

## A 6,000+ year-old specimen of a spectacled bear from an Andean cave in Peru

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**Abstract:** We report the discovery of a partial skeleton of the oldest spectacled bear (*Tremarctos ornatus*) known to date. It was found at 2,950 m elevation in the Chaquil cave, in the Departamento de Amazonas, north central Peru. Its age, as determined by accelerated mass spectrometry conventional radiocarbon dating, was, within 50 years, 5,980 years before present (YBP). After a standard correction for Holocene irregularities of atmospheric <sup>14</sup>C (carbon 14) levels, this conventional radiocarbon age translates into a calendar age of about 6,790 years before present. Anatomical features of the skull shows no significant differences from extant spectacled bears. Comparative analysis of Chaquil remains with those of modern specimens revealed some intraspecific variation at the sagittal crest, mandibular ramus and symphysis, masseteric crest, and coronoid process. We suggest that the extremely worn teeth, with the pulpar cavity exposed in the sub-fossil, are related to a primarily carnivorous diet.

**Resumen:** Se reporta el descubrimiento de un esqueleto parcial del más antiguo oso andino conocido hasta la fecha. El espécimen fue encontrado en la cueva de Chaquil a 2,950 metros de altitud, en el departamento de Amazonas, centro norte del Perú. Mediante el análisis del <sup>14</sup>C se determinó su antigüedad en 5980 ± 50 años antes del presente. Después de la corrección por los cambios

en los niveles holocénicos de <sup>14</sup>C, su edad calendario es cerca a 6790 años en el pasado. El estudio detallado del cráneo no muestra diferencias con el oso andino *Tremarctos ornatus* actual. El análisis comparativo del oso de Chaquil y especímenes modernos revela que existe una variabilidad intraespecífica en elementos como la cresta sagital, rama y sínfisis mandibular, cresta masetérica y proceso coronoides. El espécimen en estudio posee desgaste extremo en los dientes con la cavidad pulpar expuesta. Se sugiere que esta condición podría estar relacionada con hábitos principalmente carnívoros.

**Key words:** Peru, spectacled bear, sub-fossil, *Tremarctos ornatus*

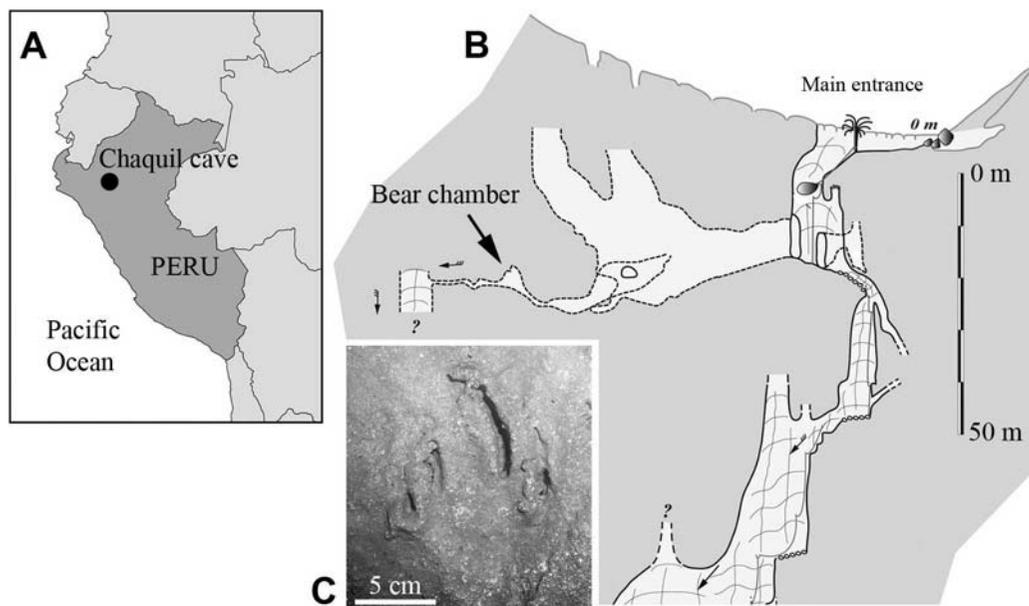
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The spectacled bear (*Tremarctos ornatus*) is the only ursid that currently lives in South America. Its distribution includes the Andes Mountains, from Venezuela to southern Bolivia. There are also reports of its presence in southeastern Panama (Goldstein et al. 2008) and in northern Argentina (Brown and Rumiz 1989, Del Moral and Bracho 2005). In Peru, the spectacled bear occupies a variety of habitats: alpine forests, tropical forests, transition forests, dry equatorial forests, the ‘puna’ and the ‘paramo’ at elevations between 250 and 4,750 m (Peyton 1999). The spectacled bear is protected under Peruvian legislation (DS-034-2004-AG) and international laws (IUCN and CITES [Convention on International Trade in Endangered Species of Wild Flora and Fauna] Appendix I) as an endangered species. In 2007, during a speleological expedition in the Departamento de Amazonas (north central Peru) a sub fossil skeleton of *Tremarctos ornatus* was discovered by Benoit Lefalher. This skeleton provides unique and thus significant data for understanding the historical biogeography of the species. Variations in some skull characters are discussed.

### Methods

The skeleton of the sub fossil bear (MUSM 1441) is housed in Universidad Nacional Mayor de San

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**Fig. 1.** A. Location of Chaquil Cave in northeastern Peru. B. Developed section of the upper region of the Chaquil Cave showing the bear chamber (Credits: topography: J.Y. Bigot, J.D. Klein, J.L. Galera, and J.L. Guyot; design: J. L. Galera). C. Paw mark of the bear in the wall of the chamber.

Marcos in Lima, Peru. The skull and mandible were compared with modern specimens of *Tremarctos ornatus* from Peru ('MUSM To1' from Apurímac, 'To s/n' from Cuzco, 'FMNH 85498' from Cuzco, 'FMNH 41294' from Lambayeque) and complemented with additional observations from literature. Measurements to a tenth of a millimeter were made using a Mitutoyo 505–671 caliper (USA) and followed von der Driesch (1976). Samples of solid long bones were crushed to extract collagen and submitted for accelerated mass spectrometry (AMS) analysis. The AMS radiocarbon analysis was performed by the Beta Analytic Radiocarbon Dating Laboratory (Miami, Florida, USA).

The conventional radiocarbon age of the bone collagen of our sample (Beta-237787) was determined to be  $5,980 \pm 50$  years before present (YBP). Conversion of this conventional radiocarbon age to calendar year followed the cubic spline fit procedure of Talma and Vogel (1993), which considers data obtained from tree rings to account for the fluctuations that occurred in the  $^{14}\text{C}$  (carbon 14) levels throughout the Holocene. This resulted in a calendar date of 4840 BC (before Christ) with a  $1\sigma$  range (68% confidence) from 4940 BC to 4800 BC (or 6,790 YBP, with 6,890 YBP to 6,740 YBP representing the  $1\sigma$

confidence interval). The  $2\sigma$  range ( $\sim 95\%$  probability) was 6,940 YBP to 6,680 YBP.

### Locality

The remains of the spectacled bear were found in Chaquil Cave ( $77^{\circ}31'48''\text{W}$ ,  $6^{\circ}18'\text{S}$ ) at 2,950 m elevation, approximately 15 km southeast of Chachapoyas, Departamento de Amazonas, Peru (Fig. 1a). This cave is part of a series of karst galleries made of volcano–sedimentary sequences of the Mitu formation (Permian period) and calcareous rocks of the Chambara formation (Triassic period; Dalmayrac et al. 1980, Baby 2006). Access to this cave is possible only by descending with ropes; thus, we believe that the bear fell through a small crevice currently closed (Fig. 1b). On the walls of the bear chamber, we found paw marks conserved by the infiltration of water loaded with calcium carbonate (Fig. 1c). No human remains or artifacts were found associated with the bear.

Chaquil Cave is geographically (eastern slope of the Peruvian Andes) and ecologically (alpine–cloud forest) within the preferred habitat of the spectacled bear. However, it has been displaced from this area because of human expansion (unpublished observation, 2002).

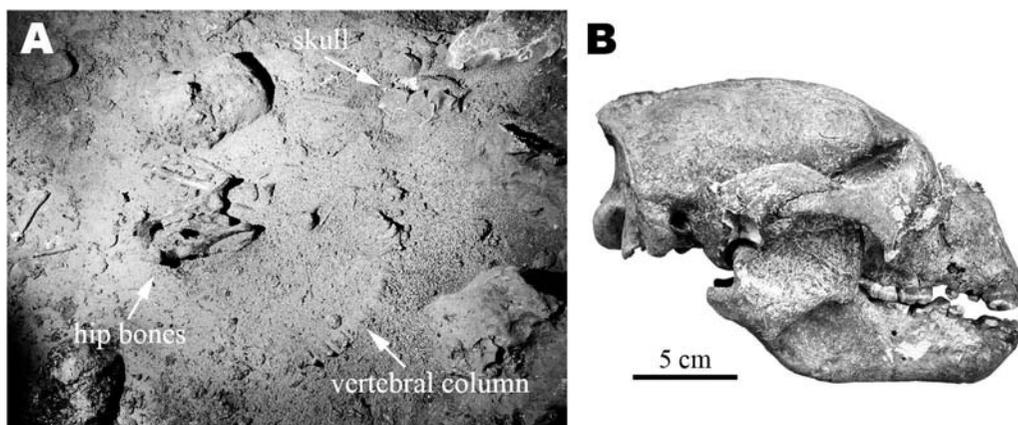


Fig. 2. A. Remains of *Tremarctos ornatus* (MUSM 1441, Chaquil Cave in north central Peru. B. Skull and mandible in lateral view.

### Anatomical description and results

The partial skeleton of the bear was discovered in articulation and buried in an unconsolidated sand bank (Fig. 2a). The specimen (MUSM 1441; Fig. 2b, 3a, 4a; Table 1) includes the skull, mandible, vertebrae, ribs, and hind and forelimbs without most of its distal elements. Missing bones were likely to have been washed away by nearby water flow.

The size and general morphology of the skull and mandible are indistinguishable from those of the extant spectacled bear *Tremarctos ornatus*. Based on characters related to sexual dimorphism in tremarctines (Kurtén 1966, Soibelzon 2002), MUSM 1441 is clearly an adult male. The skull is high, robust, and bears a steep forehead with a very short rostrum. Its dorsal profile is an arc of constant curvature. The sagittal crest is long and robust. The mandible shows a well-developed pre-masseteric fossa, typical of the genus *Tremarctos*. Compared with available material of modern *T. ornatus*, the masseteric crest is raised dorsally and somewhat more concave, whereas the horizontal ramus is deeper (Fig. 3a). The coronoid process is low and stout, resembling most extant specimens of *T. ornatus*. The articular condyle is located at the same height as the cheek teeth plane (Fig. 3a). Most of the teeth (including the canines) are extremely worn and the pulp cavity exposed. Canine teeth are flattened just over the alveolar level, whereas all the molar teeth, in particular the lower ones, make up a continuous, evenly worn surface.

### Discussion

Tremarctines (short-faced bears) are known in the fossil record from different localities in North and South America (Kurtén 1966, Soibelzon et al. 2005). Curiously, the living spectacled bear's closest relative is not one of the extinct tremarctines of South America, but *T. floridanus* from the Late Pliocene–Pleistocene of North America (Soibelzon 2002). Two circumstances obscure the evolutionary history of these 2 species of *Tremarctos*: (1) *T. ornatus* is unknown as a fossil, and (2) neither *T. floridanus*, nor any other species referable to the genus *Tremarctos*, has ever been found in South America. The remains of *T. ornatus* from Chaquil, at nearly 7,000 YBP, are the oldest known. Previous reports from 2 archaeological sites in Colombia (Correal 1990, Peña and Pinto 1996) and one in Peru (Flores 1975) were dated at 4,030, 2,725, and 1,500 YBP, respectively. The sites, as well as our cave, fall within the current geographic range of the spectacled bear, suggesting that its range throughout the Holocene was similar to its present range and restricted to the tropical Andean region.

Due to the absence of Pleistocene fossils of *Tremarctos*, it has been suggested that *T. ornatus* might have arrived in South America around the end of the Pleistocene (Soibelzon 2002). New molecular data from specimens of Venezuela, Colombia, and Ecuador indicate that population divergence occurred some 15,000–25,000 YBP (Ruiz-García 2003).

The anatomy of MUSM 1441 is essentially the same as the modern spectacled bear. We interpret several observed peculiarities as intraspecific varia-

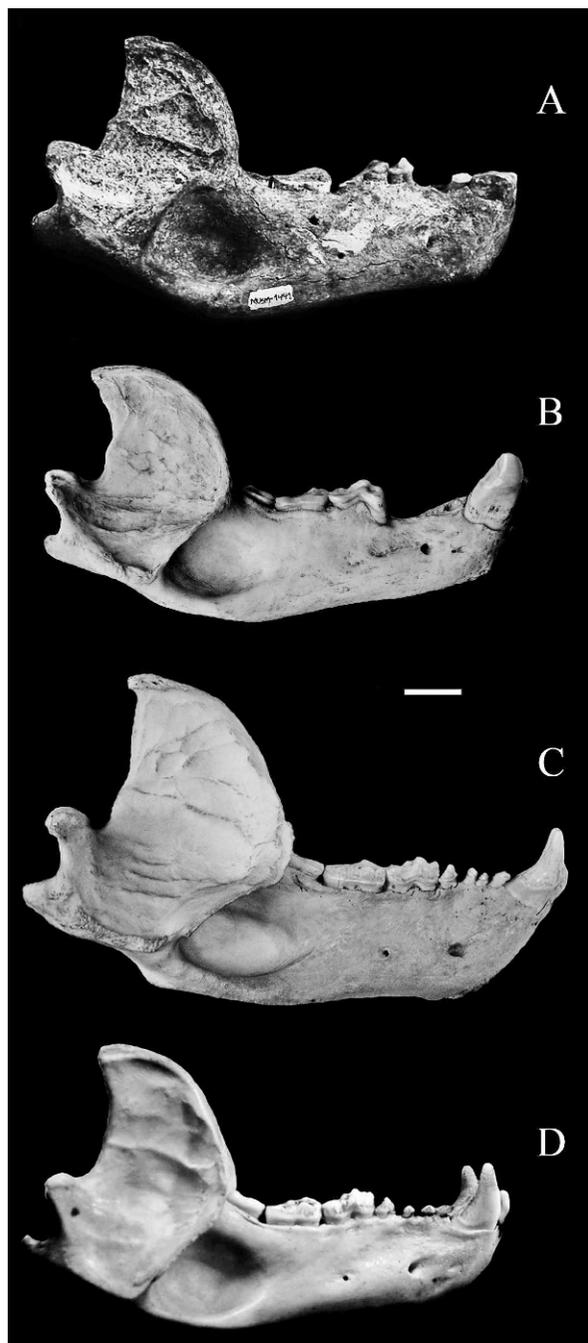


Fig. 3. Mandibles of *Tremarctos ornatus* in lateral view. A. MUSM 1441, Chaquil Cave in north central Peru. B. To s/n, Cuzco in southeastern Peru. C. FMNH 85498, Cuzco in southeastern Peru. D. FMNH 41294, Lambayeque in northwestern Peru. Scale bar equals 2 cm.



Fig. 4. Occlusal view of the right dental series of the mandible of *Tremarctos ornatus*. A. MUSM 1441, Chaquil Cave in north central Peru. B. To s/n, Cuzco in southeastern Peru. C. MUSM To1, Apurimac in south central Peru. Scale bar equals 2 cm.

tion. Within *T. ornatus*, some characters of the mandible (i.e., depth of the ramus, morphology of the symphyseal area, orientation of the masseteric crest, and proportions of the coronoid process) are highly variable among all the materials we studied, including the specimen from Chaquil (Fig. 3). In this case, it is not possible to observe any correlation between condition of the character and disparity in populations through time. In the skull, strong differences in the shape of the sagittal crest were noticed. In adult males, it can be either restricted to the posterior part of the skull or well developed along the dorsal midline of the braincase, as in MUSM 1441. As in most mammals, the latter condition might be related to an older ontogenetic age (Soibelzon 2002). Additionally, the strong sagittal crest, the morphology of the masseter crest and coronoid process, and the extremely worn teeth are evidently related to masticatory apparatus and diet. It is well known that the spectacled bear's diet is more than 90% vegetation (Peyton 1980). Extremely worn teeth are not common in the spectacled bear; however, they are quite frequent in specimens of the South American fossil tremarctine *Arctotherium*, which was suggested to be either primarily herbivorous (Berman 1994) or carnivorous (Soibelzon 2002). One specimen of a modern *T. ornatus* that we studied ("To s/n", Fig. 3b, 4b) shows especially worn teeth, but to a lesser degree than the Chaquil bear. The modern skull has a low and stout coronoid

**Table 1.** Cranial and mandible measurements (mm) of *Tremarctos ornatus* (MUSM 1441) from the Chaquil cave, Amazonas, Peru, and from 4 modern bears from Peru (origin of the sample in parentheses). Abbreviations: C = upper canine; e = estimate; L = left; M = upper molar; ML = mediolateral; m = lower molar; R = right; FMNH = Field Museum of Natural History (Chicago). Measurements follow Soibelzon (2002) and von der Driesch (1976). Basal length of the coronoid process is measured at the level mandibular condyle.

	MUSM 1441 (Amazonas)	MUSM To-1 (Apurimac)	To-s/n (Cuzco)	FMNH 85498 (Cuzco)	FMNH 41294 (Lambayeque)
Skull measurements, mm					
Condylbasal length	225.0	216.0	210 (e)	215.3	249.5
Median palatal length	110.0	105.2	91.3	96.9	112.6
Palatal breadth at M2	41.4	40.4	39.7	38.5	46.4
Breadth at the labial C alveoli	62.0	57.4	56.5	55.2	57.0
Breadth at the lingual C alveoli	37.9	33.9	33.4	31.7	35.1
Zygomatic breadth	153.4 (e)	150.9	163 (e)	161.8	170.0
Frontal breadth	81.6 (e)	81.3	84.0	79.4	102.4
Least breadth between the orbits	61.2 (e)	61.2	57.7	55.5	75.5
Facial length	116.4	110.3	112.8	115.1	117.6
C breadth (LRLC)	R: 18.6 L: 18.7	R: 16.9 L: 16.4	R: 18.9 L: 18.8	R: 18.7	R: 22.2
Mandible measurements, mm					
Mandible length	165.0	158.0	160.0	162.7	177
Height of the coronoid process	94.4	94.9	81.2	103.2	102.2
Basal length of the coronoid process	46.8	42.3	45.7	—	59.8
Height of the horizontal ramus at m2	37.9	33.6	35.9	34.2	36.3

process and strong sagittal crest. It belonged to an animal that had been observed chasing cattle on several occasions (J. Figueroa, AICB, Lima, Peru, personal communication, 2008). Diet preferences have been shown to be flexible in ursids in response to environmental conditions and opportunities (Nowak and Paradiso 1983).

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