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Comments on Late Quaternary Ursids from the Texas/Oklahoma Southern Plains, with Documentation of the Last Known Native Black Bear (*Ursus americanus*) from the Texas Hill Country

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Abstract

The black bear (*Ursus americanus*) is one of many species that has been considered as experiencing a decline in size since the Pleistocene. Age has perhaps not been fully appreciated as a factor accounting for at least some large black bear skulls, but acquisition of the remains of a large and aged black bear from a cave in Kimble County, Texas, carbon-dated at 120 ± 30 YBP, permits a meaningful comparison of one of the last native members of its species in central Texas with measurements of comparable-aged late Quaternary examples from other Texas cave sites. Together with reexamined bear material from nearby Schulze Cave of Kimble County and an isolated mandible from Montague County of northern Texas, we infer that no such diminution occurred for the species in Texas and Oklahoma. The sole remaining fossil record for *U. arctos* from the two-state area, the partial cranium and associated limb bones from Schulze Cave of central Texas, are herein reassigned to *U. americanus*.

Key words: black bear, grizzly bear, late Quaternary, Oklahoma, Texas, ursids, *Ursus americanus, Ursus arctos*

Introduction

Excepting polar regions and some of the more arid parts of the desert Southwest, the historic range of the black bear (*Ursus americanus*) once spanned nearly the entire Nearctic zoogeographic region (Pelton 2003), encompassing the entirety of Texas (Schmidly 2002, 2004) and Oklahoma (Caire et al. 1989). Even to this day, the flat and featureless expanses of the panhandle regions host the occasional vagrant bear, where the few traversing rivers and tributaries offered suitable dispersal avenues (Schmidly 2004). In contrast, the only documented, contemporary record of the grizzly or brown bear (*U. arctos*) for either state was of a "large and very old male," estimated weight of about 500 kg, taken by hunters in the Davis Mountains of Trans-Pecos Texas in 1890 (Bailey 1905). The partial skull of a bear retrieved from a cutbank in Montague County of north Texas was tentatively identified as a grizzly bear (Dalquest and Horner 1984). The specimen apparently no longer exists, and the identification must be queried.

The distributional status of *U. americanus* deteriorated rapidly following European settlement, and by the early to mid-1900s, the species persisted only in a few of the more remote or heavily forested regions. Bailey (1905) reported specimens from the granite terrain of the Wichita Mountains in southern Oklahoma, where the last four animals were killed in 1934 (Halloran and Glass 1959). Marcy (1856) remarked on the species' abundance in north-central Texas, and Bailey's (1905) detailed account for Texas suggests that the species was still widely distributed in Texas, but that viable populations of the black bear during the earliest twentieth century were restricted to pockets in the swampy woodlands of East Texas and the rugged highlands of the Chisos and Davis ranges of the Trans-Pecos. Black bears inhabiting the Davis Mountains (400-500 animals in 1941; Taylor and Davis 1947) may well have represented the last viable native population in the state. This population sustained annual bear hunts, as described by Bailey (1905), that continued through the 1940s (Stangl et al. 1994).

The status of *U. americanus* is rapidly evolving since extirpation of the species in Texas and Oklahoma, and isolated accounts of vagrant animals from contiguous states have become increasingly common. Sightings along the eastern parts of the two states can likely be traced to the 1964-1967 Louisiana introductions of 161 animals from Minnesota (Lowery 1974), and populations from the rugged Mexican mountains of Coahuila, Chihuahua, and Nuevo Leon have expanded naturally into adjoining Big Bend and Edwards Plateau regions of Texas (Onorato et al. 2004), with an established breeding population in the Chisos Mountains of Big Bend National Park (Onorato et al. 2003). Recent western incursions of individual black bears into the Edwards Plateau of central Texas (Onorato et al. 2004: Fig. 1) represent the occurrence of an animal not known from the region since 1902, when Bailey (1905) reported that the species was already scarce in the more rugged Hill Country west of Austin.

In the summer of 2010, Darcy Fricks presented us with the fragmented skull and humerus of an aged adult bear retrieved from a shallow cave on her family ranch near Junction, Kimble County, Texas. We could not visit the cave, but the material was described as partially buried by cave silts. The floor was littered with the skeletal remains of goats and sheep, some material quite recent (skin and hair attached) and some more aged. The locality is herein referred to as Boy's Cave at her request, named for the youngsters who provided her with the bones. From our initial inspection, the Boy's Cave animal appeared to be an impressive specimen of its kind, although relative size determination of a bear is not a simple task. The black bear is a species that exhibits considerable geographic variation. Overall body size and mass involves measurements not often obtained for specimens, and postcranial skeletal materials are not often retained in systematic collections. The skull most commonly represents bears in systematic collections, but other workers have noted that body proportions also vary geographically; some populations are large-bodied animals with proportionally small heads, and other populations possess large heads on small bodies (Harlow 1962; Wolverton and Lyman 1998).

Large size in some black bear specimens has led to confusion in the past, where unearthed skulls of exceptional size have been assigned to *U. arctos* in some instances, or are assumed to be of Pleistocene age on the basis of size (for discussions, see Graham 1991; Wolverton and Lyman 1998) as examples of Pleistocene gigantism. Contrary to *U. arctos*, which seldom uses caves, black bear remains are not uncommon in such settings (e.g., Kurten 1963; Kurten and Anderson 1980; Graham 1991; Wolverton and Lyman 1998; Wolverton 2008; Sagebiel 2010), where the animals either become entrapped, or simply die of natural causes after seeking refuge. Two aspects of this particular specimen were of special interest to us: 1) the surface placement of the Boy's Cave skull and accompanying domestic stock remains suggested that this animal may have been one of the last of its native kind in central Texas; and 2) the specific identity of this bear was in question, given the size of the Boy's Cave specimen, and the close proximity of the site to Schulze Cave, a well known Pleistocene/late Holocene fauna (Dalquest et al. 1969) reported to contain both black bear and grizzly bear remains.

Materials and Methods

Bone comprising the Boy's Cave specimen is darkly stained and fragile. It is comprised of two parts that fit tightly together (Fig. 1). Only the skull cap and occipital elements remain of the braincase and associated zygomatic arches. Sagittal and lambdoidal crests are well developed. The rostral component is largely complete, but upper dentition is represented only by the P4-M2 toothrows on each side. Molars are heavily worn, exposing parts of the root pulp cavities. Loose turbinal elements separated during rinsing of the specimen were retained for submission for radiocarbon dating.

Only those cranial and maxillary measurements obtainable from the partial skull of the Boy's Cave specimen were applied to comparative materials from the Midwestern State University (MWSU) Collection of Recent Mammals, as follows: P4-M2 toothrow length, M1 length and breadth, M2 length and breadth, condylobasal length (cranial components assembled for Kimble County cave specimen), least interorbital breadth, postorbital breadth, palatal length, and rostral breadth behind canines. Condylobasal length of the skull was measured with a metric ruler to the nearest 1 mm, but all other cranial and dental measurements

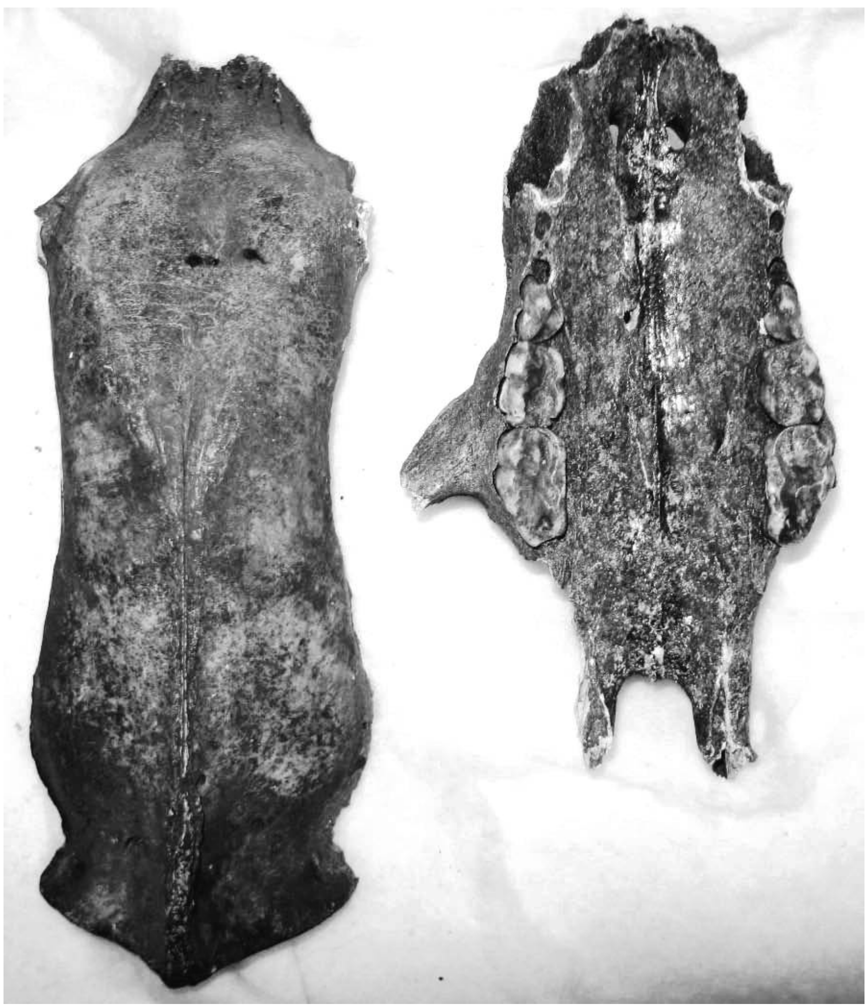

Figure 1. Views of a Holocene black bear (*Ursus americanus*) skull (TTU-M 114371) from Boy's Cave of Kimble County, Texas. Dorsal view of brain case (left) and ventral view of rostral section (right), displaying palate and maxillary dentition.

were accomplished with digital calipers and recorded to the nearest 0.01 mm.

Included in this study is the isolated left mandible (MWSU 12690) of unknown age reported by Stangl and Dalquest (1986) from the sandy Red River terrace sediments of Tillman County, southern Oklahoma (Fig. 2). Presumably of early Holocene age, all teeth were present and molars were well worn. Consequently, mandibular measurements of canine length (of alveolus), and length and width of p4, m1, m2, and m3 were recorded from our reference sample.

Comparative materials include bear material reported from the nearby Schulze Cave fauna (Dalquest et al. 1969), which include a loose M1 (MWSU-VP 7158) from the modern silts under the cave opening, dating to "…a few hundreds of years old." Latest Pleistocene sediments with carbon dates of 8,000 to 11,000 YBP contained a cub maxillary with erupting M1 (from C2 layer, MWSU-VP 7188) and an assortment of elements, including a large cranial fragment and associated ulna from C1 layer (MWSU-VP 7380).

The Boy's Cave specimen dates to 120 ± 30 years before present (YBP; ca. range of 1860-1920 A.D.), as determined in the laboratories of Beta Analytic, Inc. (sample # 292602). The original dating report is archived with the skull in the Museum of Texas Tech University's Collection of Recent Mammals (TTU-M 114371).

Our comparative sample of modern specimens is skewed towards young adults from New Mexico, but

Figure 2. Comparative labial views of left mandibles from two black bears (*Ursus americanus*). Top, the isolated Holocene mandible of unknown age retrieved from Red River sediments of Tillman County, southern Oklahoma (MWSU 12690). Bottom, large male from Prince of Wales Island, Alaska (MWSU 1304).

does span a considerable range of variation by sex, age, and geographic origin. Following the criteria of Gordon and Morejohn (1975) for specimens that included mandibles retaining c and m2, we assigned presumptive sexes. For those few specimens with recorded sexes on the collection tag, verification of sex was performed, given that animals are often incorrectly sexed by hunters (Gordon and Morejohn 1975). Although unable to consistently apply specimens to the nine relative age categories recognized by Stiner (1998) on the basis of ursid occlusal tooth wear, we compromised with the three following groupings: juveniles (age class 1) with incomplete or newly erupting dentition; young adults (age class 2) with light to moderate occlusal tooth wear; and older adults (age class 3) with heavy wear. None of our comparative specimens exhibited tooth wear as extreme as the Boy's Cave specimen.

Final comparisons and statistical analyses were restricted to *U. americanus* from several western states representing age classes 2 (n = 10, 1 ♂, 8 ♀♀) and 3 (n = 8, 2 ♂♂, 1 ♀), and two *U. arctos* of Alaskan origin. One black bear (MWSU 3204) meets the criteria for Boone and Crockett trophy size (total skull length + zygomatic breadth ≥ 508 mm or 20 in). Neither of the two *U. arctos* was sufficiently massive to meet Boone and Crockett trophy criteria for either the inland "grizzly" or coastal "Alaskan brown bear" categories, but both are age class 3 adults. The larger *U. arctos* (MWSU 3207) was older and is likely a male. The comparatively diminutive brown bear (MWSU 12632) is probably a female.

Specific determination of fossil and subfossil materials represented by partial or fragmentary remains was determined by a series of proposed criteria (Table 1), all of which rely, wholly or in part, on the M2 dimensions as proposed by Gordon (1977). Of particular usefulness to us for characters additional to the M2 was Graham's (1991) study of Quaternary black bears.

Table 1. Cranial characters and upper dental features previously determined by various authors to be useful for distinguishing between skulls of the black bear (Ursus americanus) *and brown or grizzly bear* (U. arctos). *Modified after Gordon (1977) and Graham (1991).*

Authority Character(s)	*Ursus americanus*	*Ursus arctos*
Armstrong (1972)		
alveolar maxillary toothrow	< 110 mm	> 110 mm
M2 length	< 150% length of M1	> 150% length of M1
Gordon (1977)		
M2 breadth	Broadest at mid-third	Broadest at anterior third
M2 length	< 31 mm*; <150% of M1 length	> 31 mm**; >150% of M1 length
Hall (1981)		
M2 breadth	Broadest at midlength	Broadest at anterior end
M2 length	< 29.5 mm	> 29.5 mm
Hoffmeister (1986)		
M2 breadth	Broadest at midlength	Broadest at anterior end
Rostral length	< 166 mm	>177 mm
Palatal length	< 158 mm	> 163 mm
Rostral breadth across incisors	< 39 mm	> 43.5 mm
Frontal shield breadth	< 110 mm	> 111 mm
Interorbital breadth	< 75 mm	> 75 mm

* correct ID for 100% of 144 *U. americanus*. ** correct ID for 95% of 61 *U. arctos*.

Specimens examined from the Collection of Recent Mammals, Midwestern State University (MWSU).—*Ursus americanus* (n = 26).—ALASKA: 4 mi. N Seward, 1 (MWSU 19596-♀); Prince of Wales Island, 1 (MWSU 1303-♂); Hydaburg, Prince of Wales Island, 1 (MWSU 1304-♂); Portage Bay, Hetta Inlet, Prince of Wales Island, 1 (MWSU 3205-♀); near Hydaburg, Dunbar Outlet, Sukkwan Island, 2 (MWSU 3206-♂; 5147-♀). ARIZONA: Cochise Co., 1 mi. S Duster Park Recreation Area, Huachuca Mts., 1 (MWSU 12653-♀). MICHIGAN: no specific locality, 3 (MWSU 7829-♀, 7830-♀, 11027-♂). MONTANA: Park Co., Ash Mtn., Jardine, 1 (MWSU 6434-♀). NEW MEXICO: Colfax Co., Cimarron Canyon, 8 (MWSU 3210, 3211, 3213-♀, 3396-♀, 3397, 3398-♀, 3399, 3401-♂); no specific locality, 4 (MWSU 3209, 3394-♀, 3395-♂, 3400-♀). TEXAS: Brewster Co., Frog Canyon, Black Gap WMA, 1 (MWSU 23020-♀). WASHINGTON: Chelean Co., Swanke Canyon, 1 (MWSU 13681); no specific locality, 1 (MWSU 13370). *Ursus arctos* (n = 2).—ALASKA: Favorite Bay, 2.5 mi. SE Angoon, 1 (MWSU 3207-♂); no specific locality, 1 (MWSU 12632-♀).

RESULTS

Boy's Cave skull.—Length of the M2 clearly establishes the specific identity of the cave skull. Cranial dimensions and associated dentition demonstrated an exceptional example of the black bear, measuring in the upper limits of our comparative material for postorbital and interorbital breadths, matched in size only by the largest Alaskan male specimen for greatest length of skull and M1 length, and exceeding all specimens of *U. americanus* in our sample for all other measurements (Table 2). The large size and extensive development of cranial crests strongly suggest this was a male.

Red River terrace jaw.—The river terrace mandible is of probably Holocene age. Dalquest and Schultz (1992) listed the specimen provisionally as Pleistocene in age; if true, this is the only fossil example of *U. americanus* from northwest Texas. The jaw is distinguished by an unusually short and slender p4 and robust molars. Measurements of length for m1 and m2 and breadth of m2 and m3 exceeded those of other black bears in our sample (Table 3). Following the methodology of Gordon and Morejohn (1975), the canine alveolar length (18.3) and m2 breadth (12.8) provide a cumulative index of 31.1 — a measure at the upper limits for a male *U. a. cinnamomum*, the proximal most subspecies to our study area considered by those authors.

Schulze Cave material.—Most of our reference material was available to Dalquest et al. (1969) when he described the assortment of bear material as representing both *U. americanus* and *U. arctos*, with relative size as the discriminating factor. Included are a loose M1 (from "modern" sediments of 100 years or less) and newly erupted M1 still embedded in fragments of the maxillary (from latest Pleistocene sediments). Measurements for each of these two M1s—the loose tooth of "modern" origin and that of the late Pleistocene cub—most closely approximate the Boy's Cave M1 in size (Table 2). Diagnostic elements are lacking for the partial cranial fragment (from the latest Pleistocene sediments), but there is nothing to suggest that this skull represents *U. arctos*. In a side-by-side comparison with the Boy's Cave specimen (Fig. 3), the Schulze Cave specimen is somewhat smaller and with a weaker developed sagittal crest, likely representing a large, and probably old, female black bear.

Associated limb bones.—Among an assortment of skeletal elements found in association with the Schulze Cave cranial element was an ulna (greatest length of 325 mm), which Dalquest et al. (1969) presumed might have come from the same animal. Similarly, a humerus (greatest length of 313 mm) was retrieved with the skull of the Boy's Cave skull. Given the proportional similarities of both limb elements from the skeleton of a young adult female (MWSU 23020; ulna - 263 mm, humerus - 256 mm), the Boy's Cave bear and the Schulze Cave specimen represented by the cranial fragment and ulna were comparably robust and large animals (Fig. 4) in body as well as head size.

*Table 2. Descriptive statistics of selected dental and cranial measurements (in mm) for a reference series comprised of adult black bears (*Ursus americanus*) of mixed sexes from across the western United States, material from Schulze and Boy's caves in Kimble County, Texas, and a reference pair of brown bears (*U. arctos*) from Alaska. Measurements from all specimens were confined to only those obtainable from the Boy's Cave specimen.*

Age class (N)	Mean ± SD	Min. – max.	95% C. I.	CV
	P4-M2 toothrow length			
Age class 2 (10)	52.3 ± 3.8	46.1 – 57.3	49.6 – 54.9	7.3
Age class 3 (8)	51.2 ± 5.1	45.9 – 60.3	46.9 – 55.5	10.0
Boy's Cave specimen	61.2			
U. arctos	67.7, 70.2			
	M1 length			
Age class 2 (10)	16.8 ± 1.3	14.9 – 18.4	15.9 – 17.7	7.7
Age class 3 (8)	17.2 ± 1.4	15.9 – 19.6	16.2 – 18.3	1.9
Boy's Cave specimen	19.6			
Schulze Cave cub, tooth	18.4, 18.4			
U. arctos	20.3, 21.5			
	M1 breadth			
Age class 2 (10)	12.5 ± 0.7	11.2 – 13.4	12.0 – 13.1	5.6
Age class 3 (8)	12.7 ± 0.9	11.5 – 11.4	11.9 – 13.4	7.1
Boy's Cave specimen	14.0			
Schulze Cave cub, tooth	13.6, 14.0			
U. arctos	14.5, 16.7			
	M2 length			
Age class 2 (10)	24.4 ± 2.1	21.1 – 27.1	22.9 – 25.9	8.6
Age class 3 (8)	23.8 ± 2.4	21.1 – 28.0	21.8 – 25.8	10.1
Boy's Cave specimen	29.3			
U. arctos	33.7, 35.3			
	M2 breadth			
Age class 2 (10)	14.1 ± 1.2	12.2 – 16.1	13.2 – 14.9	8.5
Age class 3 (8)	13.9 ± 1.3	12.0 – 15.5	12.8 – 14.9	9.4
Boy's Cave specimen	16.0			
U. arctos	17.5, 17.4			
	Greatest skull length			
Age class 2 (10)	265.2 ± 22.2	225 – 300	249.3 – 281.1	8.4
Age class 3 (8)	261.0 ± 31.1	228 – 310	235.0 – 287.0	11.9
Boy's Cave specimen *	310 (* incisors missing)			
U. arctos	315, 301			

Table 2. (cont.)

Age class (N)	Mean ± SD	Min. – max.	95% C. I.	CV
		Least interorbital breadth		
Age class 2 (10)	61.9 ± 5.6	56.0 – 72.7	57.9 – 65.8	9.0
Age class 3 (8)	65.9 ± 8.4	55.9 – 78.6	58.8 – 72.9	12.7
Boy's Cave specimen	74.2			
U. arctos	76.4, 69.7			
		Post orbital breadth		
Age class 2 (10)	65.3 ± 2.5	62.1 – 69.1	63.5 – 67.1	3.8
Age class 3 (7)	66.1 ± 1.9	62.6 – 68.3	64.4 – 67.9	2.9
Boy's Cave specimen	67.9			
U. arctos	71.7, 64.1			
		Palatal length		
Age class 2 (10)	133.5 ± 8.5	119.1 – 152.5	127.4 – 139.6	6.4
Age class 3 (8)	133.7 ± 13.6	115.2 – 148.6	122.3 – 145.0	10.2
Boy's Cave specimen	153.4			
U. arctos	155.0, 154.1			
		Rostral breadth behind canines		
Age class 2 (9)	52.6 ± 2.7	46.8 – 55.4	50.5 – 54.7	5.1
Age class 3 (8)	53.3 ± 2.5	50.8 – 56.4	51.2 – 55.3	4.7
Boy's Cave specimen	63.5			
U. arctos	60.7, 70.7			

Table 3. Mandibular dental measurements (in mm) for black bears (Ursus americanus) *of mixed sexes from the western United States, the mandible of a black bear from Holocene sediments of unknown age from southern Oklahoma, and a reference pair of brown bears* (U. arctos) *from Alaska.*

Specimens (N)	Mean ± SD	Min. – max.	95% C. I.	CV
		Lower canine length		
Total sample (21)	16.9 ± 2.1	13.8 – 22.6	16.0 – 17.9	12.5
Holocene mandible	18.3			
U. arctos	19.7, 18.5			
		p4 length		
Total sample (23)	8.8 ± 1.2	6.4 – 11.38	8.2 – 9.3	13.6
Holocene mandible	8.2			
U. arctos	12.0, 11.4			

Table 3. (cont.)

Specimens (N)	Mean ± SD	Min. – max.	95% C. I.	CV
		p4 breadth		
Total sample (23)	5.2 ± 0.6	4.3 – 7.0	4.9 – 5.5	11.5
Holocene mandible	5.1			
U. arctos	7.0, 6.6			
		m1 length		
Total sample (23)	17.8 ± 1.2	13.9 – 19.7	17.3 – 18.3	6.7
Holocene mandible	19.9			
U. arctos	22.4, 22.5			
		m1 breadth		
Total sample (23)	8.9 ± 0.6	7.6, 10.0	8.6, 9.1	6.7
Holocene mandible	9.9			
U. arctos	11.4, 10.6			
		m2 length		
Total sample (24)	19.2 ± 2.6	15.92 – 20.2	18.1 – 20.3	13.5
Holocene mandible	21.5			
U. arctos	24.0, 23.9			
		m2 breadth		
Total sample (24)	11.4 ± 0.7	9.8 – 12.7	11.1 – 11.7	6.1
Holocene mandible	12.8			
U. arctos	14.3, 13.9			
		m3 length		
Total sample (23)	14.7 ± 1.2	12.8 – 16.7	14.2 – 15.2	8.2
Holocene mandible	15.1			
U. arctos	21.5, 19.1			
		m3 breadth		
Total sample (23)	11.1 ± 0.7	9.6 – 12.3	10.8 – 11.4	6.3
Holocene mandible	12.7			
U. arctos	13.7, 14.3			

Figure 3. Comparisons of cranial components of Schulze Cave specimen (left) with Boy's Cave specimen. Note comparative degree of sagittal crest development, suggesting female (left) and male (right).

Figure 4. Comparisons of select limb bones from Schulze (left) and Boy's (right) caves, bracketing the ulna and humerus (center) of a young adult female *Ursus americanus* (MWSU 23020) from Brewster County, Texas.

Discussion

Preservation of bear material of Pleistocene and early Holocene age is a matter of chance. Skulls of animals that die in the open are obliterated by scavengers, weather and sun. Bone that is covered by wind- or water-born sediments typically remains forever hidden from discovery. Erosion uncovered our Red River terrace mandible, and the two skulls reported by Stovall and Johnson (1935) were incidentally excavated from the river gravel quarries of central Oklahoma; these are uncommon finds. The remains of *U. americanus* are far more likely to be preserved until later discovery in caves, which are prevalent in the limestone formations of central Texas. From a practical perspective, there are two categories of "bear" caves: the pitfall trap (usually a sinkhole) and the refuge or shelter (any cave with negotiable access).

Pitfall traps and random sampling.—Pitfall traps afford no exit and tend to randomly sample the resident bear population. Two such caves in Missouri reported by Wolverton (2008) were natural sampling mechanisms that functioned only during historic times (Lawson Cave with carbon date of 170 ± 60 YBP; Jerry Long Cave with intermixed "historic debris"). These caves reflected both age and sex biases (mostly young adults, emphasizing males) that closely matched Pelton's (2003) profile of a typical black bear population. In each of these studies, the younger animals were more vulnerable to sampling methods, and the larger and older animals (ca. > 15-20+ years-of-age) that represent a small fraction of any bear population are poorly represented.

Black bear remains from the modern sediments of Schulze Cave suggest the effectiveness of that cave as a trap for bears until the species' recent extirpation. However, the narrow shelf is a precarious perch for both incoming sediments and entrapped animals, as it ends with a deep vertical shaft of > 20 m in depth (Dalquest et al. 1969; Fig. 1). Association of the large bear and juvenile cub in the same Pleistocene sediments is speculative, but might represent entrapment of one as a fatal lure to the other.

Cave shelters and old bears.—Black bears of all ages readily utilize caves, but such caves that afford ready access for refuge and shelter are more likely to contain the large skulls and worn dentition of older animals that perished of natural causes. Residence by older animals probably also inhibit simultaneous use by younger cohorts. This best explains the Boy's Cave specimen, and probably accounts for large specimens examined by Graham (1991) from three central Texas caves (Friesenhahn Cave of Bexar County, Longhorn Cavern of Burnet County, Zesch Cave of Mason County), whose measurements compare favorably to those of the Boy's Cave specimen. It is likely no coincidence that these large bear skulls, judged to be large examples of the species, are probably most often aged animals, as evinced by heavily worn dentition, that died of natural causes after retiring to their respective caves of origin.

Persistent Pleistocene Gigantism in *Ursus americanus* from Texas and Oklahoma

Determination of relative size in bears is a complex matter. Geographic variation exists for head-body proportions, and skull measurements vary greatly with age (although this has yet to be detailed in the literature). The dentition offers several advantages and has been addressed in more detail (e.g., Wolverton and Lyman 1998; Wolverton 2008; Miller et al. 2009). Suitable sample sizes do not exist for either modern black bears or their Pleistocene precursors, and a great Holocene void exists in the sampling record. However, the cursory review permitted by our limited material indicate that black bears of the last few hundred years were comparable in size to their Pleistocene predecessors in Texas and Oklahoma.

Cranial characters.—Without access to a series of comparable-aged modern specimens of *U. americanus*, it is not feasible to determine relative size of many, and perhaps most, of these large skulls of Pleistocene to early Holocene age. The only morphometric assessment of cranial characters for *U. americanus* are those of Kennedy et al. (2002a, 2002b), which pooled adults of ≥ 4.5 years-of-age from the eastern United States. Unfortunately, we are aware of no study that assesses age variation and the effects of age variation on bear skulls. Such a study will have to be performed with specimens from another geographic locality, for faunal listings clearly indicate an insufficient number of specimens of native or pre-extirpation origin from Texas (e.g. Schmidly 1977, 1983) or Oklahoma (Caire et al. 1989).

The central Texas cave skulls represent the only meaningful basis for size comparisons. Graham (1991) provided dimensions of cranial and dental characters for a series of Pleistocene and early Holocene black bears that included specimens from three central Texas caves and the two large Oklahoma skulls with heavily worn teeth that were originally identified by Stovall and Johnson (1935) as *U. arctos*. The uniquely fragmentary nature of the damaged skulls precludes many cranial comparisons, although the greatest skull length of the Boy's Cave skull (310 mm *sans* incisors) slightly exceeded measurements presented by Graham (1991: Table 2) for the mean of 25 adult Florida males of unknown age (range 282-349 mm), and closely approached the skull length of 329.5 mm for an old Pleistocene specimen from Virginia. Demonstration of the persistence or continuum of large size of regional black bears from Pleistocene to modern times must await a future discovery of materials from the intervening Holocene periods. Nevertheless, partial comparisons suggest that the Boy's Cave skull was of comparable size to its progenitors of Pleistocene and early Holocene age.

Dental characters.—Use of molar measurements offers several advantages over cranial characters, aside from the utility of the M2 as a diagnostic character for species. Sexual dimorphism is weak, dimensions are age-independent (genetically set and predetermined upon eruption), and molar size is positively correlated with aspects of the skull (maxillary and mandible; Miller et al. 2009). Further, even loose teeth or those of a partial or fragmented skull retain their value as diagnostic characters. These characters offer the strongest evidence for a persistence of Pleistocene dimensions (Friesenhahn, Longhorn, and Zesch caves, Graham 1991; Schulze Cave, Table 2) with the modern examples of the Boy's Cave specimen and the loose tooth from the surface sediments of Schulze Cave (Table 2).

Almost without exception, teeth of modern specimens in our comparative collection, regardless of geographic origin, were diminutive by comparison to our cave samples (Table 2). Three of four molar measurements of the Boy's Cave specimen fell within the range of measurements provided by Graham (1991) for three late Pleistocene bears from central Texas; the M2 breadth (16 mm) was marginally narrower than the Pleistocene specimens (range of 16.7-18.0 mm). Similarly, the M1s of both modern and Pleistocene materials from Schulze Cave compared favorably, each measuring just below the range of measurements for length, but within the lower limits for M1 breadth.

The Red River terrace mandible was marked by an unusually diminutive p4 that fell within the range for our comparative material, but exceeded those bears in four of the six measurements of the three lower molars (Table 3). However, measurements were somewhat smaller than the teeth of two Pleistocene mandibles recorded for the Friesenhahn and Zesch caves (Graham 1991). This was clearly a large, if not exceptional bear, and geographically intermediate between the central Texas cave specimens and the river gravel skulls initially identified by Stovall and Johnson (1935) as *U. arctos*.

Geographic Significance of the Boy's Cave Black Bear Skull

The skull of the Boy's Cave specimen represents an extirpated Texas Hill Country population that was familiar to the earliest settlers of the region, as reflected in the naming of a local watercourse. Bear Creek is a tributary of the Llano River in central Texas, presumably named for the local occurrence of its namesake species. The two waterways merge in the town of Junction, Kimble County, Texas. Ranchers first settled this section of the Hill Country in the 1840s, and incorporation of the town followed in 1876. Bailey (1905) cited reports that *U. americanus* still persisted in this part of Texas, west of Austin, but the most significant mortality factor for the black bear is contact with man (Pelton 2003). Persecuted as a competitor by stockmen and sought after by hunters and sportsmen, the species in central Texas was certainly gone shortly thereafter. The carbon date of 120 ± 30 YBP places the Boy's Cave black bear as one of the last of those native bears, a time frame that spans perhaps two decades from early settlement through encroachment by human habitations and highways.

SUMMARY AND CONCLUSIONS

There is no evidence that brown bear or grizzly ever habitually ranged over the Southern Plains of Texas and Okalahoma, as the Pleistocene records from Texas (Dalquest et al. 1969) and Oklahoma (Stovall and Johnson 1935; see Graham 1991) instead represent large examples of the black bear. A partial skull from Montague County of north-central Texas (Dalquest and Horner 1984) has since been lost, and is herein queried. The species in North America seems always to have been a resident of rugged, mountainous terrain of the west. The sole record for the region remains Bailey's (1905) specimen of an 1890 lone male from the Davis Mountains of Trans-Pecos Texas, likely representing a wanderer from known populations in Mexico or New Mexico. Given the overlap of cranial measurements for the two ursid species, we suggest that other reports of *U. arctos* that seem remarkable in time and place (e.g. Gallo-Reynoso et al. 2008) be reexamined using dimensions of the M2 as the primary identifying criterion (Table 1 and sources cited therein).

Cranial dimensions of the Boy's Cave specimen dwarf most of our comparative material of younger animals from a variety of localities across the species' western range including two trophy-class black bears from Alaska (Table 2). This skull compares most favorably with a series of large bear skulls representing Pleistocene and early Holocene of like age reported by Graham (1991) from central Texas. This association of age and size does not escape us, although we are aware of no studies that detail the effects of age and skull size in *U. americanus* by absolute age or relative age classes in the literature. Caves functioning as pitfall traps tend to sample a broad spectrum of age classes among black bears (e.g., Wolverton 2008), but caves with ready access serve as refuges, and old bears (i.e., large of skull size and of heavily worn dentition) are more likely than younger animals to perish of natural causes after entry—hence an expected bias towards older, larger animals in such shelters. Lesser human-induced hunting pressures prior to European settlement of the region might well have permitted more bears to live longer, culminating in more impressive skulls.

Dimensions of the crowns of molars offer characters that are age-independent. Dental characters also tend to bolster sample sizes of cave specimens, as teeth typically remain intact after skulls fragment or disintegrate. Again, the Boy's Cave tooth measurements and those M1s from both modern and fossil Schulze Cave material compare more favorably with those of Graham's (1991) material of Pleistocene and early Holocene age than with our modern material. Molar measurements from the Holocene-aged Red River terrace mandible are of intermediate size between modern comparative material and Pleistocene specimens reported by Graham (1991).

We are reluctant to categorize aspects of size among the last of the region's native black bears on the basis of limited samples both modern and Pleistocene, and temporal void of material for most of the Holocene. However, material from Schulze and Boy's caves is certainly suggestive of Hill Country black bears not reflecting any appreciable diminution since Pleistocene times.

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