing rim rock of Sapinero Mesa Tuff on the east side of Blue Mesa Reservoir, Gunnison Co., at an elevation of 2,438 m. The cave is tube-shaped, approximately 2.3 m in diameter and 12 m long, and probably formed as a lava bubble (Emslie, 1986; Medville, 1998). Because the cave is within the impermeable Sapinero Mesa Tuff, the interior of the cave has remained dry for thousands of years. It is

this geological setting that has allowed for the excellent preservation of vertebrate fossils and plant remains that have been deposited in the cave over the past 20,000 years. The cave is protected with a gate, installed by the Bureau of Land Management (BLM), to prevent vandals from disturbing the fragile deposits.

The environment surrounding Haystack Cave currently consists of dry, interior basin habitat dominated by sagebrush (*Artemisia tridentata*) with sparse stands of Gambel's oak (*Quercus gambellii*) and Rocky Mountain juniper (*Juniperus scopulorum*). Other common plants in the area include skunkbush (*Rhus trilobata*), chokecherry (*Padus virginiana*), wax current (*Ribes cereum*), mountain spray (*Holodiscus dumosus*), ricegrass (*Oryzopsis hymenoides*), rabbitbrush (*Chrysothamnus nauseosus*), and cactus (*Opuntia* sp.). This community typifies the entire lower portion of the Upper Gunnison Basin at elevations between 2,200 and 2,600 m.

Haystack Cave was first excavated in 1978 by personnel at the National Park Service and again in 1986 and 1987 by D. Nash at the University of New Mexico. The large assemblage of fossil vertebrates that were recovered includes 2 extinct taxa (cheetah, cf. *Acinonyx trumani,* and horse, *Equus* sp.) and is 1 of the richest late Pleistocene collections now known from Colorado (Emslie, 1986). The vertebrate taxa identified from the cave deposits also represent a mixture of species that currently occur in high and low-elevations, including American pika (*Ochotona princeps*), Wyoming ground squirrel (*Spermophilus elegans*), northern pocket gopher (*Thomomys talpoides*), sagebrush vole (*Lemmiscus curtatus*), long-tailed vole (*Microtus longicaudus*), and heather vole (*Phenacomys intermedius*). These taxa, with pollen evidence, indicate a paleoenvironment of primarily sagebrush grassland (Emslie, 1986). In 1998, collapsing sediments in the cave were stabilized and a new stratigraphic sample was collected so that paleoecological data spanning the late Pleistocene and Holocene could be obtained.

Excavations were completed in a 0.5 × 1.40 m grid, in 5-cm arbitrary levels, near the center of the cave. For each level, all sediments were screened through 3 screens with mesh sizes of 0.64, 0.32, and 0.025 cm^2. Twenty-seven levels (numbered 1 through 27 from surface to bottom) were excavated to a depth of 1.35 m, where the bedrock floor of the cave was encountered. Nearly all organic remains (plant parts, seeds, bones, and teeth) preserved in the sediments were recovered for identification and analysis. Most deposits in Haystack Cave have been dated to the late Pleistocene, between 19,990 to 12,910 B.P., based on 10 radiocarbon dates on vertebrate fossils (bone collagen) collected during the 1998 excavations.

Cement Creek Cave—Cement Creek Cave is located in a limestone outcrop on a south-facing slope at the head of Cement Creek near Crested Butte, Gunnison Co., at an elevation of 2,950 m. The cave has multiple entrances. One, on the west side of the outcrop, opens into several chambers; the easternmost chamber has over 30 m of passages that extend into the limestone formation (Medville, 1994). Excavations were completed in a small room of the east chamber at the bottom of a sloping passage where sediments accumulate.

The environment surrounding Cement Creek Cave consists of pine forest with Englemann and blue spruce (*Picea engelmannii* and *P. pungens*), Douglas fir (*Pseudotsuga menziesii*), Rocky Mountain juniper (*Juniperus scopulorum*), and quaking aspen (*Populus tremuloides*). Ground cover on the slopes and near the cave entrance include big and pasture sagebrush (*Artemisia tridentata* and *A. frigida*), lupin (*Lupinus* sp.), kinnikinnick (*Arctostaphylos uva-ursi*), mountain maple (*Acer glabrum*), Indian paintbrush (*Castilleja chromosa*), vetch (*Vicia americana*), sweet pea (*Lathyrus* sp.), wallflower (*Erysimum* sp.), wax currant (*Ribes cereum*), snowberry (*Symphoricarpos* sp.), mountain spray (*Holodiscus dumosus*), tansy mustard (*Descurainia richardsonii*), and penstemon (*Penstemon* sp.).

Test excavations were completed in the cave in June 1998. A 50 × 50 cm test pit was excavated in 10-cm arbitrary levels (levels 1 through 13, surface to bottom) and exposed a 1.30 m deep stratigraphic profile consisting of dry to moist and degraded packrat midden in the top 60 cm (levels 1 through 6), cave sediments and rock spalls characterize the lower 70 cm (levels 7 through 13). The upper midden deposits were sampled by removing a 1-liter unscreened sample from each level. These samples are rich in macroplant remains (sticks, leaves, needles, and cones) and date to the early to late Holocene (Table 1). The lower sediments are rich in vertebrate fossils, especially rodents. Bones of larger mammals (*Bison* sp. and other artiodactyls), birds, amphibians, and reptiles also were recovered. All matrix from these lower levels was washed through 0.64, 0.32, and 0.025 cm^2 mesh screens. Thousands of bones were recovered from the 0.64 and 0.32 cm^2 screens after the washed matrix was dried and sorted for all organic remains using magnifying lamps and a low-power binocular scope. Radiocarbon analyses on bone from the lower levels of the cave indicate that these deposits date to the late Pleistocene from 43,330 to 11,870 B.P. (Table 1).

SYSTEMATIC PALEONTOLOGY

Sorex nanus (Merriam, 1895)

Referred material—Cement Creek Cave, level 7: distal left mandible with i1, m1–2, DMNH 42800; left mandible with i1, p4, and m1–3,

TABLE 1—Accelerator mass spectrometry (AMS) radiocarbon dates, given in years before present (B.P. ± *SD*), on bone collected from a test pit in Cement Creek Cave, Upper Gunnison Basin, Colorado. For each date, the stratigraphic level, species, laboratory number, and material analyzed are provided.

Level	Species	Age (years B.P.)	Lab no.	Material
4	*Marmota flaviventris*	1,120 ± 40	Beta-128214	left i1
5	*Marmota flaviventris*	8,070 ± 50	Beta-125777	left I1
6	*Odocoileus hemionus*	4,520 ± 50	Beta-135139	right femur shaft fragment
7	*Thomomys talpoides*	11,870 ± 110	Beta-128215	partial cranium
8	*Phenacomys intermedius*	11,970 ± 50	Beta-125780	left mandible with m1-m2
9	*Spermophilus elegans*	12,480 ± 50	Beta-125781	right maxilla with P4 and M2
10	*Marmota flaviventris*	28,820 ± 180	Beta-129369	left tibia missing proximal end
11	*Lepus americanus*	28,330 ± 170	Beta-125783	distal left tibia
12	*Lepus townsendii*	39,690 ± 620	Beta-125784	right ilium
13	*Marmota flaviventris*	34,980 ± 600	Beta-120098	left innominate
13	*Marmota flaviventris*	43,330 ± 760	Beta-135140	left I1

DMNH 42801; level 10: right mandible with i1 and m1, DMNH 42802; right mandible with m2–3, DMNH 42803. Haystack Cave, slump: left mandible with p4 and m1–3, 5GN189-S1; left mandible with m1–2, 5GN189-S2.

Description—These specimens are distinctly smaller than *Sorex palustris, S. monticolus,* and *S. merriami* (Table 2; Carraway, 1995—Table 2). *Sorex cinereus* has a relatively larger i1 and narrower teeth, *S. vagrans* is larger and slightly more robust. *Sorex hoyi* and *S. preblei* are similar in size to the fossil specimens, but the ascending ramus is relatively more robust in *S. hoyi* and i1 is shorter in both species compared with the fossil material. In addition, the depth of the dentary below m1 is not greater than the height of m1 (m1 height higher than dentary depth in *S. preblei*; Carraway, 1995).

Discussion—The dwarf shrew occurs at elevations >1,600 m in Colorado in habitats ranging from coniferous forest, bogs, open woodlands, to alpine meadows (Fitzgerald et al., 1994). In Arizona, the species has been found in forested habitats dominated by ponderosa pine (*Pinus ponderosa*; Berna, 1990).

Sorex palustris Richardson, 1828

Referred Material—Cement Creek Cave, level 7: left mandible with m1–3, DMNH 42813.

Description—This species is distinguishable from *Sorex monticolus, S. nanus, S. hoyi, S. preblei, S. cinereus,* and *S. vagrans* by its relatively larger size, more robust mandibular condyle, height of coronoid process >4.0 mm (Table 2; Carraway, 1995—Table 2), and long and narrow ascending ramus (ramus smaller in *S. monticolus* and *S. cinereus*; shorter in *S. vagrans*). *Sorex arcticus* is slightly larger than *S. palustris* and has a more robust ascending ramus.

Discussion—This species is found primarily near rivers and streams in Colorado, especially in riparian vegetation, and is semiaquatic in habits (Beneski and Stinson, 1987; Fitzgerald et al., 1994).

Sorex cf. *S. preblei* Jackson, 1922

Referred Material—Cement Creek Cave, level 8: left mandible with i1, p4, m1–3, DMNH 42804 (Fig. 1A).

Description—This specimen is very similar to modern specimens of *Sorex preblei,* especially in having the depth of the dentary below m1 equal to or greater than the height of m1, length of c1-m3 ≤4.2 mm, and coronoid height ≤3.3 mm (Fig. 1A; Carraway, 1995). It is easily recognized by its relatively small size except that the dentary length is slightly longer, and the coronoid height slightly smaller, than that found in modern specimens (Table 2; Carraway, 1995—Table 1).

Discussion—Preble's shrew is found throughout the southern Rocky Mountains, from Canada to New Mexico, and in eastern Washington and Oregon (Cornely et al., 1992; Kirkland and Findley, 1996). It most frequently occurs in arid sagebrush (*Artemisia* sp.) and grassland communities, but it also has been found in forested habitats in Washington. One record of

TABLE 2—Measurements (mm) of fossil mandibles of *Sorex* from Cement Creek and Haystack caves, Gunnison Co., Colorado. Each specimen listed by catalogue number. Measurement are: DL, dentary length; COR, coronoid height; COR-CON, coronoid-condylar height; c1-m3 length, and m1 through m3, length/breadth. See Carraway (1995) for illustration of measurements.

Species	DL	COR	COR-CON	c1-m3	m1	m2	m3
Sorex nanus							
DMNH 42800	6.3	3.0	2.6	4.1	1.3/0.6	1.1/0.6	0.9/0.5
DMNH 42801					1.2/0.7	1.1/0.6	
DMNH 42802	6.3	2.6	2.1		1.1/0.7		
DMNH 42803						1.0/0.6	0.8/0.4
5GN189-S1	5.9	2.8	2.6	3.8	1.1/0.8	1.0/0.7	0.9/0.5
5GN189-S2		3.5	2.8		1.3/0.7	1.0/0.6	
Sorex cf. *S. preblei*							
DMNH 42804	6.8	3.2	2.7	4.2	1.4/0.7	1.2/0.6	0.9/0.5
Sorex cf. *S. cinereus*							
DMNH 42812					1.4/0.6		
5GN189-16-1		3.4	3.1		1.4/—	1.1/—	
USNM 574262	6.5	3.1		4.0	1.4/0.6	1.1/0.5	0.8/0.4
Sorex monticolus							
DMNH 42805	7.5	4.3	3.9	4.5	1.6/1.0	1.5/0.9	1.0/0.7
DMNH 42806	7.0	4.0	3.5		1.5/0.9	1.4/0.8	1.0/0.6
DMNH 42807	6.7	3.8	3.4	4.8	1.5/0.8	1.2/0.8	0.9/0.6
DMNH 42808					1.6/1.0	1.2/0.8	1.0/0.6
DMNH 42809					1.5/0.8	1.3/0.8	0.9/0.6
DMNH 42810					1.5/0.9	1.2/0.9	
DMNH 42811					1.6/1.1		
Sorex palustris							
DMNH 42813	—	4.4	3.8	—	—	1.3/0.8	1.1/0.5
Sorex sp.							
5GN189-S3	6.9	4.0	3.4	4.4	1.7/1.0	1.2/0.9	0.9/0.8

Sorex preblei (USNM 574262; female) has been reported from the Black Canyon, Montrose Co., Colorado (Long and Hoffmann, 1992). However, that specimen strongly resembles *S. cinereus* based on its slightly longer rostrum and mandible, plus the height of dentary below m1 is not equal to or greater than the height of m1 (Table 2; Carraway 1995—Table 2). Given the questionable identification of this specimen from Colorado, the nearest reliable records of *S. preblei* to Cement Creek Cave today are in salt grass habitats in northern Utah (Tomasi and Hoffmann, 1984) or in ponderosa pine forest in the Jemez Mountains, northern New Mexico (Kirkland and Findley, 1996).

Sorex monticolus Merriam, 1890

Referred Material—(*Sorex monticolus*)—Cement Creek Cave, level 7: 2 left mandibles with i1, p4, and m1–3, DMNH 42805–42806; level 9: right mandible with p4 and m1–3, DMNH 42807; level 10: proximal half of right mandible with m1–3, DMNH 42808; level 12: medial right mandible with m1–3, DMNH 42809—(*Sorex* cf. *S. monticolus*)—Cement Creek Cave, level 11: left mandible with i1, p4, and m1–2, DMNH 42810; fragment of left mandible with m1, DMNH 42811.

Description—These fossils are very similar in size and characters to modern *Sorex monticolus* (Table 2). *Sorex nanus, S. hoyi,* and *S. preblei* are distinctly smaller, and *S. palustris* larger, than the fossil material. *Sorex merriami* is similar in size to the fossils, but has a well-developed post-mandibular canal (Junge and Hoffmann, 1981) not present in the fossils, and the teeth are narrower and less robust. The fossils are distinguished from *S. cinereus* by relatively

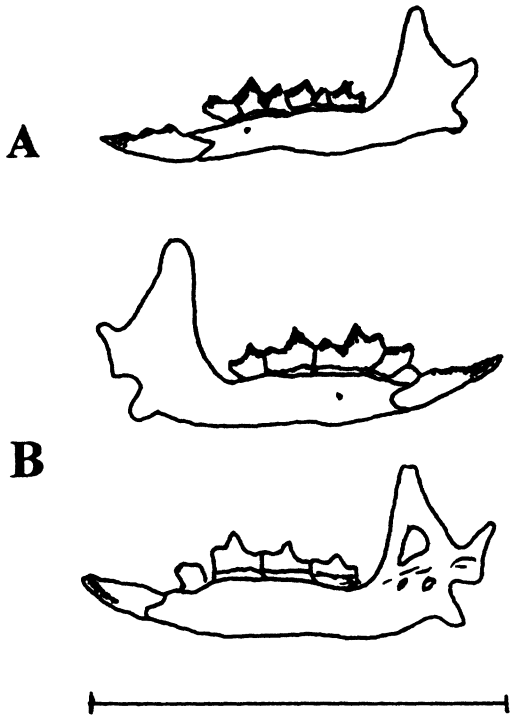

FIG. 1—Camera-lucida drawings of shrew mandibles from Gunnison Co., Colorado: A) left mandible (DMNH 42804; lateral view) of *Sorex* cf. *S. preblei* from level 8, Cement Creek Cave; B) right mandible (5GN189-S3), lateral (top) and labial (bottom) views, of *Sorex* sp. from slump in Haystack Cave. Scale bar = 1 cm.

greater depth of dentary below m1, greater length of the coronoid-condyloid process (Table 2; *S. cinereus* has length <3.2 mm), and by a greater length of m1 (Table 2; Carraway, 1995—Table 2).

Discussion—This species commonly occurs in high-elevation coniferous forests and alpine tundra, but also is reported from pinyon-juniper woodlands and shrub-steppe habitat dominated by sagebrush (*Artemisia* sp.) in the Great Basin (Sutter et al., 1999). It prefers areas with dense understory and ground cover (Smith and Belk, 1996). In Colorado, the montane shrew occurs in coniferous forests, aspen stands, and wet meadows, bogs, or thickets near beaver ponds, frequently in association with *Sorex cinereus* (Fitzgerald et al., 1994).

Sorex cf. *S. cinereus* (Kerr, 1792)

Referred Material—Cement Creek Cave, level 7: left mandible with i1, c1, and m1, DMNH 42812. Haystack Cave, level 16: left mandible missing distal end with m1–2, 5GN189-16-1.

Description—This specimen is distinguished as *Sorex cinereus* by its relative size (Table 2; larger than *S. nanus, S. preblei,* and *S. hoyi*; smaller than *S. monticolus* and *S. palustris*) and depth of dentary below m1 less than height of m1.

Discussion—This species occurs in high-elevation forests and meadows, especially moist areas near streams or wetlands in Colorado (Fitzgerald et al., 1994). It frequently occurs in association with *Sorex monticolus* (see previous section).

Sorex sp.

Referred Material—Cement Creek Cave, level 7: 7 mandibular fragments, DMNH 42814–42820, 1 upper U, DMNH 42821; level 8: left mandible with m2–3, DMNH 42822; m1 or m2, DMNH 42823; level 10: medial left mandible with m1–3, DMNH 42824; 3 mandibular and 2 maxillary fragments, DMNH 42825–42829; level 11: 4 mandibular and 2 cranial fragments, DMNH 42830–42835; level 12: 2 medial mandibular fragments, DMNH 42836–42837; level 13: 2 medial mandibular fragments, DMNH 42838–42839. Haystack Cave, slump: right mandible with p4 and m1–3 (5GN189-S3; Fig. 1B); level 9: partial cranium with U4, M1–3, 5GN189-9-1; level 21: medial right mandible with m1-m3, 5GN189-21-1; level 23: medial left mandible with m2–m3 (5GN189-23-1) and medial right mandible with m1–m2, 5GN189-23-2.

Description—The specimens from Cement Creek Cave are too fragmentary for positive identification, but probably represent *Sorex monticolus, S. cinereus,* or *S. nanus.* The 2 specimens from slump at Haystack Cave are distinctly larger and more robust than *S. nanus, S. hoyi,* and *S. preblei,* and smaller than *S. palustris* and *S. monticolus* (Table 2). The mandible is similar to *S. merriami* in having a well-developed post-mandibular canal (Junge and Hoffmann, 1981), but differs in having a relatively more robust dentary and low-crowned molars. In addition, both the mandible and the rostrum are relatively short compared to *S. merriami, S. monticolus, S. palustris,* and *S. cinereus.* In present day *S. cinereus,* the dentary is longer and less deep than in the fossil specimen. Other specimens from Haystack Cave listed previously are too fragmentary for comparison.

Discussion—The specimens from the slump at Haystack Cave may represent an undescribed species of *Sorex* from the late Pleistocene of Colorado or a temporal variant of *S. merriami*. Additional specimens are needed before this can be resolved.

DISCUSSION—All 5 species of shrews identified here previously have been reported in the fossil record of North America. The fossil records for *Sorex nanus, S. monticolus, S. palustris,* and *S. preblei* (Hoffmann and Owen, 1980; Beneski and Stinson, 1987; Cornely et al., 1992; Smith and Belk, 1996) are herein updated for the western United States (see also Harris, 1985 for a summary of fossil localities in the western United States). The dwarf shrew (*S. nanus*) has been reported from late Pleistocene deposits in Hermit's Cave, New Mexico (Findley, 1965) and Moonshiner and Middle Butte caves, Idaho (Mullican and Carraway, 1990). *Sorex monticolus* also has been identified from these last 2 caves (Mullican and Carraway, 1990) as well as from Dry Cave, New Mexico (Harris, 1985; Harris and Carraway, 1993).

The 4 taxa (*Sorex monticolus, S. palustris, S. nanus,* and *Sorex* cf. *S. cinereus*) identified from level 7 at Cement Creek Cave probably had a sympatric distribution in Colorado during the late Wisconsin. All but *S. palustris* have been captured in the same pitfall traps in the Arkansas River watershed of Colorado (Armstrong et al., 1973), though *S. nanus* appears to be more tolerant of drier conditions than the other species (Hoffmann and Owen, 1980). The water shrew (*S. palustris*) is restricted to streams and riparian habitat (Beneski and Stinson, 1987), an environment that currently exists along Cement Creek within 1 km below the cave. *Sorex monticolus* was identified from levels 7, 9, 10, 11, and 12 and is the most common species in the deposits. It, along with *S. nanus* and *S. cinereus,* occurs in alpine and subalpine environments, especially moist meadows and bogs, but also sagebrush steppe (Sutter et al., 1999). These habitats probably were present near the cave during deposition of levels 7 through 13 in the late Pleistocene.

Preble's shrew (*Sorex preblei*) is known from late Pleistocene (mid to late Wisconsin) deposits in U-bar Cave, Hidalgo Co., and Dry Cave, Eddy Co., New Mexico (Harris and Carraway, 1993). These are the most southern records known for this species and indicate that it had a far more extensive range in the Pleistocene than at present. However, 2 modern specimens were reported from the Jemez Mountains, northern New Mexico (Kirkland and Findley, 1996), indicating that at least relict populations still remain in isolated mountain ranges in the southern Rocky Mountains. Although the species has been collected in a variety of habitats, including marsh, coniferous forest, and areas dominated by dry bunchgrass, it most commonly occurs in association with sagebrush (Cornely et al., 1992). In addition, it is known to occur with other *Sorex* species including *S. merriami, S. monitcolus,* and *S. cinereus* (Cornely et al., 1992). Referring to *S. preblei* and other taxa, Harris and Carraway (1993) hypothesized that a sagebrush and grassland habitat existed near U-bar Cave (elevation 1,570 m) during the mid-Wisconsin at about 35,890 B.P.

Given the extensive range of *Sorex preblei* in the Pleistocene and Holocene, the record at Cement Creek Cave is not unusual. This species appears in only 1 stratigraphic level in the lower deposits (level 8) that date to the late Wisconsin (Table 1), or slightly younger than the deposits at U-bar and Dry Caves (Harris and Carraway, 1993). Other taxa found in this level lend support to a paleoenvironment of sagebrush steppe and alpine tundra, (e.g., snowshoe hare–*Lepus americanus*, American pika, yellow-bellied marmot–*Marmota flaviventris*, northern pocket gopher, sagebrush vole, and montane vole–*Microtus montanus*). The last 3 taxa also are known associates of Preble's shrew within its current range (Cornely et al., 1992). However, 4 mandibles of *Phenacomys* also were identified in this level evincing that subalpine forest was near the cave as well. These data suggest that a mixed periglacial community, comprised of both steppe and subalpine plants, occurred at a 3,000-m elevation in Colorado during the late Wisconsin. Based on previous fossil evidence (Emslie, 1986), data from Haystack Cave suggest that this environment extended as low as 2,400 m in the Upper Gunnison Basin.

Radiocarbon dates from Cement Creek Cave (Table 1) indicate large gaps in the depositional sequence at levels 9 and 10 and levels 11 and 12. These gaps may have been caused by the Wisconsin glaciation that peaked at 20,000–

18,000 B.P. (Mickelson et al., 1983; Dawson, 1992), which may have caused snow, ice, or debris to block the cave entrance. However, shrews and other vertebrates identified from the deposits do not indicate major paleoenvironmental differences before or after these gaps; species identified from level 8 listed previously also occur throughout levels 7 through 13. Thus, the paleoenvironment surrounding the cave appears to have remained relatively consistent with mixed steppe and subalpine habitats dominated by sagebrush.

These results agree with vertebrate fossil, packrat midden, and pollen evidence from late Pleistocene sites throughout the Southwest, Great Basin, and southern Rocky Mountains. This period was marked by a downward shift and intermixing of subalpine forest and steppe plants and faunal assemblages (Van Devender and Spaulding, 1979; Spaulding et al., 1983; Betancourt, 1990; Nowak et al., 1994). Markgraf and Scott (1981) and Fall (1997*a*, 1997*b*) used pollen and macroplant evidence to show that timberline lowered by as much as 300 to 700 m between 15,000 to 10,000 B.P. in the Upper Gunnison Basin. These vegetational shifts at higher elevations probably facilitated the southward expansion of *Sorex preblei*, among other species, in the southern Rocky Mountains.

All *Sorex* identified here represent the first fossil records for these taxa in Colorado. The paucity of rich, late Pleistocene localities in the state, especially in montane environments, in part explains this poor record. The vertebrate assemblages at Haystack and Cement Creek caves are helping to fill this gap and are adding new information to the biogeography of extinct and extant vertebrates in the southern Rocky Mountains during the late Pleistocene and Holocene. Additional excavations at these and other sites should provide more information on intermontane vertebrate communities in the western United States.

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