

## CHRONOLOGICAL DISTRIBUTION OF BRAZILIAN *GLYPTODON* SP. REMAINS: A DIRECT $^{14}\text{C}$ DATE FOR A SPECIMEN FROM IPORANGA, SÃO PAULO, BRAZIL

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**ABSTRACT.** *Glyptodon* sp. fossil remains can be found throughout Brazil. However, little information is available about their chronological distribution. With the intention to contribute to this issue, we present, as far as we know, the first direct radiocarbon date for 1 specimen of this genus found in Brazil. The osteoderm MZSP-PV660 found in Abismo do Fóssil Cave (SP-145), Iporanga, São Paulo, Brazil, was dated by accelerator mass spectrometry at the Beta Analytic Radiocarbon Dating Laboratory. The  $^{14}\text{C}$  date obtained was between 20,680 and 21,370 calibrated years before the present. Unfortunately, the scant (and often imprecise or unreliable) chronological data regarding this species and genus in Brazil and elsewhere in South America precludes a robust comparison among the dates available and the one presented here. Nevertheless, our finding supports the existence of this genus in South America at least until the Last Glacial Maximum.

### INTRODUCTION

Glyptodontidae (Gray, 1869) encompasses all glyptodont species known thus far. They are easily identified by their striking and unique thick armor formed by osteoderms that covered both skull and body and the bone rings that surrounded the tail (Cartelle 1994). These animals are considered herbivores (Fariña 1995; Rancy 1999; Bargo et al. 2006), with the largest forms weighing up to 2 tons (Fariña 1995; Fariña et al. 1998). According to the fossil records, this family was widely distributed in the Americas (Simpson 1980; Fariña 1995).

Among Glyptodontidae, the genus *Glyptodon* (Owen, 1838) is well accepted. Soibelzon et al. (2006) recognize 4 species within this genus from the middle Pleistocene to the beginning of the Holocene. One of the best known species is *Glyptodon clavipes* (Owen, 1839), geographically limited to South America (Paula Couto 1979), with fossil records reported in Venezuela (Chávez-Aponte et al. 2008), Peru (Pujos and Salas 2004), Argentina (Powell and Deraco 2005), Uruguay (Castellanos 1953), and Brazil (Paula Couto 1979).

The records for this species come from different states of Brazil (Figure 1): Minas Gerais (Winge 1915); São Paulo (Paula Couto 1973); Paraíba (Bergqvist 1989); Bahia (Cartelle 1992); Rio Grande do Sul (Oliveira 1996); Piauí (Faure et al. 1999); Rio Grande do Norte (Porpino 2000); Acre, Rondônia (Lima and Cozzuol 2005); Pernambuco (Alves and Barreto 2007); Sergipe (Dantas 2009); and probably Ceará (Gomide 1989).

In spite of *Glyptodon*'s well-known geographic distribution, other data, such as chronology, are lacking. Here, we present, as far as we know, the first direct  $^{14}\text{C}$  date obtained for a Brazilian *G. clavipes* from the state of São Paulo. The aim is to contribute to a better understanding of *Glyptodon* chronological distribution in the country.

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**SAMPLE CONTEXT**

The Abismo do Fóssil Cave (SP-145), located at Iporanga, São Paulo, Brazil ( $4^{\circ}35'S$ ,  $48^{\circ}43'W$ ; Figure 1), was developed in Meso Proterozoic low-grade metamorphic limestones of the Açungui Group in the Ribeira Fold Belt. The local topography is characterized by a polygonal karst. The entrance to the cave represents the bottom of an ancient closed depression with centripetal drainage.

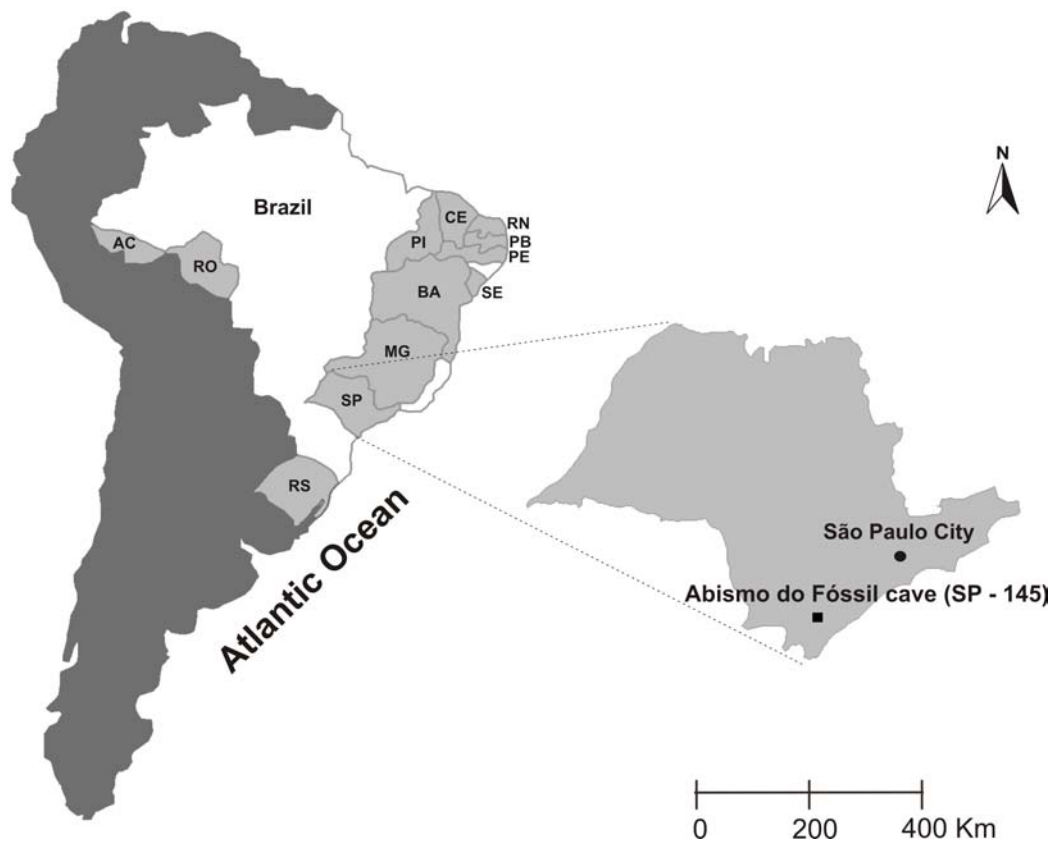


Figure 1 Location of the Brazilian states (light gray areas) where *Glyptodon* sp. remains were found. At the right, detail of São Paulo State showing the location of Abismo do Fóssil Cave (SP-145). AC, Acre; BA, Bahia; CE, Ceará; MG, Minas Gerais; PB, Paraíba; PE, Pernambuco; PI, Piauí; RN, Rio Grande do Norte; RO, Rondônia; RS, Rio Grande do Sul; SE, Sergipe; SP, São Paulo.

The cave consists of a main vertical pit (45 m) and 2 subhorizontal passages, one at the bottom and another close to the entrance, which is presently connected to a sinkhole of a small closed depression (Figure 2).

Cave sediments are mainly gravitational deposits, represented by a mixture of clastic materials from the surface that were washed into the closed depression sinkhole. Part of this material is preserved in traps formed along the cave passages. The sediments are very poorly sorted, and coarse clastic material is mixed together with fine dark sediments, rich in organic matter and clay. The scant material from *G. clavipes* (isolated osteoderms) was found in this sedimentary matrix in both subhorizontal passages (Lino et al. 1979).

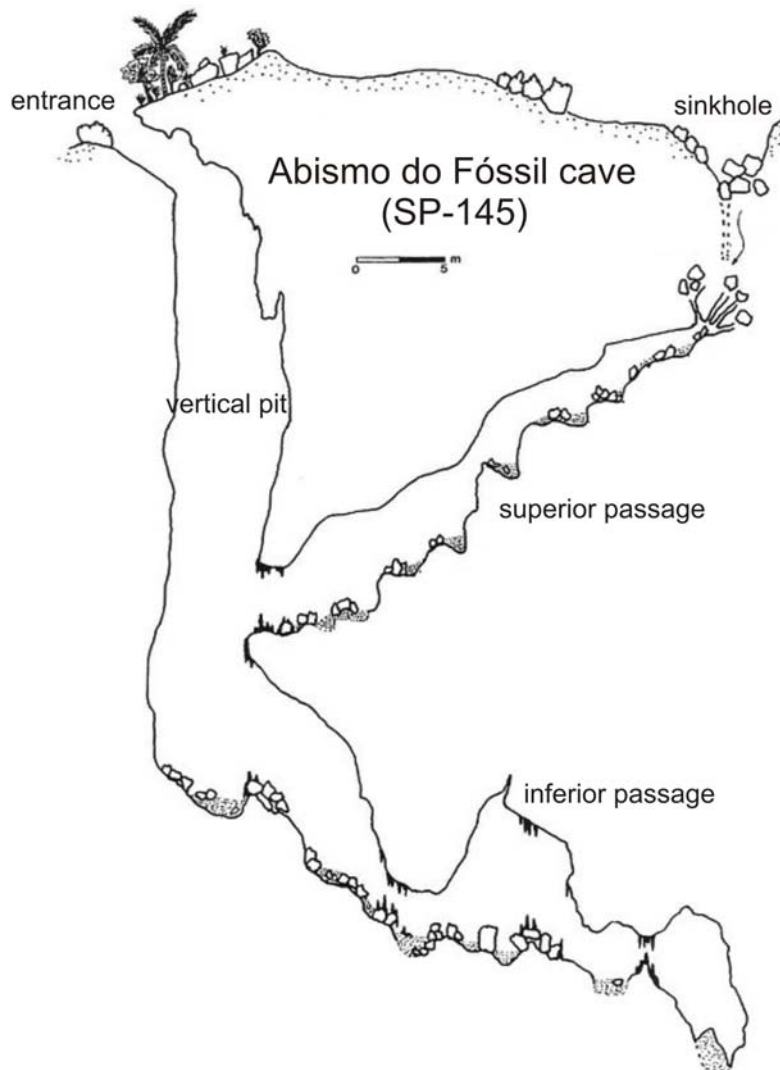


Figure 2 Schematic cross-section of Abismo do Fóssil Cave (SP-145). Adapted from Lino et al. (1979).

## MATERIAL AND METHOD

After splitting the *G. clavipes* osteoderm MZSP-PV660 (Figure 3), housed at the Museu de Zoologia da Universidade de São Paulo, Brazil, in 2 halves with a saw, one of its parts was sent to be dated by accelerator mass spectrometry (AMS) at the Beta Analytic Radiocarbon Dating Laboratory (Miami, Florida, USA). Collagen extraction and dating followed the strict protocols of the chosen laboratory.

According to the  $^{13}\text{C}/^{12}\text{C}$  ratio obtained, the measured date was corrected to the conventional age ( $^{14}\text{C}$  yr before present; BP). Based on this date and in accordance with Reimer et al. (2004) and Talma and Vogel (1993), the 2- $\sigma$  calibration age interval was obtained and is presented as calibrated years before present (cal BP).

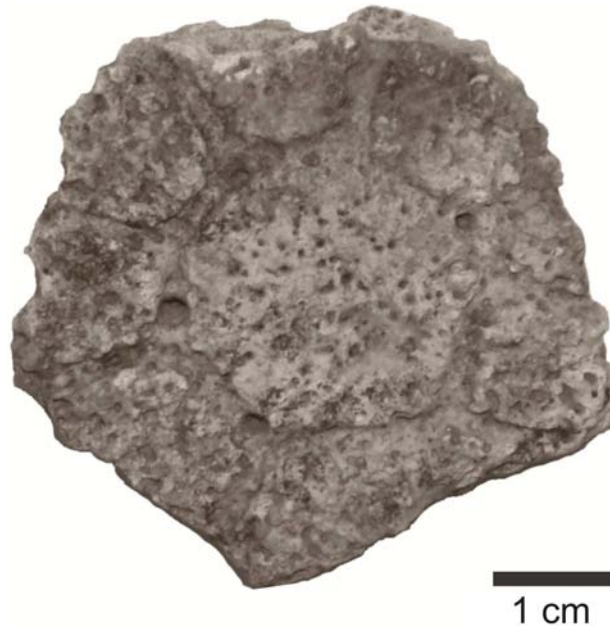


Figure 3 Dorsal view of the *Glyptodon clavipes* osteoderm MZSP-PV660

## RESULTS AND DISCUSSION

The  $^{14}\text{C}$  date of  $17,800 \pm 70$  BP (20,680–21,370 cal BP; BETA 237350; Table 1) obtained on the *G. clavipes* osteoderm MZSP-PV660 places the fossil within the Last Glacial Maximum (Yokoyama et al. 2000; Clark et al. 2009). It is the oldest direct  $^{14}\text{C}$  date for Brazilian megafauna (Czaplewski and Cartelle 1998; Neves and Piló 2003; Rossetti et al. 2004; Neves et al. 2007; Hubbe et al. 2009), pre-dating by ~8000 yr the most recent date obtained so far (*Smilodon populator* Lund, 1842; Hubbe et al. 2007). However, if indirect dates are taken into account (mainly minimum ages; Auler et al. 2006 and references therein), the  $^{14}\text{C}$  date obtained by us could be considered relatively young. For example, it is much younger than the oldest Brazilian Glyptodontidae record revealed by indirect dating in Lagoa Santa (*Hoplophorus* Lund, 1839; about >70,000 yr; Piló 1998; Auler et al. 2006).

Table 1  $^{14}\text{C}$  AMS date obtained for a *Glyptodon clavipes* from Abismo do Fóssil cave (SP-145), Iporanga, São Paulo, Brazil.

Sample ID	Lab nr	Material dated <sup>a</sup>	Taxon	$^{13}\text{C}/^{12}\text{C}$ (‰)	Conventional age (BP)	2- $\sigma$ calibration (cal BP)
MZSP-PV660	BETA 237350	Bone collagen	<i>Glyptodon clavipes</i>	-18.1	$17,800 \pm 70$	20,680–21,370

<sup>a</sup>Treated with multiple alkali extractions and ultrapurified prior to dating.

Besides the  $^{14}\text{C}$  date presented here, there are few other indirect ages for *Glyptodon* sp. remains found in Brazil (Faure et al. 1999; Kerber and Oliveira 2008). Faure et al. (1999) reported for Toca do Serrote do Artur, Piauí (Figure 1), a stratigraphic level containing isolated plates of *G. clavipes* dated to between  $6890 \pm 60$  BP (7570–7820 cal BP; GIF10515) and  $8490 \pm 120$  BP (9030–9660 cal BP; GIF10516). Below this Holocene level, more plates of *G. clavipes* were found with a minimum age of ~8500 BP.

Although early Holocene ages have already been reported for South American megafauna (Hubbe et al. 2007, 2009), the dates assigned by Faure et al. (1999) to the *Glyptodon* remains are questionable. Due to the general complexity of cave deposits (Auler et al. 2006, 2009), the scarce material found at Toca do Serrote do Artur is not necessarily contemporary to the stratigraphic levels dated, thus diminishing the reliability of the generated age (Mead and Meltzer 1984; Barnosky and Lindsey 2010).

In addition to the dates above, Kerber and Oliveira (2008) presented for Rio Grande do Sul (Figure 1) a *Glyptodon* sp. fossil in a deposit dated by thermoluminescence to ~14,800 yr. Due to uncertainties on the provenience of the material, they suggested this age should be interpreted as a minimum age. Elsewhere in South America, *Glyptodon* sp. chronology is scarce, imprecise, and often open to dispute (Rossello et al. 1999, 2001; Cione et al. 2001; Suárez 2003; Jull et al. 2004; Coltorti et al. 2007; Chávez-Aponte et al. 2008; Rincón et al. 2008).

Consequently, the *Glyptodon* chronology in South America must be currently considered as a problematic and yet unresolved topic. More dates are required to build a reliable chronology for the group. Nevertheless, in the ranking scale to quantify the reliability of  $^{14}\text{C}$  dates developed by Mead and Meltzer (1984; see updates in Barnosky and Lindsey 2010), the  $^{14}\text{C}$  date reported here reaches the highest possible score (12); therefore, our finding supports the existence of this genus in South America at least until the Last Glacial Maximum.

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