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The Late Pleistocene/Early Holocene archaeological record in Brazil: A geo-referenced database

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ABSTRACT

Between 13,000 and 8000 ^{14}C BP, eastern South America was settled by a stable and diversified population of hunter–gatherers. Archaeological excavation in the past twenty years has yielded increasingly consistent evidence of occupation in different regions of Brazil since the end of the Pleistocene, with dates at least contemporary to the Clovis Horizon in North America. This is addressed by documenting and analysing the quantity, quality and distribution of archaeological ^{14}C dates from Brazil during this period. A total of 277 dates from 90 sites are tabulated, mapped, and included in the analysis. During the Late Pleistocene there was a pioneer phase of human colonization, with dispersal inland through the major river systems. Subsequently, the Early Holocene saw the first phase of established settlement of Brazil's interior. There seems to be an archaeological threshold reached at ca. 10,500 years ^{14}C BP: numbers of sites increase, there is evidence of settlement of all major biomes, and there is clear evidence of inter-regional cultural diversity.

1. Introduction

The focus of this paper is the early peopling of Brazil, which we address by documenting and analysing the quantity, quality and distribution of archaeological ^{14}C dates between 13,000 and 8000 ^{14}C BP. By compiling and analysing a database of all known archaeological radiocarbon dates for this period, we intend to highlight major trends in early settlement, making inferences about human dispersal processes that have relevance at both the continental and the regional scales. Recent models of continental-scale human dispersal into the Americas have emphasised the importance of understanding the roles of biogeographical zones, river systems, and topographic relief in channelling early exploration and settlement (e.g. Steele et al., 1998; Anderson and Gillian, 2000; Alroy, 2001). We therefore structure the discussion around the correspondences between early occupation evidence and the distribution of Brazilian's major biomes and river systems.

Although there is some evidence pointing to human presence in the continent prior to 13,000 ^{14}C BP, this survey is limited to the period following that date. This chronological cut-off was defined taking two major factors into account: it is only after 13,000 ^{14}C BP that there is a clear and unambiguous signal of established human settlement; and the Pleistocene/Holocene transition was a period of major change in the environment and in human dispersal and adaptive strategies in South America more generally (cf. Bryan, 1973, 1986; Gruhn, 1991, 2005; Dillehay et al., 1992; Meltzer et al., 1994; Borrero, 1996; Dillehay, 1997; Gnecco, 2003; Faught, 2008; Goebel et al., 2008). By the end of the survey period, almost all of South America had been occupied, or at least visited by human groups who would have had some geographical and historical knowledge of them. Therefore, 13,000–8000 ^{14}C BP corresponds to the period when landscape became territory in eastern South America, and where landmarks, rivers and forests would have acquired fixed cultural associations encoded in histories, sentiments and patterns of activity, creating a sense of relatedness between humans and their natural environment (cf. Zedenõ, 1997; Rockman, 2003; Zedeño and Anderson, 2010).

2. Environmental background: the major biomes of Brazil

Brazilian natural land cover is, in the present day, characterised by six main biome types: 1) tropical forest, covering all the northern region and strongly associated with the Amazon river basin; 2) cavannah (*cerrado*), the second major biome in Brazil, extending across all the Brazilian Plateau, and reaching the north-east, central and southeast regions of the country; 3) *caatinga*

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(xerophytic formations), spatially restricted to the northeast region, and corresponding to the driest area of the country; 4) Atlantic Forest, with a spatial distribution that follows the Atlantic Coast and spreads into the interior in the southeast, covering a large area of the southeastern and southern regions of Brazil; 5) pampas, the southernmost biome type in the country, corresponding to an extension of the vast open areas dominated by *gramineae* that cover large parts of southern countries such as Uruguay and Argentina; and 6) *Pantanal*, a small area of tropical wetland in the central-western part of Brazil, in the country bordering Bolivia, and corresponding to an extension of the Bolivian Chacos (Fig. 1).

For the selected period there is occupational evidence in all of these biomes except the Pantanal. However, natural land cover has changed in composition and distribution during the study period.

In the northern region, dominated today by tropical forest, contrasting hypotheses have been presented about the existence and impact of drier and colder climates on the biogeographical configuration of this zone (Ab'Saber, 1977; Van der Hammen and Absy, 1994; Colinvaux et al., 1996, 2000; Van der Hammen and Hooghiemstra, 2000). During the 1970s and 1980s, the refugia theory was the main hypothesis used to explain the biodiversity of the tropical forest. By the end of the 1980s, and particularly in the 1990s, based on new data on temperature fluctuation and precipitation rates during the Late Glacial Maximum (LGM) and their influence on vegetation cover, this hypothesis was strongly criticized (Colinvaux et al., 1996, 2000). Paleoenvironmental studies conducted in central-western Amazon indicate that at the LGM, about 20,000 ^{14}C BP, the decrease in rainfall was not enough to reduce vegetation cover. Sedimentological studies at the mouth of the Amazon River point to low deposits of grass pollen, indicating the persistence of tropical forests during the Pleistocene. As has been argued by Colinvaux, although both temperature and precipitation rates decreased at times during the Pleistocene, the Amazon was not arid at any time; most of the lowlands were always forested and the forest biota were never fragmented into isolates or refugia (Colinvaux et al., 2000: 166).

On the Central Brazilian Plateau the available paleoenvironmental data comes mainly from pollen analysis and lake sediments from several different sites (Ledru, 1993; Salgado-Laboriau et al., 1997, 1998; Ledru et al., 1998, 2006; De Oliveira et al., 1999; Auler and Smart, 2001; Barberi, 2001; Pessenda et al., 2004). These studies indicate regionalised and diverse changes in the duration and intensity of dry climates in central and northeastern Brazil, and it is difficult to identify general patterns during the Holocene (Behling, 1998, 2002; Ledru et al., 1998; De Oliveira et al., 1999; Markgraf et al., 2000; Behling and Hooghiemstra, 2001; Ledru and Mourguiart, 2001).

In the northeast region, which is today the core area of *caatinga*, short and abrupt alternating dry and wetter climatic events occurred at the end of the Pleistocene before the establishment of more stable conditions during the Early Holocene, followed by increasing seasonality and a tendency to drier conditions approaching the Mid-Holocene. On the northeast coast, the opposite seems to have happened, with predominantly drier climatic conditions in the Pleistocene–Holocene transition, a wetter event at the onset of the Holocene and the establishment of a moister phase approaching the Mid-Holocene (De Oliveira et al., 1999; Behling et al., 2002; Pessenda et al., 2004; Ledru et al., 2006).

In Central Brazil, the savannah core area, there is a somewhat different picture, with more local variability and oscillation at the beginning of the Holocene, with evidence for colder and drier conditions prevailing from just after 19,000 until 13,000 ^{14}C BP. After this period there are some contrasting data, with evidence for persistence of a dry and cold climate in some cases pointing to the existence of extreme conditions of aridity that remain dominant throughout the Early Holocene, until 8000 to 6000 ^{14}C BP. On the other hand, some sites show evidence of wetter conditions in the Late Pleistocene, favouring the expansion of *cerrado* in some areas and forest in others, thus showing regional climatic diversity; nevertheless this trend toward more humidity is interrupted by short and abrupt changes towards drier conditions, possibly represented by extended dry phases, between 11–10,000 ^{14}C BP and the Early Holocene (Ledru, 1993; Salgado-Laboriau, 1997; Behling, 1998; Barberi, 2001).

In southeast and southern Brazil, paleoenvironmental data indicate that the formation of the Atlantic Forest biome began during the Pleistocene–Holocene transition. Pollen analysis for different areas indicates that during the last glacial, pampas grasslands predominate in this region, with forests restricted to river valleys and mountain slopes, due to a drier climate and temperatures between 5 °C and 7 °C lower than the current ones. Around 17,000 ^{14}C BP there was a gradual increase in humidity and temperature which enabled the expansion of the forests into areas of higher altitude. Between 12,300 and 9800 ^{14}C BP, favorable climatic conditions, along with a gradual increase in humidity, influenced the development of the Atlantic Forest. In the Mid-Holocene, the Atlantic Forest spreading process inland was intensified by the reduction of the polar air mass and the increase of temperature and humidity, with the grasslands being restricted to the higher elevations of the southern plateau and the southwestern portion of Rio Grande do Sul State. On the coast, the completed spread of Atlantic Forest only occurred after the last sea-level maximum event, at around 5000 ^{14}C BP (Martin et al., 1988; Behling and Negrelle, 2001; Behling, 2002; Angulo et al., 2006).

3. Materials and methods: constructing and analysing the database

The sources for the database included articles published in national and international peer-reviewed journals, completed research dissertations and theses, unpublished reports of CRM projects (with the authors' permission), and the official Brazilian archaeological site registry (CNSA/IPHAN; http://portal.iphan.gov.br/portal/montaPaginaSGPA.do). The inclusion criteria for ^{14}C dates in the present database are similar to those proposed by Roosevelt et al. (2002:164). Information must be available on: 1) type of material dated, method of analysis and sample lab number; 2) stratigraphic provenience of dated sample; 3) cultural associations (artefacts, features) with the dated sample; and 4) statistical uncertainty of the date (with the additional criterion that the standard error bars should be no greater than 300 years).

All radiometric dates from the survey period that meet these criteria are included, and consequently there are many more samples than sites in the database. The number of dates from a site is likely to reflect the date of the excavation and biases in scientific research effort, as well as depth or complexity of each site's stratigraphy. To control for such biases in the analyses, we have tried to segregate dates from multi-component or multi-occupation sites by cultural affiliation and, within cultural phases or components, by averaging statistically indistinguishable dates that could theoretically derive from a single occupation event. When a site publication described cultural changes in the stratigraphy, we have separated dates according to culturally-defined periods of occupation. Where such information was absent, or where the dates derived from a single cultural phase, we have grouped dates that are statistically close enough in age to be potentially derived from a single event, using a standard averaging procedure (Ward and Wilson, 1978). By these means we have defined a minimum number of occupation events for each site and estimated a single date for each occupation event. The minimum number of occupation events in any one site is not necessarily correlated with the number of radiocarbon dates obtained.

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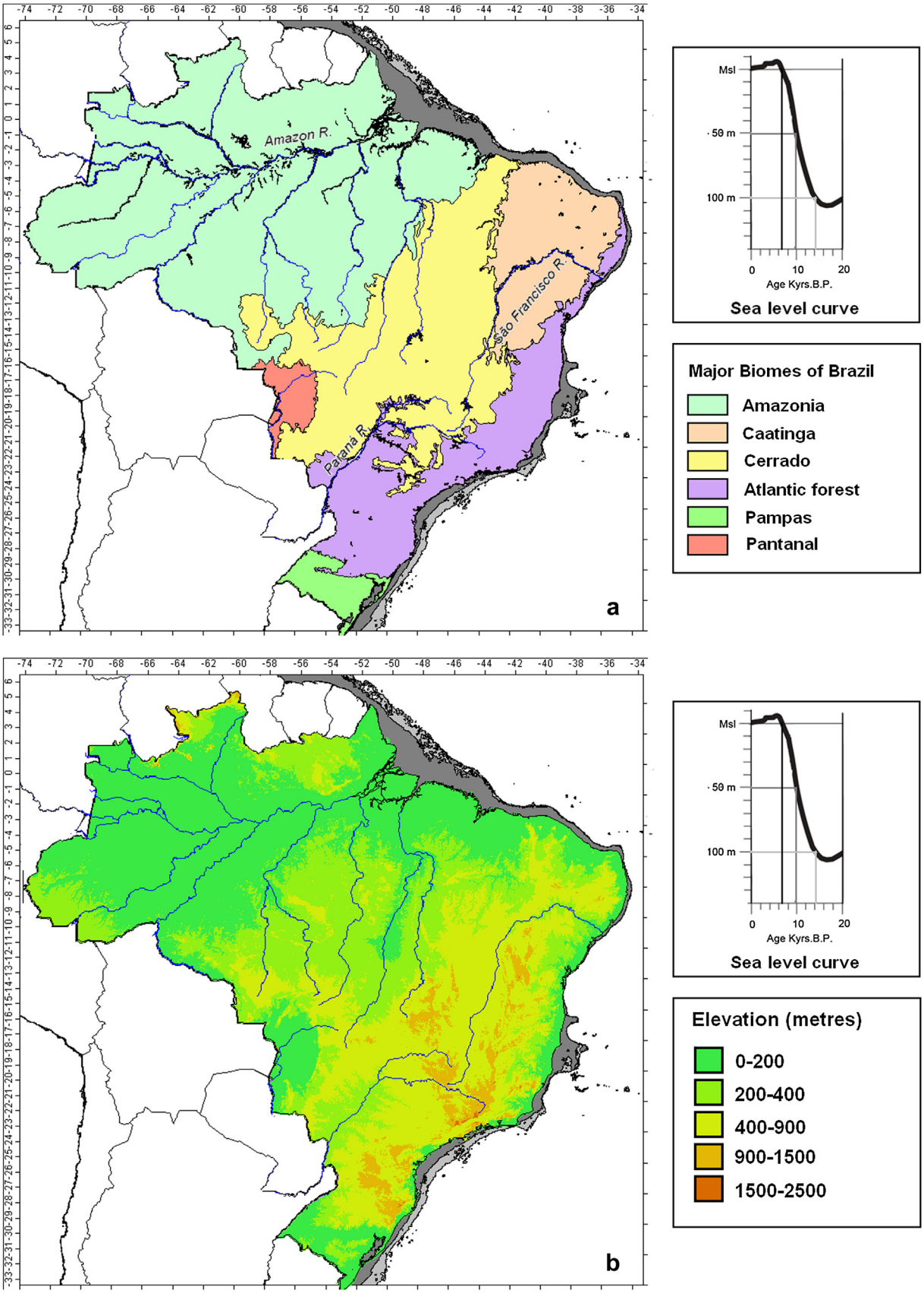

Fig. 1. a and b. Major biomes of Brazil (upper) and surface relief (lower). Grid scales are in degrees of latitude and longitude. Inset shows a possible reference relative sea-level curve from Violante and Parker (2004), and greyscale shading on the maps indicates the modern 50 m and 100 m depth contours. The timescale for the rsl curve is given in uncalibrated ^{14}C BP.

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Based on these procedures and criteria, the database contains, for the period between 13,000 and 8000 ^{14}C BP, 277 accepted dates samples for 90 sites distributed in 174 occupation events (see Tables 1–5). There are 63 additional samples that were rejected based on the defined criteria (see Table 6). Calibration of the accepted dates used Oxcal 4.1 (Bronk Ramsey 2009) and the INTCAL09 calibration curve (Reimer et al., 2009).

There is still some uncertainty in estimation of the calibration curve for ^{14}C dates in the earlier part of the survey period. INTCAL04 (Reimer et al., 2004) and INTCAL09 (Reimer et al., 2009) use the same tree-ring series for the period 0–12,550 cal BP, but diverge for the immediately preceding period. INTCAL09, which also nearly doubles the length of the calibration curve to 50,000 cal BP, uses marine data for periods before 12,550 cal BP (Reimer et al., 2009).

Table 1
^{14}C dates and occupational events for 13th millennium BP. All geographical co-ordinates in this and the four succeeding tables are in degrees South and degrees West.

Site name	Latitude	Longitude	^{14}Cdates	Labcode	Dated material	Original reference	^{14}C dates (occupations)
Toca do Sitio do Meio	8° 50′21″	42° 33′50.1″	12,440 ± 230	GIF-5403	Charcoal	Guidon, 1986	12,440 ± 230
Toca do Gordo do Garrincho	8° 55′29″	42° 36′29.9″	12,210 ± 40	Beta 136204	Human teeth	Guidon et al., 2000	12,210 ± 40
Lapa do Boquete	15° 07′	44° 13′	12,070 ± 170	CDTN-2403	Charcoal	Fogaça, 2001	12,053 ± 148
			12,000 ± 300	CDTN-1084	Charcoal	Prous and Fogaça, 1999	

Table 2
^{14}C dates and occupational events for 12th millennium BP.

Site name	Latitude	Longitude	^{14}C dates	Lab code	Material	Original reference	^{14}C dates (occupations)
Caverna da Pedra Pintada	1° 60′	54° 4′	11,145 ± 135	GX-17413	Seed	Roosevelt et al., 1996	11,145 ± 135 (but see text)
Lapa do Dragao	14° 25′	44° 24′	11,000 ± 300	CDTN-1007	Charcoal	Prous et al., 1996/1997	11,000 ± 300
Lapa do Boquete	15° 07′	44° 13′	11,440 ± 240	CDTN-1080	Charcoal	Prous, 1991	11,303 ± 127
			11,250 ± 150	CDTN 2697	Charcoal	Prous, 1991	
			11,000 ± 232	CDTN-1003	Charcoal	Prous, 1991	11,000 ± 232

Table 3
^{14}C dates and occupational events for 11th millennium BP.

Site name	Latitude	Longitude	^{14}C dates	Lab code	Dated material	Original reference	^{14}C dates (occupations)
Caverna da Pedra Pintada	1° 60′	54° 4′	10,905 ± 295	GX-17407	Seed	Roosevelt et al., 1996	10,890 ± 208
			10,875 ± 295	GX-17414	Seed	Roosevelt et al., 1996	(but see text)
			10,683 ± 80	NZA9898	Seed	Roosevelt et al., 2002	10,606 ± 47
			10,655 ± 285	GX-17420	Seed	Roosevelt et al., 1996	
			10,560 ± 60	B76953	Seed	Roosevelt et al., 1996	
			10,450 ± 60	B76952	Charcoal	Roosevelt et al., 1996	10,372 ± 23
			10,470 ± 70	GX-19537	Seed	Roosevelt et al., 1996	
			10,410 ± 60	GX-19538	Seed	Roosevelt et al., 1996	
			10,392 ± 78	GX-17400	Seed	Roosevelt et al., 1996	
			10,390 ± 70	GX-19538	Seed	Roosevelt et al., 1996	
			10,360 ± 70	GX-19536	Seed	Roosevelt et al., 1996	
			10,305 ± 275	GX-17422	Seed	Roosevelt et al., 1996	
			10,275 ± 275	GX-17421	Seed	Roosevelt et al., 1996	
			10,261 ± 62	NZA9897	Seed	Roosevelt et al., 2002	
			10,250 ± 70	GX-19537	Seed	Roosevelt et al., 1996	
Santa Elina	16° 19′50″	56° 45′50″	10,120 ± 60	GIF-8954	Charcoal	Vialou, 2005	10,120 ± 60
MT-SL-31-Morro da Janela	15°55′18"	54°22′42"	10,080 ± 80	Beta 78053	Charcoal	Wust, 1990	10,080 ± 80
Miracema do Tocantins 1	9° 38′37″	48° 24′40″	10,530 ± 90	Beta 190080	Charcoal	Bueno, 2007	10,530 ± 90
Capivara 5	10°08′10″	48° 26′16″	10,050 ± 80	Beta 179196	Charcoal	Bueno, 2007	10,050 ± 80
Lajeado 18	9° 45′01″	48° 22′18″	10,300 ± 60	Beta 179198	Charcoal	Bueno, 2007	10,300 ± 60
GO-JA-01	18°17′11"	52° 2′52"	10,580 ± 115	SI-3699	Charcoal	Schmitz, 1987	10,501 ± 86
			10,400 ± 130	N-2348	Charcoal	Schmitz, 1987; Schmitz et al., 1989, 2004	
GO-JA-02	18° 18′40″	52° 2′13″	10,120 ± 80	SI-3108	Charcoal	Schmitz, 1987	10,120 ± 80
GO-JA-14	18° 26′50″	52° 0′ 20″	10,740 ± 85	SI-3111	Charcoal	Schmitz, 1987	10,740 ± 85
GO-NI-49	14° 29′	49° 28′	10,750 ± 300	SI-2769	Charcoal	Barbosa et al., 1976–77 (in Schmitz, 1987)	10,750 ± 300
MS-PA-02	19° 35′	52° 40′	10,340 ± 110	Beta-22645	Charcoal	Veroneze, 1992	10,432 ± 65
			10,480 ± 80	Beta-47240	Charcoal	Veroneze, 1992	
			10,090 ± 70	Beta-22634	Charcoal	Veroneze, 1992	10,090 ± 70
Boqueirao da Pedra Furada	8° 51′	42° 33′ 20″	10,454 ± 114	FZ-430	Charcoal	Parenti, 1996	10,439 ± 96
			10,400 ± 180	GIF-5862	Charcoal	Parenti, 1996	
			10,050 ± 80	GIF-8352	Charcoal	Parenti, 1996	10,045 ± 57
			10,040 ± 80	GIF-8389	Charcoal	Parenti, 1996	
Toca do Sitio do Meio	8° 50′21″	42° 33′50″	10,530 ± 100	Beta 32971	Charcoal	Guidon and Pessis, 1993	10,530 ± 100
Toca de Cima do Pilao	8° 51′57″	42° 35′9″	10,390 ± 80	Beta-27345		Kipnis, 1998	10,390 ± 80
Toca do Elias	8° 50′ 40″	42° 33′ 42″	10,270 ± 35	CAMS 95865	Charcoal	Guidon et al., 2009	10,270 ± 35
Toca do João Leite	8° 44′ 17″	42° 44′ 35″	10,800 ± 70	Beta 220088	Charcoal	Guidon et al., 2009	10,800 ± 70

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Table 3 (*continued*)

Site name	Latitude	Longitude	^{14}C dates	Lab code	Dated material	Original reference	^{14}C dates (occupations)
Sitio Toca dos Coqueiros	8° 51′20″	42° 35′24″	10,640 ± 50	Beta 104571	Hair		10,640 ± 50
Toca da Lagoa de Cima IX			10,480 ± 50	Beta 233909	Charcoal	Guidon et al., 2009	10,480 ± 50
Boa Vista I	8° 37′44″	42° 21′47″	10,530 ± 110	Beta-32971	Charcoal	Kipnis, 1998	10,530 ± 110
Lapa do Dragao	14° 25′	44° 24′	10,000 ± 255	CDTN-1008	Charcoal	Kipnis, 1998	10,000 ± 255
Lapa do Boquete	15° 07′	44° 13′	10,910 ± 140	CDTN-3114	Charcoal	Kipnis, 2002	10,910 ± 140
			10,250 ± 345	CDTN-3015	Charcoal	Kipnis, 2002	10,123 ± 153
			10,200 ± 250	CDTN2731	Charcoal	Kipnis, 2002	
			10,000 ± 232	CDTN-1004	Charcoal	Kipnis, 2002	
Lapa dos Bichos	15° 8′9″S	44° 14′39″	10,450 ± 70	Beta-100397	Charcoal	Kipnis, 1998, 2002	10,450 ± 70
Lapa do Caboblo	18° 17′ 7″	43° 51′ 14″	10,560 ± 40	Beta-199503	Charcoal	Isnardis, 2009	10,560 ± 80
			10,380 ± 60	Beta-233764	Charcoal	Isnardis, 2009	10,380 ± 60
Lapa do Peixe Gordo	18° 18′ 12″	43° 44′ 31″	10,210 ± 60	Beta-233762	Charcoal	Isnardis, 2009	10,210 ± 60
Coqueirinho	19° 32′17″	43° 57′4″	10,460 ± 60	Beta 237346	Charcoal	Neves et al., 2004a,b	10,460 ± 60
Lapa das Boleiras	19° 30′59″	44° 4′3″	10,150 ± 130	BETA 168451	Charcoal	Neves et al., 2004a,b	10,150 ± 130
MG-RP-6-Lapa do Gentio	16° 15′42″	46° 02′55″	10,190 ± 120	SI 6837	Charcoal	Dias, 1976–77 (Schmitz, 1987)	10,190 ± 120
RS-I-66/Milton Almeida	29° 43′05″	56° 39′50″	10,810 ± 275	SI-2722	Charcoal	Dias and Jacobus, 2001; Dias, 2003	10,810 ± 275
RS-I-69/Laranjito	29° 36′48″	56° 55′48″	10,800 ± 150	N-2523	Charcoal	Dias and Jacobus, 2001; Dias, 2003	10,800 ± 150
			10,400 ± 110	N-2521	Charcoal	Dias and Jacobus, 2001; Dias, 2003	10,275 ± 57
			10,240 ± 80	SI-3106	Charcoal	Dias and Jacobus, 2001; Dias, 2003	
			10,200 ± 125	N-2522	Charcoal	Dias and Jacobus, 2001; Dias, 2003	

Table 4
^{14}C dates and occupational events for 10th millennium BP.

Site name	Latitude	Longitude	^{14}C dates	Labcode	Dated Material	Original reference	^{14}C dates (occupations)
Gruta do Pequiá	6°05′15″	50°07′13′	9000 ± 50	Beta 110699	Charcoal	Magalhães, 2005	9000 ± 50
Breu Branco 1	3°45′18″	49°37′19″	9570 ± 70	Beta 215041	Charcoal	Caldarelli et al., 2005	9570 ± 70
Breu Branco 2	345′40″	49 33′54″	9510 ± 60	Beta 215042	Charcoal	Caldarelli et al., 2005	9510 ± 60
Dona Stella	3°12′1.33"	60°19′39.97"	9460 ± 50	Beta 202678	Charcoal	Costa, 2009	9460 ± 50
Santa Elina	16° 19′50″	56° 45′50″	9790 ± 20	GIF-11121	Charcoal	Vialou, 2005	9720 ± 20
			9705 ± 20	GIF10685	Charcoal	Vialou, 2005	9705 ± 20
			9635 ± 20	GIF-10686	Charcoal	Vialou, 2005	9608 ± 14
			9580 ± 20	GIF-10684	Charcoal	Vialou, 2005	
			9460 ± 90	GIF-9367	Charcoal	Vialou, 2005	9333 ± 14
			9340 ± 20	GIF-10683	Charcoal	Vialou, 2005	
			9340 ± 70	GIF-11122	Charcoal	Vialou, 2005	
			9320 ± 20	GIF-10535	Charcoal	Vialou, 2005	
Miracema do Tocantins 1	9° 38′37″	48° 24′40″	9990 ± 60	Beta 168605	Charcoal	Bueno, 2007	9990 ± 60
			9790 ± 70	Beta 148339	Charcoal	Bueno, 2007	9721 ± 46
			9670 ± 60	Beta 190081	Charcoal	Bueno, 2007	
			9456 ± 95	GIF 11836	Charcoal	Bueno, 2007	9421 ± 61
			9397 ± 80	GIF 11835	Charcoal	Bueno, 2007	
Miracema do Tocantins 2	9° 38′15″	48° 24′50″	9890 ± 80	Beta 190082	Charcoal	Bueno, 2007	9890 ± 80
Mares 2	9° 48′11″	48° 23′37″	9940 ± 60	Beta 160599	Charcoal	Bueno, 2007	9940 ± 60
Capivara 5	10°08′10″	48° 26′16″	9850 ± 70	Beta 160595	Charcoal	Bueno, 2007	9850 ± 70
			9410 ± 60	Beta 179197	Charcoal	Bueno, 2007	9410 ± 60
GO-JA-01	18°17′11"	52° 2′52.84"	9510 ± 60	SI-3700	Charcoal	Schmitz, 1987	
			9060 ± 65	SI-3698	Charcoal	Schmitz, 1987	9401 ± 48
			9020 ± 70	SI-3697	Charcoal	Schmitz, 1987	
GO-JA-02	18° 18′40″	52° 2′13,25″	9195 ± 75	SI-3107	Charcoal	Schmitz, 1987	9195 ± 75
GO-JA-03	18° 26′41″	52° 0′1,7″	9765 ± 75	SI-3110	Charcoal	Schmitz, 1987; Schmitz et al., 1989	9765 ± 75
Boqueirao da Pedra Furada	8° 51′	42° 33′ 20″	9800 ± 60	GIF-8351	Charcoal	Parenti, 1996; Martin, 1996	9800 ± 60
			9506 ± 135	FZ-436	Charcoal	Parenti, 1996; Martin, 1996	9506 ± 135
Toca do Sitio do Meio	8 50′21″	42 33′50″	9200 ± 60	Beta 65856	Charcoal	Guidon and Pessis, 1993	9200 ± 60
Toca da Janela da Barra do Antoniao	8°48′09″	42° 25′01″	9670 ± 140	GIF-8712	Charcoal	Martin, 1996	9670 ± 140
Toca do Morcego	8° 29′ 25″	42° 38′ 27″	9200 ± 40	Beta 200145	Charcoal	Guidon et al., 2009	9190 ± 28
			9180 ± 40	Beta 200148	Charcoal	Guidon et al., 2009	
Toca do Bojo			9700 ± 200	GIF-4627	Charcoal	Guidon, 1986	9700 ± 200
			9080 ± 170	GIF-4925	Charcoal	Guidon, 1986	9080 ± 170

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Table 4 (*continued*)

Site name	Latitude	Longitude	^{14}C dates	Labcode	Dated Material	Original reference	^{14}C dates (occupations)
Sitio Toca dos Coqueiros	8° 51′20″	42° 35′24″	9870 ± 50	Beta 109844	Charcoal		9870 ± 50
Caldeirao do Rodrigues	8° 49′30″	42° 34′28″	9480 ± 170	GIF-5650	Charcoal	Guidon, 1986	9480 ± 170
Toca do Zé Luis	8° 52′8″	42° 36′46,9″	9920 ± 70	Beta 159042	Charcoal		9920 ± 70
Baixaodo Perna I	8° 51′16″	42° 36′28″	9540 ± 170	GIF-5414	Charcoal	Guidon, 1981 (in Schmitz, 1987)	9386 ± 117
			9.250 ± 160	MC-1056	Charcoal	Laroche et al., 1977 (in Schmitz, 1987)	
Boa Vista I	8°37′44″	42°21′47″	9730 ± 140	GIF-4629	Charcoal	Guidon, 1981	9677 ± 81
			9650 ± 100	Beta 32972	Charcoal	Guidon, 1981	
			9160 ± 170	GIF-5864	Charcoal	Guidon, 1986	9160 ± 170
Boa Vista II	8° 38′40″	42° 22′51″	9850 ± 120	MC-2513	Charcoal	Guidon, 1981 (in Schmitz, 1987)	9775 ± 85
			9700 ± 120	MC-2481	Charcoal	Guidon, 1986	
Pedra do Alexandre	6° 33′	36° 35′	9400 ± 90	CSIC 1051	Charcoal	Martin, 1996	9400 ± 90
			9400 ± 35	CSIC 967	Charcoal	Martin, 1996	9400 ± 35
Furna do Estrago	8° 08′	36° 22′	9150 ± 140	SI 6296	Charcoal		9150 ± 140
Abrigo do Pilão	11° 00′	42° 00′	9610 ± 90	Beta 10015	Charcoal	Bryan and Gruhn, 1993	9483 ± 52
			9450 ± 90	Beta 10605	Charcoal	Bryan and Gruhn, 1993	
			9390 ± 90	Beta 10017	Charcoal	Bryan and Gruhn, 1993	
Morro Furado (BA-RC-28)	13° 44′	44° 03′	9110 ± 100	SI-6748		Schmitz et al., 1996	9110 ± 100
Lapa do Boquete	15° 07′	44° 13′	9870 ± 260	CDTN-1077	Charcoal	Kipnis, 2002	9870 ± 260
			9350 ± 80	Beta 98573	Charcoal	Kipnis, 2002	9350 ± 80
Lapa dos Bichos	15° 8′9″	44° 14′39″	9500 ± 130	Beta 202775	Charcoal	Kipnis personnal comunication	9280 ± 67
			9390 ± 160	Beta 100396	Charcoal	Kipnis, 1998, 2002	
			9140 ± 90	Beta 100391	Charcoal	Kipnis, 1998, 2002	
MG-VG-11 _ Boqueirão Soberbo	15° 42′55″	44° 01′3″	9135 ± 105	SI-5508		Dias, 1991	9135 ± 105
Lapa Vermelha IV	19°36′53″	43°59′43″	9580 ± 200	GIF-3208	Charcoal	Laming-Emperaire, 1979	9387 ± 57
			9370 ± 60	Beta 84439	Human bone	Laming-Emperaire, 1979	
Cerca Grande 6	19° 31′16″	44° 0′11,92″	9720 ± 128	P-521	Charcoal	Hurt and Blasi, 1969	9720 + 128
			9028 ± 120	P-519	Charcoal	Neves et al., 2004a,b	9028 ± 120
Cerca Grande 7	19° 31′19″	44° 0′17″	9130 ± 60	Beta 84446	Charcoal	Neves et al., 2004a,b	9130 ± 60
Lapa das Boleiras	19° 30′59″	44° 4′3″	9850 ± 40	Beta 168449	Charcoal	Neves et al., 2004a	9850 ± 40
			9600 ± 60	Beta 159236	Charcoal	Neves et al., 2004a	9600 ± 60
			9210 ± 130	Beta 159233	Charcoal	Neves et al., 2004a	9210 ± 130
Lapa do Braga			9780 ± 70	Beta 174736	Human bone	Neves and Hubbe, 2005	9780 ± 70
Lapa do Santo	19° 28′ 38″	44° 2′ 21″	9900 ± 40	Beta 214130	Charcoal	Neves et al., 2004a,b	9900 ± 40
			9520 ± 60	Beta 256223			9520 ± 60
			9150 ± 40	Beta 214143	Charcoal	Neves et al., 2004a,b	9125 ± 28
			9100 ± 40	Beta 216518	Charcoal	Neves et al., 2004a,b	
Lapa Grande de Taquaruçu	19° 36′23″	43° 44′4″	9620 ± 40	Beta 216525	Charcoal	Neves et al., 2008	9591 ± 31
			9550 ± 60	Beta 183575	Charcoal	Neves et al., 2008	
			9540 ± 90	Beta 216526	Charcoal	Neves et al., 2008	
			9040 ± 40	Beta 216532	Charcoal	Neves et al., 2008	9040 ± 40
Lapa Mortuária de Confins	19°38′20″	43°58′35″	9760 ± 70	Beta 221079	Charcoal	Neves et al., 2008	9760 ± 70
Santana do Riacho (Abrigo Grande de Santana do Riacho)			9460 ± 110	GIF 4508	Bone	Prous, 1991; Kipnis, 2002	9460 ± 110
MG-RP-6-Lapa do Gentio			9580 ± 200	GIF 3208		Dias, 1976–77 (Schmitz, 1987)	9580 ± 200
Gruta do Marinheiro	20°24′2″	45°48′47″	9610 ± 60	Beta 230980	Charcoal	Koole, 2007	9610 ± 60
Capelinha	24°50′80″	48°14′38″	9890 ± 150		Shell	Plens, 2007	9890 ± 150
			9250 ± 50	Beta 189331		Plens, 2007	9210 ± 45
			9050 ± 100	Beta 189329	Shell	Figuti, 2004	
Batatal I	24°43′12″	48°20′11″	9050 ± 100	Beta 181329	Shell	Plens, 2007	9050 ± 100
RS-I-67/Touro Passo I	29° 47′ 21″	57° 4′32″	9840 ± 105	N-2519	Charcoal	Dias and Jacobus, 2001; Dias, 2003	9840 ± 105
			9230 ± 145	SI-2625		Dias and Jacobus, 2001; Dias, 2003	9230 ± 145
RS-I-72/Palmito 2	29° 31′56″	56° 51′54″	9450 ± 115	SI-2634	Charcoal	Dias and Jacobus, 2001; Dias, 2003	9450 ± 115
RS-IJ-67/Pessegueiro	29° 04′59″	56° 23′24″	9855 ± 130	SI-3749		Dias and Jacobus, 2001; Dias, 2003	9763 ± 104
			9595 ± 175	SI-2637	Charcoal	Dias and Jacobus, 2001; Dias, 2003	

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Table 5
^{14}C dates and occupational events for 9th millennium BP.

Site name	Latitude	Longitude	^{14}C dates	Labcode	Material dated	Original reference	^{14}C dates (occupations)
Gruta do Gavião	6° 02′32″	50° 12′04″	8140 ± 130	Teledyne Isotoptes 1-14,912	Charcoal	Magalhães, 2005	8140 ± 130
Gruta do Rato	6°02′25″	50°16′12′	8470 ± 50	Beta 110706	Charcoal	Magalhães, 2005	8470 ± 50
Gruta do Pequiá	6°05′15″	50°07′13′	8520 ± 60	Beta 110701	Charcoal	Magalhães, 2005	8520 ± 60
			8340 ± 60	Beta 110702	Charcoal	Magalhães, 2005	8340 ± 60
			8119 ± 60	Beta 110700	Charcoal	Magalhães, 2005	8119 ± 60
Gruta da Guarita	6°01′09″	50°15′15′	8260 ± 50	Beta 110703	Charcoal	Magalhães, 2005	8260 ± 50
NV-V	5° 56′	50° 40′	8850 ± 40	Beta 210858	Charcoal	Kipnis et al., 2005	8850 ± 40
			8680 ± 40	Beta 210857	Charcoal	Kipnis et al., 2005	8680 ± 40
N4-WS-017	5° 57′	50° 37′	8310 ± 60	Beta215050	Charcoal	Kipnis et al., 2005	8310 ± 60
N4-WS-012	5° 57′	50° 36	8240 ± 90	Beta 215053	Charcoal	Kipnis et al., 2005	8240 ± 90
N4-WS-005	5° 58′	50° 32	8110 ± 60	Beta 215056	Charcoal	Kipnis et al., 2005	8085 ± 46
			8050 ± 70	Beta 215057	Charcoal	Kipnis et al., 2005	
MT-SL-31			8390 ± 80	B-110550	Charcoal	Schmitz et al., 1996	8231 ± 33
			8270 ± 80	B-110551	Charcoal	Schmitz et al., 1996	
			8210 ± 80	B-110549	Charcoal	Schmitz et al., 1996	
			8180 ± 80	B-91898	Charcoal	Schmitz et al., 1996	
			8160 ± 60	B-91897	Charcoal	Schmitz et al., 1996	
Capivara 5	10°08′10″	48° 26′16″	8980 ± 70	Beta 160594	Charcoal	Bueno, 2007	8980 ± 70
GO-JA-01	18°17′11"	52° 2′52"	8915 ± 115	SI-3695	Charcoal	Schmitz, 1987	8806 ± 58
			8805 ± 100	SI-3696	Charcoal	Schmitz, 1987	
			8740 ± 90	N-2347	Charcoal	Schmitz, 1987	
GO-JA-26	18° 26′41″	52° 2′13″	8880 ± 90	SI-5563	Charcoal	Schmitz, 1987	8880 ± 90
Boqueirao da Pedra Furada	8° 51′	42° 33′ 20″	8600 ± 60	GIF-8350		Kipnis, 1998	8546 ± 48
			8450 ± 80	GIF-6162		Kipnis, 1998	
			8170 ± 80	GIF-6436		Kipnis, 1998	8130 ± 62
			8080 ± 120	GIF-6157		Kipnis, 1998	
			8050 ± 170	GIF 4625		Guidon, 1986	
Toca do Sitio do Meio	8 50′21″	42 33′50″	8960 ± 70	Beta 47493	Sherd	Melo, 2007	8868 ± 46
			8800 ± 60	Beta 47494		Kipnis, 1998	
Toca da Baixa do Cipo			8700 ± 90	GIF-6957		Kipnis, 1998	8700 ± 90
Toca da Ema do sítio do Brás	8° 51′ 34″	42° 35′ 17″	8820 ± 70	Beta 153987	Seeds of *Mucuna* sp.	Guidon et al., 2009	8820 ± 70
			8190 ± 60	Beta 148100	Charcoal	Guidon et al., 2009	8177 ± 46
			8160 ± 70	Beta 148102	Charcoal	Guidon et al., 2009	
Toca do vento	8° 39′ 42″	42° 43′ 32″	8500 ± 60	Beta 200147	Charcoal	Guidon et al., 2009	8500 ± 60
Toca do Bojo			8050 ± 170	GIF-4626	?	Guidon, 1986	8050 ± 170
Toca da Baixa da Cabaceira	8° 47′14″	42° 30′56″	8800 ± 60	Beta 159040	Charcoal	Guidon et al., 2009	8735 ± 42
			8670 ± 60	Beta 158554	Charcoal	Guidon et al., 2009	
Toca do Paraguaio			8780 ± 120	MC-2511	?	Guidon, 1981	8673 ± 65
			8670 ± 120	MC-2480	?	Guidon, 1986	
			8600 ± 100	MC-2510	?	Guidon, 1981	
Toca do Fundo do Baixão da Pedra Furada	8° 49′14″	42° 33′28″	8170 ± 90	Beta 154635	Charcoal	Guidon et al., 2009	8170 ± 90
Toca da Roça do Dalton			8670 ± 60	Beta 236594	Charcoal	Guidon et al., 2009	8670 ± 60
Justino	9°35′50"	37°51′58"	8950 ± 70	Beta	Charcoal	Fagundes, 2007	8950 ± 70
Abrigo Pilão	11° 00′	42° 00′	8860 ± 115	SI-5565	?	Bryan and Gruhn, 1993	8813 ± 66
			8790 ± 80	Beta-10014	?	Bryan and Gruhn, 1993	
Morro Furado (BA-RC-28)	13° 44′	44° 03′	8860 ± 115	SI-5565	?	Schmitz et al., 1996	8860 ± 115
Lapa dos Bichos	15° 8′9″S	44° 14′39″	8890 ± 90	Beta-89592	Charcoal	Kipnis, 1998	8890 ± 90
			8640 ± 90	Beta-100392	Charcoal	Kipnis, 1998	8640 ± 90
MG-VG-11_Boqueirão Soberbo	15° 42′55″	44° 01′3″	8865 ± 110	SI-5509	?	Dias, 1991	8865 ± 110
Lapa Pequena			8240 ± 160	Birm-868	Charcoal	Bryan and Gruhn, 1978	8240 ± 160
Cerca Grande 6	19° 31′16″	44° 0′11″	8240 ± 40	Beta-161668	Human Bone	Neves et al., 2004a,b	8240 ± 40
			8230 ± 50	Beta-161666	Human Bone	Neves et al., 2004a,b	8230 ± 50
Lapa da Amoreira			8040 ± 40	Beta 205340	Human Bone	Neves and Hubbe, 2005	8040 ± 40
Lapa da Lagoa Funda	19° 36′9″	44° 0′42″	8520 ± 40	Beta 208077	Human Bone	Neves and Hubbe, 2005	8520 ± 40
Lapa das Boleiras	19° 30′59″	44° 4′3″	8820 ± 150	Beta 159242	Charcoal	Neves and Hubbe, 2005	8753 ± 44
			8750 ± 150	Beta 183563	Charcoal	Neves et al., 2004a,b	
			8730 ± 110	Beta 159245	Charcoal	Neves et al., 2004a,b	
			8420 ± 100	Beta 155658	Human Bone	Neves and Hubbe, 2005	8309 ± 28
			8360 ± 50	Beta 159244	Charcoal	Neves and Hubbe, 2005	
			8300 ± 50	Beta 155659	Human Bone	Neves and Hubbe, 2005	
			8240 ± 50	Beta 159232	Charcoal	Neves et al., 2004a,b	
Lapa do Baú 2	19° 33′ 0″	43° 59′ 34″	8830 ± 50	Beta 174735	Human Bone		8830 ± 50
Lapa do Sumidouro	19° 32′ 31″	43° 56′ 28″	8960 ± 50	Beta 172187	Shell		8960 ± 50
Lapa Mortuária	19°38′20″	43°58′35″	8810 ± 50	Beta 161658	Human Bone	Neves and Hubbe, 2005	8810 ± 50
			8350 ± 40	Beta 161663	Human Bone	Neves and Hubbe, 2005	8320 ± 28
			8290 ± 40	Beta 161662	Human Bone		

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Table 5 (*continued*)

Site name	Latitude	Longitude	^{14}C dates	Labcode	Material dated	Original reference	^{14}C dates (occupations)
Lapa do Santo	19° 28′ 38″	44° 2′ 21″	8980 ± 40	Beta 214141	Charcoal	Neves and Hubbe, 2005	8900 ± 17
			8930 ± 40	Beta 214140	Charcoal	Neves et al., 2004a,b	
			8930 ± 40	Beta 214139	Charcoal	Neves et al., 2004a,b	
			8900 ± 40	Beta 246246	Charcoal	Neves et al., 2004a,b	
			8870 ± 100	Beta 214134	Charcoal	Neves et al., 2004a,b	
			8820 ± 60	Beta 170723	Charcoal	Neves et al., 2004a,b	
			8820 ± 40	Beta 214137	Charcoal	Neves et al., 2004a,b	
			8810 ± 90	Beta 216520	Charcoal	Neves et al., 2004a,b	
			8800 ± 40	Beta 216522	Charcoal	Neves et al., 2004a,b	8711 ± 13
			8790 ± 40	Beta 214132	Charcoal	Neves et al., 2004a,b	
			8750 ± 40	Beta 214135	Charcoal	Neves et al., 2004a,b	
			8730 ± 60	Beta 271249	Bone	Neves et al., 2004a,b	
			8710 ± 80	Beta 214136	Charcoal	Neves et al., 2004a,b	
			8710 ± 40	Beta 216524	Charcoal	Neves et al., 2004a,b	
			8700 ± 40	Beta 214133	Charcoal	Neves et al., 2004a,b	
			8690 ± 40	Beta 216519	Charcoal	Neves et al., 2004a,b	
			8690 ± 90	Beta 216520	Charcoal	Neves et al., 2004a,b	
			8670 ± 40	Beta 214131	Charcoal	Neves et al., 2004a,b	
			8640 ± 50	Beta 253505	Bone collagen	Neves et al., 2004a,b	
			8620 ± 40	Beta 216523	Charcoal	Neves et al., 2004a,b	
			8600 ± 50	Beta 202763	Charcoal	Neves et al., 2004a,b	8541 ± 20
			8600 ± 50	Beta 202763	Charcoal	Neves et al., 2004a,b	
			8560 ± 50	Beta 253507	Bone collagen	Neves et al., 2004a,b	
			8530 ± 40	Beta 202767	Charcoal	Neves et al., 2004a,b	
			8480 ± 50	Beta 265182	Bone collagen	Neves et al., 2004a,b	
			8480 ± 50	Beta 253511	Bone collagen	Neves et al., 2004a,b	
			8230 ± 50	Beta 183573	Charcoal	Neves et al., 2004a,b	8206 ± 31
			8190 ± 40	Beta 215196	Bone collagen	Neves et al., 2004a,b	
Lapa Grande de Taquaruçu	19° 36′23″	43° 44′4,2″	8910 ± 40	Beta 216531	Charcoal	Neves et al., 2008	8910 ± 40
			8730 ± 40	Beta 216530	Charcoal	Neves et al., 2008	8730 ± 31
			8730 ± 50	Beta 183577	Charcoal	Neves et al., 2008	
			8310 ± 40	Beta 216529	Charcoal	Neves et al., 2008	8279 ± 31
			8230 ± 50	Beta 183576	Charcoal	Neves et al., 2008	
			8080 ± 40	Beta 216527	Charcoal	Neves et al., 2008	8080 ± 40
Grande abrigo Santana do Riacho			8990 ± 100	GIF 4511	Charcoal	Prous, 1991; Kipnis, 2002	8899 ± 77
			8840 ± 130	CDTN-1069	Charcoal	Prous, 1991; Kipnis, 2002	
			8400 ± 300	CDTN-1002	Charcoal	Prous, 1991; Kipnis, 2002	8262 ± 35
			8381 ± 280	CDTN 1044	Charcoal	Prous, 1991; Kipnis, 2002	
			8280 ± 40	Beta 162014	Human Bone	Prous, 1991; Kipnis, 2002	
			8230 ± 150	GIF 5088	Bone	Prous, 1991; Kipnis, 2002	
			8185 ± 110	CDTN 1039	Charcoal	Prous, 1991; Kipnis, 2002	
			8150 ± 150	GIF 5087	Bone	Prous, 1991; Kipnis, 2002	
MG-RP-6-Lapa do Gentio			8620 ± 110	SI-3210		Dias, 1976–77 (Schmitz, 1987)	8615 ± 98
			8595 ± 215	SI-5077	Charcoal	Dias, 1991	
			8215 ± 120	SI-2373		Schmitz, 1987	8215 ± 120
MG-VG-19-Barreirinho	15° 43	44° 01	8845 ± 90	SI-5511		Dias, 1991	8845 ± 90
Capelinha	24°50′48″	48°14′23″	8860 ± 60	Beta 153988	Human Bone	Figuti, 2004	8843 ± 51
			8795 ± 100	A 11239	Charcoal	Figuti, 2004	
			8500 ± 100	A 11236	Shell	Figuti, 2004	8500 ± 100
RS-TQ-58/Garivaldino	[22J 437 953	6727 084]	8230 ± 190	Beta 32183	Charcoal	Ribeiro and Ribeiro, 1999	8101 ± 118
RS-TQ-58/Garivaldino			8020 ± 150	Beta 33458	Charcoal	Ribeiro and Ribeiro, 1999	
RS-S-327/Sangão	29° 46′ 21″	50° 33′ 44″	8790 ± 40	Beta 160845	Charcoal	Dias, 2003	8790 ± 40
RS-C-61/Adelar Pilger	29° 33′ 35″	51° 23′ 45″	8430 ± 50	Beta 260455	Charcoal	Dias and Neubauer, 2010	8430 ± 50
			8150 ± 50	Beta 260456	Charcoal	Dias and Neubauer, 2010	8090 ± 30
			8030 ± 50	Beta 229583	Charcoal	Dias and Neubauer, 2010	
ACH-LP1	[UTM/6.996.689N	297.708E]	8270 ± 70	Beta 236423	Charcoal	Scientia, 2010	8328 ± 46
			8370 ± 60	Beta 236422	Charcoal	Scientia, 2010	
RS-IJ-67/Pessegueiro	29° 04′59″	56° 23′24″	8585 ± 115	SI-2636	?	Dias and Jacobus, 2001; Dias, 2003	8585 ± 115

Table 6
Dates that were excluded from the database.

Site name	Millennium	Radiocarbon dates	Lab code	Reason for exclusion	Date reference
Lapa Vermelha/Lagoa Santa	13 ka	12,960 ± 300	GIF-3906	Uncertain cultural evidence	
RS-I-50/lajeado dos Fósseis	13 ka	12,770 ± 220	SI-801	Uncertain cultural evidence (see Milder, 1995)	Miller, 1976, 1987
RS-Q-2B/Sanga do Salso	13 ka	12,690 ± 100	SI-2351	Uncertain cultural evidence (see Milder 1994, 1995)	Miller, 1976, 1987
Lapa das Boleiras	13 ka	12,240 ± 50	Beta 168457	Uncertain cultural evidence	
Santana do Riacho (Abrigo Grande de Santana do Riacho)	13 ka	12,760 ± 70	Beta 96759	Uncertain cultural evidence	Neves et al., 2003
MT-GU-1	13 ka	12,300 ± 95	SI-3477	Uncertain cultural evidence (see Milder 1994, 1995)	Miller, 1987
Toca do Sitio do Meio	13 ka	12,200 ± 600	GIF-4628	Sigma too high	Guidon, 1986

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Table 6 (*continued*)

Site name	Millennium	Radiocarbon dates	Lab code	Reason for exclusion	Date reference
Lapa do Boquete	13 ka	12,000 ± 500	CDTN-2264	Sigma too high	Prous, 1986
MT-GU-1	12 ka	11,600 ± 115	N-3055	Weak evidence of cultural association and stratigaphic provenience of the sample	Miller, 1987
Brejo da Madre de Deus 3	12 ka	11,060 ± 90	SI-6298	Weak evidence of cultural association and stratigaphic provenience of the sample	Schmitz, 1987
Cha do Caboclo (orChao do Caboclo)	12 ka	11,250 ± 250	MC-1046	Weak evidence of cultural association and stratigaphic provenience of the sample	Laroche et al., 1977
Lapa do Boquete	12 ka	11,000 ± 1000	N/A	Sigma too high	Prous, 1986
Lapa do Boquete	12 ka	11,440 ± 475	CDTN-3009	Sigma too high	Kipnis, 1998
Lapa Mortuária	12 ka	11,990* ± 50	Beta 174680	Date to be confirmed	Neves and Hubbe, 2005
Santana do Riacho (Abrigo Grande de Santana do Riacho)	12 ka	11,960 ± 250	GIF 5089	The associated cultural material may be intrusive	Prous, 1986; Prous and Fogaça, 1999
Caverna da Pedra Pintada	12 ka	11,110 ± 310	GX-17406	Sigma too high	Roosevelt et al., 1996
Lapa Vermelha IV	12 ka	11,680 ± 500	GIF 3726	Sigma too high	Prous, 1986
RS-I-107	12 ka	11,010 ± 190	SI-9628	Weak evidence of cultural association and stratigraphic provenience of the sample	Miller, 1976, 1987
RS-IJ-68: Garruchos	12 ka	11,555 ± 230	SI-3750	Weak evidence of cultural association and stratigraphic provenience of the sample	Miller, 1976, 1987
MT-GU-1	11 ka	10,405 ± 115	SI-3476	No clear stratigraphy and material cultural association	Miller, 1987
GO-JA-01	11 ka	10,740 ± 90		No sample lab number	Kipnis, 1998
GO-NI-08	11 ka	10,605 ± 125	N/A	No sample lab number	
Toca do João Leite	11 ka	10,520 ± 80	Beta 219672	No clear stratigraphy and material cultural association	Guidon et al., 2009
Toca do João Leite	11 ka	10,400 ± 100	Beta 223088	No clear stratigraphy and material cultural association	Guidon et al., 2009
Lapa do Varal	11 ka	10,100 ± 110	n/a	No sample lab number, no clear stratigraphy and material cultural association	
Alice Boer	11 ka	10,970 ± 1020		No clear stratigraphy and material cultural association	Beltrão et al., 1986
Alice Boer	11 ka	10,950 ± 1000		No clear stratigraphy and material cultural association	Beltrão et al., 1986
Boqueirao da Pedra Furada	11 ka	10,540 ± 350	Beta-22859	Sigma too high	Parenti, 1996
Capelinha	11 ka	10,500 ± 1500	Nucleo-Bras/BH	Sigma too high, no sample lab number	Collet, 1985
RS-I-98: Saudade	11 ka	10,180 ± 110	SI-3752	No clear stratigraphy and material cultural association	Miller, 1976
MT-GU-1	10 ka	9775 ± 70	SI-3737	No clear stratigraphy and material cultural association	Miller, 1987
MT-GU-1	10 ka	9245 ± 120	SI-3739	No clear stratigraphy and material cultural association	Miller, 1987
Mirador	10 ka	9410 ± 100	CSIC 720	No clear stratigraphy and material cultural association	
Toca do Bojo	10 ka	9700 ± 120	GIF-4624	No clear stratigraphy and material cultural association	Guidon et al., 2009
Cha do Caboclo (or Chao do Caboclo)	10 ka	9520 ± 160	MC-1056	No clear stratigraphy and material cultural association	Laroche et al., 1977
Maximiano	10 ka	9810 ± 150	GIF-7493	No clear stratigraphy and material cultural association	Neves et al., 2004a,b
Lapa das Boleiras	10 ka	9640 ± 50	Beta-178556	No information about stratigraphic provenience	Neves et al., 2004a,b
Lapa das Boleiras	10 ka	9650 ± 60	Beta-221458	No information about stratigraphic provenience	Neves et al., 2004a,b
Lapa das Boleiras	10 ka	9420 ± 60	Beta-221460	No information about stratigraphic provenience	Neves et al., 2004a,b
Lapa das Boleiras	10 ka	9060 ± 60	Beta-221457	No information about stratigraphic provenience	Neves et al., 2004a,b
Lapa do Boquete	10 ka	9870 ± 485	CDTN-3011	Sigma too high	Prous, 1986
RS-TQ-58/Garivaldino	10 ka	9430 ± 360	Beta 44739	Sigma too high	Miller, 1976
RS-I-69/Laranjito	10 ka	9620 ± 110	SI-2631	No clear stratigraphy and material cultural association	Miller, 1976
RS-I-70/Imbaá I	10 ka	9120 ± 340	SI-2632	Sigma too high	Miller, 1976
RS-I-99: Ponta Leste 6	10 ka	9035 ± 100	SI-3755	No clear stratigraphy and material cultural association	Miller, 1976
RS-I-97: Carumbé	10 ka	9605 ± 120	SI-3754	No clear stratigraphy and material cultural association	Miller, 1976
MT-GU-1	9 ka	8930 ± 100	SI-3736	No clear stratigraphy and material cultural association	Miller, 1987
RO-PV-48	9 ka	8320 ± 10	Beta 27015	No clear stratigraphy and material cultural association	Miller, 1987
Brejo da Madre de Deus 3	9 ka	8495 ± 75	SI-6296	No clear stratigraphy and material cultural association	Schmitz, 1987
Cha do Caboclo	9 ka	8100 ± 135	MC-1042	No clear stratigraphy and material cultural association	Laroche et al., 1977
Pedra do Caboclo	9 ka	8400 ± 200	MC-1003	No clear stratigraphy and material cultural association	Laroche et al., 1977
Santana do Riacho (Abrigo Grande de Santana do Riacho)	9 ka	8500 ± 500	CDTN-1001	Sigma too high	Kipnis, 1998
Lapa do Sumidouro	9 ka	8150 ± 450		Sigma too high	Neves and Hubbe, 2005
Abrigo do Malhador	9 ka	8500 ± 400	UFMG 2564	Sigma too high	Kipnis, 2002
Toca do Bojo	9 ka	8080 ± 170	GIF-170	No clear stratigraphy and material cultural association	Guidon et al., 2009
Toca da Roça do Dalton	9 ka	8910 ± 50	Beta 236595	No clear stratigraphy and material cultural association	Guidon et al., 2009
Lapa do Varal	9 ka	8286 ± 70	n/a	No lab reference	
Lapa da Chica	9 ka	8760 ± 60	Beta-254271		
Lapa do Santo	9 ka	8880 ± 50	Beta 159247	Sample from the profile/no clear stratigraphic context	Strauss, 2010
SC-U-6	9 ka	8640 ± 95	SI-995	No clear stratigraphy and material cultural association	Dias and Jacobus, 2001
SC-U-6	9 ka	8095 ± 90	SI-994	No clear stratigraphy and material cultural association	Dias and Jacobus, 2001
PR-NL-8	9 ka	8115 ± 80	SI-6401	No clear stratigraphy and material cultural association	Dias and Jacobus, 2001

* Indicates "date to be confirmed."

The SHCal southern hemisphere calibration curve (McCormac et al., 2004) is available for the period 0–11,000 cal BP. The mean offset from recent dendrochronological control data is 56 ± 24 years, SHCal-calibrated dates being that much younger than those calibrated using a northern hemisphere curve. McCormac and colleagues note that this offset should not be generalized to pre-Holocene situations because of the unknown effects of large-scale carbon reservoir changes. Future analyses will explore the selective use of this curve for the younger dates in the sample. However, in this paper we conservatively analyse the database by grouping events into ^{14}C millennium intervals, while also indicating their approximate calendar age ranges based on INTCAL09.

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4. Dates as indicators of human occupation in Brazil: chronological and geographical distribution

The evidence is first considered in aggregate, to try to detect temporal trends in the frequency of early human occupation. Radiocarbon dates from archaeological sites have increasingly often been used as a demographic proxy, based on the assumption that population density is in some way correlated with site size and number and the volume of archaeological remains – and thus with the number of potential samples available for dating (e.g. Rick, 1987; Gamble et al., 2005). This approach is complicated by taphonomic and sampling biases, and by calibration curve artefacts (cf. Surovell and Brantingham, 2007; Steele, 2010; Williams, 2012). In particular, it is clear that frequencies of events in radiocarbon years may not reflect frequencies of events in calendar years, because of past variation in atmospheric ^{14}C production rates (Williams, 2012). Fig. 2a shows the summed probability distributions of the occupation events in the present database. The distribution has several clear 'spikes' or peaks, but these are likely to be artefacts of the calibration curve. To show this, we have simulated (using OxCal 4.1's R_Simulate module, Bronk Ramsey, 2009; and the INTCAL09 calibration curve, Reimer et al., 2009) a radiocarbon date for every calendar year in the interval 8000–14,000 cal BP, with a constant (and small) error of radiocarbon measurement of ±25. We have then calibrated these simulated dates in OxCal, and calculated the uncertainty in 'true' age as the full 95.4% confidence interval for the calibrated distribution (where this includes two or more separate sub-ranges, we calculated the uncertainty using their combined upper and lower bounds). Fig. 2b shows that the peaks in the summed probability plot for occupations in the database align

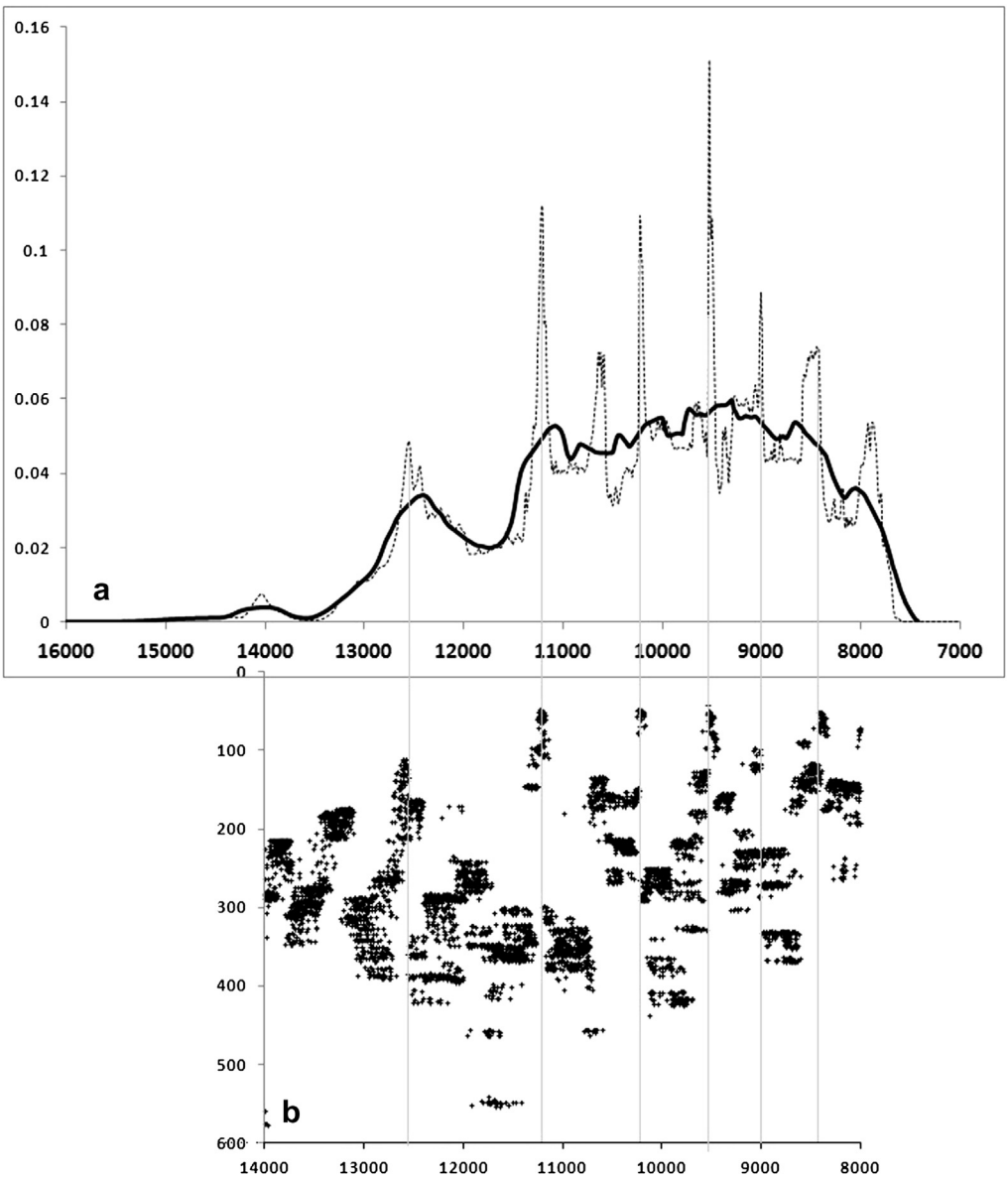

Fig. 2. a. (Upper): summed calibrated probability distribution for all occupation events in the database, after averaging. ($n = 226$ events; scale in calendar BP; curve calculated in OxCal, Bronk Ramsey, 2009, using the INTCAL09 curve, Reimer et al., 2009). The dotted line shows the unsmoothed distribution and the solid line shows the 500-year moving average. b. (Lower): uncertainty in the calendar ages of a uniform series of events, based on simulations in OxCal (see text for details). The precise alignment of the peaks in the unsmoothed curve in Fig. 2a with the periods of very low age uncertainty in the simulated dataset (Fig. 2b), shown by the vertical lines connecting the two plots, indicates that those peaks are probably artefacts of the calibration curve.

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almost perfectly with the times when dates simulated from an underlying uniform distribution will have very low age uncertainty. The spikes or peaks in the summed probability plot are therefore probably just artefacts of the inflections of the calibration curve.

In Fig. 2a we have also plotted a 500-year moving average to smooth out these 'spikes'. This curve suggests an underlying trend to increasing numbers of events in the latter half of the survey period, with a possible reduction in frequencies at its end.

This paper focuses on the associated dynamic of population expansion and cultural diversification. The core hypothesis is that the peopling process of eastern South America and of its individual biogeographical regions involved a pioneer and then an established phase, which may have been initiated at different times in different regions, but which will have left distinctive demographic and cultural signatures in the archaeological record. The first, pioneer period would have involved entering, exploring and gaining familiarity with the landscape, with the selection of specific places as foci of recurrent activity to facilitate navigation of previously uninhabited lands (Kelly, 2003; Meltzer, 2003; Zedeño and Stoffle, 2003). This is predicted to lead to an archaeological record of low average population density, but concentrated in physically salient or distinctive places that could have been frequently re-occupied: landmarks that would have given a sense of familiarity, meaning and direction in this period of familiarization with the landscape (Zedenõ, 1997; Zedeño and Anderson, 2010). This process can be expected to be most clearly represented in Brazil by sites dated between 12,500 and 11,000 ^{14}C BP. This is also a period characterized by marked climatic change and variability, with an alternation between extremely dry conditions and periods with seasonally heavy rainfall.

Around the onset of the Early Holocene of Brazil, climate seems to begin to stabilizing by about 11,000 ^{14}C BP and to have stabilized from 10,000 ^{14}C BP until at least 8000 ^{14}C BP. This may be mirrored in the date frequency distribution, in that we have an increasing number and geographical dispersion of occupation evidence after 11,000 ^{14}C BP, reaching a peak by 10,000 ^{14}C BP with sites found in all regions of the country, and with those frequencies maintained until 8500 ^{14}C BP. This period, between 10,000 and 8500 BP may be related to the establishment phase of the colonization process, with regional cultural boundaries becoming more clearly defined throughout Brazil.

In contrast to this changing pattern of occupation during the survey period, the subsistence pattern – where it has been identified in the earliest sites – appears to be basically the same across time and in all the survey area, namely that of a broad-spectrum diet based on small and medium sized game, roots, fruit, and other plant material. There is no clear evidence of trends towards specialization, or intensification of exploitation of a specific resource (Kipnis, 1998, 2003; Jacobus, 2003; Schmitz et al. 2004).

4.1. 13th and 12th ^{14}C Millennium BP (ca. 15,500–12,800 cal BP): entering the landscape

There are three sites in the database dated to the 13th ^{14}C millennia BP, with a total of four ^{14}C dates (Fig. 3 and Table 1). These rock shelters are found in the Serra da Capivara (northeastern

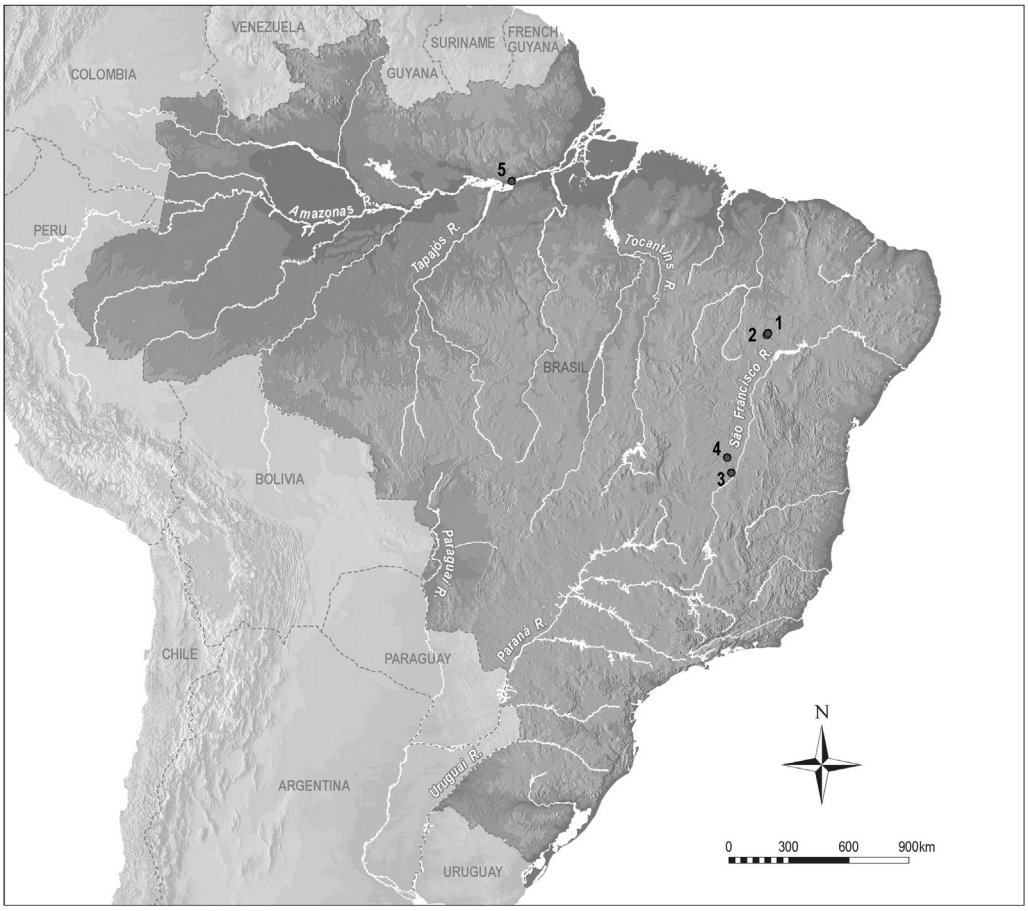

Fig. 3. Sites with reliable dates for the 13th and 12th ^{14}C millennia BP, superimposed on a map of surface relief and the major rivers of Brazil. For Figs. 3–6 see the key list in Appendix.

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Brazil) and the Peruaçu river valley (Central Brazil), both regions within the São Francisco basin, the main river valley that connects central and northeastern Brazil. It provides a perennial water source and an exceptional place to obtain different kinds of resources, for both technology (lithic raw material and wood) and subsistence (fish, mammals, and edible plants). The locations of these sites could be related to the selection of this valley as one of the main entry and dispersion routes into the Continental interior (Bueno et al., in press).

Two sites are located in Serra da Capivara, in northeast region of Brazil: Toca do Sítio do Meio and Toca do Gordo do Garrincho (Guidon, 1986; Melo, 2007; Guidon et al., 2009). At Toca do Sítio do Meio there is a clear stratigraphic association between the charcoal sample dated to 12,440 ± 240 ^{14}C BP and a lithic assemblage of unretouched and retouched flakes, cores, scrapers and *limaces* made of siltite, quartz and quartzite (Melo, 2007). It would be useful to obtain further dates to establish more conclusively the age of this archaeological occupation. At Toca do Gordo do Garrincho, the date of 12,210 ± 40 ^{14}C BP is on carbon from the acid pretreatment washes of a composite sample of two human teeth (one found with associated alveolar bone), from different levels but both overlain by a stalagmite dated to 10120 ± 20 BP (GIF-9335). There was insufficient collagen for dating this sample after pretreatment, and Guidon et al. (2000) report this outcome commenting that readers can then make their own judgements. This date must therefore be interpreted with caution (for further details of this site see also Peyre, 1993; Guidon et al., 2000, 2009; Peyre et al., 2009). The third site, Lapa do Boquete, is located in the Peruaçu river valley near the boundary between the modern *caatinga* and *cerrado* biomes and has two dates from the same stratigraphic level which can be averaged to give at least one occupation event at 12,053 ^{14}C BP. This lowest stratigraphic unit with human occupation evidence has dates spanning 12,000–11,000 ^{14}C BP, and includes hearths, animal bones, marine and freshwater shells, and many burned palm nuts associated with anvilstones with pecked circular depressions (Prous and Fogaça, 1999). Given the potential importance of precise and accurate dating of the earliest human presence at this site of the site for the pre-Clovis debate, a further programme of dating of previously-excavated organic samples from this unit would be highly valuable. The lithic assemblage from the lower levels of Lapa do Boquete is associated with hearth features and consists of large utilized flakes, small cores, thick scrapers, end and side scrapers, and *limaces*. Some bifacial flaking is found in these strata and one fragment of a projectile point has also been found (Fogaça, 2001; Kipnis, 2002). Other than fragments of projectile points and bifacial flakes this is essentially a unifacial industry, classified in the 1980s as the Itaparica Tradition (Schmitz, 1980, 1981).

For the next ^{14}C millennium, between 12,000 and 11,000 ^{14}C BP, we also have a sample of just three sites (Fig. 3 and Table 2). One of these sites is again Lapa do Boquete, with three dates averaging to at least one occupation event at 11,172 ^{14}C BP, and associated with a lithic assemblage having the same technological characteristics of the Itaparica Tradition (Prous, 1991; Fogaça, 2001). Lapa do Dragão rockshelter (Prous et al., 1996/97), located no more than 100 km from Lapa do Boquete, has a date of 11,000 ± 300 ^{14}C BP associated with hearth structures and a lithic assemblage that has similar characteristics. Meanwhile in the lower Amazon basin, the lowest cultural layer at Pedra Pintada rockshelter (17c, the Initial A stratum; Roosevelt et al., 2002:195) has dates of 11,145 ± 135 ^{14}C BP, 11,110 ± 310 ^{14}C BP, 10,905 ± 295 ^{14}C BP and 10,875 ± 295 ^{14}C BP which span this and the succeeding ^{14}C millennium BP. These are associated with faunal and edible plant remains and with lithic artefacts that include both unifacial and bifacial artefacts, such as fragments of triangular stemmed projectile points (Roosevelt et al., 1996, 2002).

The data are very sparse for these first two ^{14}C millennia of the survey period, so we must be cautious about using them to infer dispersal patterns and routes. Given the locations of the five sites discussed here we can, however, hypothesize that initial populations may have dispersed preferentially along the valleys of large rivers, finding a route inland.

4.2. 11th ^{14}C Millennium BP (ca. 12,800–11,400 cal BP): population expansion

The archaeological visibility of early human settlement improves dramatically after about 11,000 ^{14}C BP (Fig. 4). While in the preceding two ^{14}C millennia we have just 9 reliable dates in the database, in the 11th ^{14}C millennium BP there are 56 dates representing at least 37 occupation events (Table 3). The site locations illustrate another important change: while there is continuing occupation of the Peruaçu valley and Serra da Capivara, and also of the site of Pedra Pintada in lower Amazonia, occupation evidence is now also found at widely dispersed locations in almost all the biomes of present-day Brazil (Fig. 4).

In the Amazonian biome of northern Brazil, Pedra Pintada rockshelter is again the only site recorded in the database for this period. The site has a minimum of three occupation events spanning this and the end of the preceding ^{14}C millennium. Roosevelt et al. (1996, 2002) calculate a weighted mean age of four dates from the Initial A stratum as 11,075 ± 110 ^{14}C BP and a weighted mean age of eleven Initial B stratum dates as 10,420 ± 23 ^{14}C BP. However, adding the two NZA dates from Roosevelt et al. (2002) causes the 13 Initial B dates to fail Ward and Wilson's test, and we have therefore calculated two possible occupations within that stratum, one at 10,606 ± 47 ^{14}C BP and one at 10,372 ± 23 ^{14}C BP. In each case there is plentiful cultural evidence (lithic artefacts, animal bones, plant remains and shells). The lowest occupation layer is stratigraphically subdivided into three (Initial A, Initial B, and Early; Roosevelt et al., 2002), but there is no clear cultural differentiation between them. The inferred behaviour patterns resemble those from the earliest occupation of the site, for which the oldest single date is 11,145 ± 135 ^{14}C BP. The lithic assemblage comprises scrapers, *limaces*, blade-like flakes, a graver, and bifacial artefacts; most of the projectile points are triangular shapes and some are stemmed (Roosevelt et al., 2002:196).

In the Serra da Capivara region in northeastern Brazil nine dated occupations have been recognized at eight sites, with a range of ages spanning this ^{14}C millennium: Toca do João Leite (10,800 ± 70 ^{14}C BP), Toca dos Coqueiros (10,640 ± 50 ^{14}C BP), Toca do Sítio do Meio (10,530 ± 100 ^{14}C BP), Toca da Boa Vista I (10,530 ± 110 ^{14}C BP), Toca da Lagoa de Cima IX (10,480 ± 50 ^{14}C BP), Boqueirão da Pedra Furada (an averaged date of 10,439 ± 96 ^{14}C BP), Toca de Cima do Pilão (10,390 ± 80 ^{14}C BP), Toca do Elias (10,270 ± 35 BP) and Boqueirão da Pedra Furada (an averaged date of 10,045 ± 57 ^{14}C BP) (Guidon et al., 2009). In all of these sites hearths were excavated, associated with lithic assemblages assigned to the Itaparica Tradition (Guidon et al., 1996, 2009). By the end of this period, the oldest evidence of rock art in the Serra da Capivara rockshelters also is recorded (Guidon, 1985; Pessis, 1987, 1999; Martin, 1996).

During the second half of this ^{14}C millennium increased numbers of occupations are recorded on the Central Brazilian Plateau (predominantly the *cerrado* savannah biome). In the first 500 ^{14}C years there are four occupation events recorded, but in the next 500 ^{14}C years there are seven. Two of the sites occupied in this ^{14}C millennium also have earlier occupation evidence: Lapa do Boquete and Lapa do Dragão; both have similar cultural characteristics in this and in the preceding periods. However, nine sites with no previous evidence of occupation, all assigned culturally to the Itaparica Tradition, are also recorded in the western and

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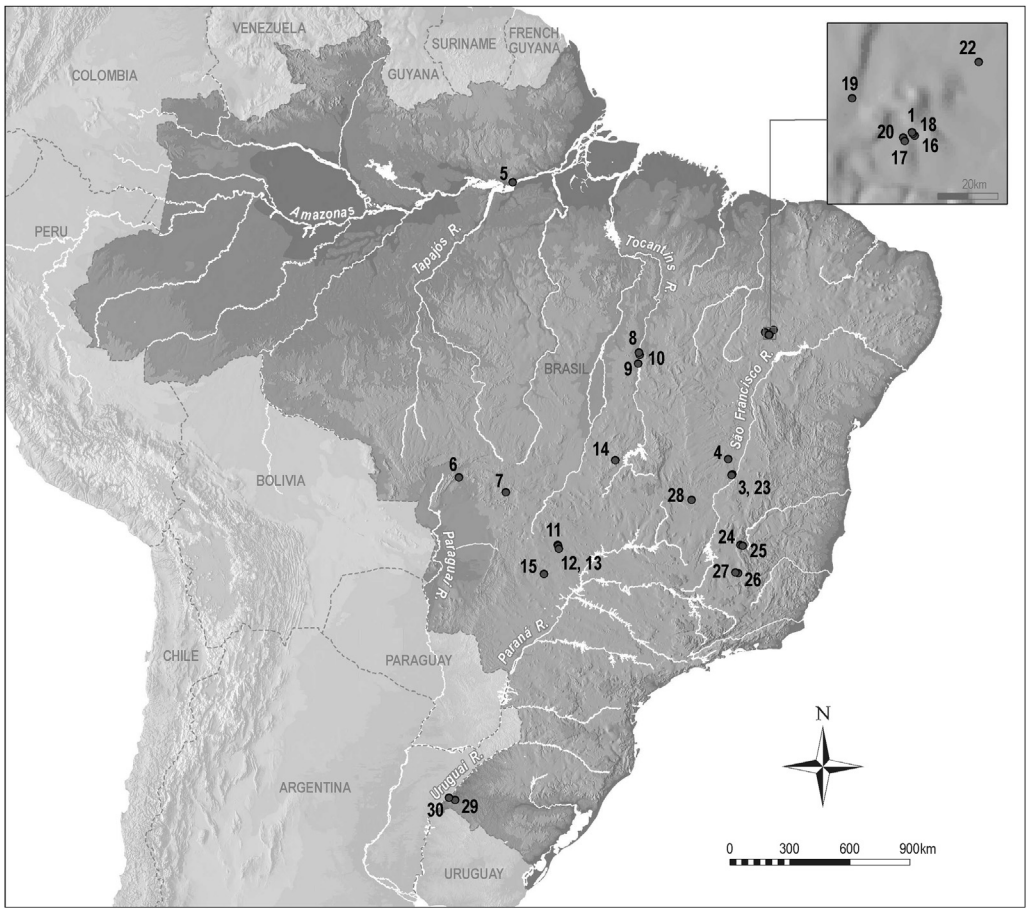

Fig. 4. Sites with reliable dates for the 11th ^{14}C millennium BP, superimposed on a map of surface relief and the major rivers of Brazil.

northern parts of the Central Brazilian Plateau at considerable distances from the São Francisco valley (MT-SL-31, GO-JA-01, GO-JA-02, GO-JA-14, GO-NI-49, MS-PA-2, Lajeado 18, Miracema do Tocantins 1 and Capivara 5). Similarities in lithic assemblage characteristics between these sites, located in some cases more than 2000 km apart, have been recognized based on assemblage composition, raw material procurement behaviour, and the techniques of production of the *limace* artefact type (cf. Bordes, 1954). Inter-site similarities have also been recognized at smaller spatial scale, as has inter-regional variation in the *chaine operatoire* related to production of some formal artefact types that may relate to cultural transmission mechanisms and use-life histories (Schmitz et al., 1989, 2004; Wust, 1990; Veroneze, 1992; Kipnis, 2002; Jacobus, 2003; Schmitz et al., 2004; Bueno, 2005/2006, 2007, 2008; Lourdeau, 2010).

There is one site in this period in Central Brazil that we cannot assign to the Itaparica Tradition: Santa Elina, MT. The site is a limestone rockshelter, located at Serra das Araras, 100 km northeast from Cuiabá, MT. Based on a series of different samples that have been dated by different analytical methods, the researchers responsible for work at this site have defined four main periods of occupation, extending from 25,000 ^{14}C BP until the colonial period (Vialou, 2005). During their second period, between 10,000 and 7000 ^{14}C BP, one of the most important aspects of the lithic assemblages is the virtual absence of formal artefacts. In all levels related to this period a lithic assemblage predominates with simple and cortical flakes made of limestone, chert and quartz. These raw materials are all found in the vicinity of the rockshelter and the flaked limestone is the same as the rock of the rockshelter. Most of the flakes were used without retouch; when it is present, it is frequently marginal, producing small and abrupt edges. Beside the absence of retouching and the short extension of the edge, most of the flakes are large and wide, offering very robust cutting edges (Vialou, 2005). Elsewhere in Central Brazil, there is evidence of the earliest known occupation of the inland semi-deciduous forest zones which form a transitional habitat between Central and southeastern Brazil. The five occupations recorded at four sites are concentrated in the second half of this ^{14}C millennium and include Lapa do Caboclo (10,560 ± 40 ^{14}C BP and 10,380 ± 60 ^{14}C BP); Coqueirinho (10,460 ± 40 ^{14}C BP); Lapa do Peixe Gordo (10,210 ± 60 ^{14}C BP) and Lapa das Boleiras (10,150 ± 130 ^{14}C BP) (Isnardis, 2009; Araujo and Neves, 2010; Bueno, 2010). Both Lapa do Caboclo and Lapa do Peixe Gordo are located in the northern part of Serra do Espinhaço, at high altitudes, while the other two sites are located on the Lagoa Santa Plateau (a karstic area in the middle São Francisco basin). There are some differences in the lithic assemblages between the sites in these two areas. At Lapa do Caboclo and Lapa do Peixe Gordo the lithic assemblages are composed of local quartzite, but with unifacial formal artifacts and flakes of kinds associated elsewhere with the *limace* production technique (Isnardis, 2009). However, in Coqueirinho and Lapa das Boleiras the lithic assemblage essentially consists just of flakes and informal tools made of local quartz (Pugliese, 2007; Bueno, 2010). The cultural relationship between these two areas is uncertain, although the lithic assemblage from another site located in between these two areas (Santana do Riacho) suggests that the differences between their assemblages do not reflect any clear regionalization (Prous, 1991a; Bueno, 2010).

In the southern region of Brazil we also find the first solid evidence of occupation during this ^{14}C millennium, at the open-air

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sites of Milton Almeida (10,810 ± 275) and Laranjito (10,800 ± 150 ^{14}C BP, with a second occupation at an averaged date of 10,275 ± 57 ^{14}C BP). These sites are located on the southwestern Brazilian border, in the Uruguay River basin, and are related to the Pampa biome (Miller, 1987; Dias and Jacobus, 2001, 2003). They are culturally related to the Umbu Tradition, which is characterized by a bifacial lithic assemblage containing stemmed projectile points of different shapes and sizes (Meggers and Evans, 1977).

As suggested by Hadler et al. (2012), the absence of fishtail projectile points in these assemblages suggest that initial colonization routes into the Brazilian Pampa could be more closely related to the occupation of Paraguai and Parana Rivers valley, which are unfortunately still poorly known archaeologically.

We should also note that Fishtail Projectile Points, which are dated elsewhere in South America to this ^{14}C millennium BP, have been found in undated contexts, mainly in Rio Grande de Sul and Santa Catarina States in the south with one example and as far north as Bahia State on the central Brazilian coast (Lopes and Nami, 2011), with an example from the base of the stratigraphic sequence at one site in Rio Grande de Sul recently interpreted as "indicating possible cultural exchanges with populations of the extreme South America Southern Cone in the Early Holocene" (Dias, 2012: 16).

The 11th ^{14}C millennium BP seems to have been the period in which human populations expanded into most of Brazil, a process associated with increased cultural diversification. By the middle of this ^{14}C millennium, ca. 10,500 ^{14}C BP, there are at least four well defined and different lithic technological complexes in Brazil: 1) in the Amazonian tropical forest, a tradition with stemmed triangular bifacial projectile points and different kinds of scrappers, including the *limace* represented by the Pedra Pintada assemblage; 2) in the *cerrado* (savannah) biome, the Itaparica Tradition, with an essentially unifacial technology and a variety of scrapers, but also with well-defined and symmetrical *limaces*; 3) a separate tradition in the southern part of central Brazilian Plateau, in an ecological transition zones of semi-deciduous forest, characterized by informal tools made of local raw material, specially quartz and quartzite, but with some evidence of production of both *limaces* and small bifacial projectile points; and 4) in the southern, pampas biome, a distinctive bifacial industry including different sorts of stemmed projectile point shapes, made of local raw material and assigned to the Umbu Tradition.

Sites of this period in all regions contain evidence of a broad-spectrum diet based on small and medium game animals, and with substantial plant food component, even in areas where there is evidence of survival of megafauna into the Early Holocene. At the same time, in this period there is evidence of differentiation of rock art styles throughout the Central Plateau (Ribeiro, 2006). Consequently, ca. 10,500 ^{14}C BP is not just a quantitative threshold in the evidence for the peopling of eastern South America, but also the beginning of a period of more intensive landscape familiarization and 'marking'.

4.3. 10th ^{14}C Millennium BP (ca. 11,400–10,200 cal BP): cultural diversification

The 10th ^{14}C Millennium BP is represented by a minimum of 65 dated occupation events in the database (Fig. 5 and Table 4). It is characterized by archaeological evidence of greater cultural

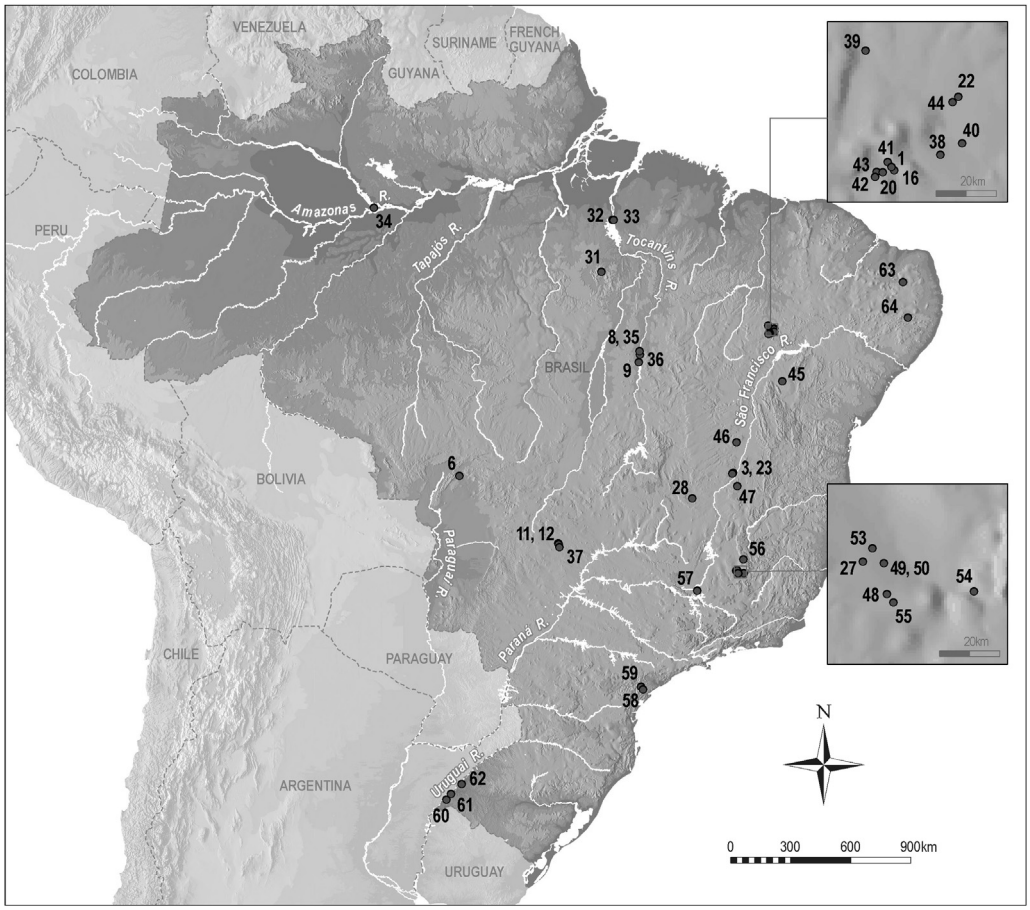

Fig. 5. Sites with reliable dates for the 10th ^{14}C millennium BP, superimposed on a map of surface relief and the major rivers of Brazil.

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variability, a wider range of preserved material remains, and further geographical expansion of the settlement record. It is the first period in which we have a reliably dated and well-preserved representative sample of human remains and well-dated rock art.

In the Amazonian biome there are at least four known occupation events, at sites far remote from one another and in very dissimilar ecological zones (Magalhães, 1994, 2005; Caldarelli et al., 2005; Costa, 2009). Dona Stella is an open-air site located in the middle Amazon basin, near the confluence of the Negro and Solimões rivers. In its older layers, dated to 9460 ± 50 ^{14}C BP, the lithic assemblage contains both unifacial and bifacial tools made of local raw materials (sandstone and quartzite) (Costa, 2009). At the other extreme of the Amazonian biome, near the transition zone with the *cerrado* (savannah), there is evidence of intensive exploitation of forest resources for both technology and subsistence at the Gruta do Pequiá rockshelter site, located in Serra dos Carajás, southwestern Pará State. The lithic assemblage is dominated by informal artefacts made of quartz, with evidence of a bipolar flaking technique (Magalhães, 2005).

During the 10th ^{14}C millennium BP, the Itaparica Tradition reaches its greatest spatial extent in the *cerrado* and *caatinga* biomes of the Central Plateau and Northeast. On the Central Brazilian Plateau there are at least 23 known occupation events, fairly evenly distributed across that time range. With three exceptions – Santa Elina, Morro Furado and Boqueirão do Soberbo – all the occupied sites can be associated with the Itaparica Tradition. In the northeast region at least 18 occupation events are known from this period, again fairly evenly distributed across that time range. With the exception of Abrigo do Pilão, located in the central-eastern part of Bahia State, all of them are located in Serra da Capivara and all contain lithic assemblages that can be assigned to the Itaparica Tradition (Schmitz, 1987; Dias, 1991; Bryan and Gruhn, 1993; Menezes, 2000; Fogaça, 2001, 2003; Bueno, 2007, 2011; Vialou, 2005; Rodet, 2006; Guidon et al., 2009).

Another ecological zone where there is a great increase in the number of occupation events recorded from this period is the inland semi-deciduous (mesophytic) Atlantic forest, with 7 occupation events during the first half of the 10th ^{14}C millenium BP and eight in the second half (Neves et al., 2003, 2004a,b; Araujo and Neves, 2010). The most striking aspect of the archaeological record of this area and period is the presence of human burials in several rock shelters at Lagoa Santa and at Santana do Riacho. In the succeeding, 9th ^{14}C millennium BP human burials have been found at Cerca Grande 6 and 7, Lapa Vermelha IV, Santana do Riacho, Lapa do Braga, and Lapa Mortuária de Confins (Neves and Hubbe, 2005), making this the largest and best preserved sample of human bones that has yet been found in Brazil from this period (Prous, 1991a, 1992/1993; Neves et al., 2003). The associated lithic assemblages are composed mainly of quartz flakes (mostly less than 4 cm long). Most of the tools are informal, with one or two well-defined edges. There is some evidence of hafting, even in these small and mainly unifacially flaked tools. Another tool that is commonly found in the Lagoa Santa rockshelters is the polished hand-axe, made of hematite or igneous rock, which are raw materials not common in the vicinity (Hurt, 1960; Prous, 1991; Pugliese, 2007; Bueno, 2010).

The Gruta do Marinheiro site may mark the northernmost extent of the Umbu Tradition, as the lithic assemblage associated there with a dated sample of 9610 ± 60 BP is composed mainly of flakes, artifacts made of chert and quartzite, and a great variety of small projectile points (Koole, 2007). In southern Brazil during this period Umbu Tradition sites also expand into the Atlantic Forest biomes. Continuity of pampas occupation in Rio Grande do Sul State is attested at three sites with at least four known occupation events: Touro Passo I (9840 ± 105 BP) Pessegueiro (9763 ± 74 BP), Palmito 2 (9250 ± 115 AP) and Touro Passo I (9230 ^{14}C BP) (Miller, 1987; Dias and Jacobus, 2001, 2003).

The earliest evidence of occupation of the Atlantic Forest occurs during this period at two sites, Capelinha and Batatal I, represented by 3 occupation events at 9850 ± 150 ^{14}C BP, 9210 ± 45 ^{14}C BP, and 9050 ± 100 ^{14}C BP (Penin, 2005; Plens, 2007). Both sites are riverine shell mounds located in the Ribeira de Iguape valley, São Paulo State, one of the main river corridors connecting the interior to the Atlantic shore of southeast Brazil. The Capelinha shell mound contained mainly terrestrial gastropod remains, and included human burials. The lithic industries from this area resemble those of the pampas, despite the more than 1000 km which separates the two areas, with predominantly bifacial technologies and a variety of stemmed projectile points made in local raw materials.

4.4. 9th ^{14}C Millennium BP (ca. 10,200–8900 cal BP): rebuilding territories and occupying unexploited landscapes

For the 9th ^{14}C millennium BP there appear to be markedly fewer dates from the cerrado (savannah) biome, while recorded occupancy of the semi-deciduous forest zone region appears to be largely unchanged from the previous period, and settlement of the Amazonian and Atlantic Forest biomes appears to have undergone considerable expansion (Fig. 6 and Table 5). In the savannah, together with a decrease in the quantity of occupation events, there is an abrupt cultural change: in all places where there had been a previous occupation associated with the Itaparica Tradition, we now observe the production of a different lithic assemblages. This shift is associated with a regionalization of lithic technological traditions. There is no longer a dominant pattern for areas that were more than 2000 km apart, as was seen in the previous period. During the 9th ^{14}C millennium BP, lithic assemblages assume regional characteristics and are in almost all cases characterized by the production of informal tools made of local raw materials. However, this is not the only aspect that presents evidence of change. In Toca do Sitio do Meio, a layer dated to 8960 ± 70 ^{14}C BP also contains pottery fragments; although this evidence must be viewed with some caution and more work is needed to clarify the cultural data and stratigraphic provenience before this date can be accepted as marking an initial stage of pottery manufacture. The rock art styles of these areas are also changing (Martin, 1996; Guidon et al., 2009).

These changes are especially evident after 8500 ^{14}C BP. In northeast Brazil, 11 sites are known to have been occupied during the first 500 ^{14}C years of this ^{14}C millennium, but only four between 8500 and 8000 ^{14}C BP. In the Central Brazilian savannah there are 8 occupation events known between 9000 ^{14}C BP and 8500 ^{14}C BP, and just three between 8500 and 8000 ^{14}C BP.

In the central area of Minas Gerais State, in the inland semi-deciduous (mesophytic) Atlantic forest zone, there are increasing numbers of burials in the rock shelters. At Lapa do Santo, for example, 26 burials have been excavated containing 36 individuals, which have yielded seven dates on human bone defining a period of intensive occupation between ca. 8730 and 7400 ^{14}C BP (Strauss, 2010). Another remarkable site of this area and period is Santana do Riacho, which has yielded a sample of 40 individuals of both sexes and varying ages. The bodies were buried in shallow graves and the "burial activities were so intense that several burials were damaged when a pit was dug to bury a new individual" (Neves et al., 2003:28). Burials are also known at other sites in this region, including Cerca Grande 6, Lapa da Amoreira, Lapa da Lagoa Funda, Lapa das Boleiras, Lapa do Baú 2 and Lapa Mortuária de Confins. Apart from this record of increased rates of human burial, the archaeological record maintains the same characteristics as in the previous period. The lithic assemblages are characterized by small informal artefacts made of quartz, there are a few polished tools

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(mostly axes), and the faunal remains suggest the dietary predominance of small and medium game animals. There is no clear evidence of a stratigraphic horizon of marked cultural change in this region, contrasting with what was happening in other areas of Central Brazil formerly associated with the Itaparica Tradition. However, drastic change does occur after 8000 ^{14}C BP, with the abandonment of the great majority of these sites and virtually no evidence of continuing human burial in rockshelters that had been occupied for more than 2000 ^{14}C years. Most of the sites seem to have been abandoned, and for some time after 8000 ^{14}C BP the sample of dated occupation events in this area is sparser than that from the 11th ^{14}C millennium BP (Araujo et al., 2003).

In Amazonia, in contrast, the number of sites increases during this period. From three known occupation events in the first 500 ^{14}C years the sample increases to eight between 8500 and 8000 ^{14}C BP. All sites dated to this period in Amazonia are located in the Serra dos Carajás (Hilbert, 1993; Magalhães, 1994, 2005; Silveira, 1994; Kipnis et al., 2005; Oliveira, 2008).

In the pampas during this period only one occupation event has been recorded, at the Pessegueiro site (8585 ± 115 ^{14}C BP). However, there are five sites with dated occupations in Atlantic Forest biome. In São Paulo State, 9th ^{14}C millennium BP dates are recorded at Capelinha I, and a first occurrence of the Umbu Tradition in the middle Uruguay River valley, southwest of Santa Catarina State, is attested at the open-air site ACH-LP1 (averaged date of 8328 ± 46 ^{14}C BP (Dias and Hoeltz, 2010; Scientia, 2010). In the northeast part of Rio Grande do Sul State, three rockshelter sites have yielded evidence of at least four occupation events: Sangão (8790 ± 40 ^{14}C BP), Pilger (8430 ± 50 ^{14}C BP and 8090 ± 35 ^{14}C BP), and Garivaldino (averaged date of 8101 ± 118 ^{14}C BP) (Ribeiro and Ribeiro, 1999; Dias, 2003, 2012; Dias and Neubauer, 2010). The locations and chronology of these sites suggests that initial human settlement of this area may have been associated with the expansion of the Atlantic Forest biome, formerly restricted to mountain slopes and river valleys. This suggestion is supported by evidence of the preferential exploitation of faunal resources associated with forest environments (Rosa, 2010; Rosa and Jacobus, 2010).

In general, this ^{14}C millennium in Brazil seems to be associated with a transformation of earlier cultural traditions and boundaries. In the savannah there are quantitative and qualitative changes that indicate the rupture or the reconfiguration of ancient connections that had supported, since the Late Pleistocene, an extended communication flow responsible for the maintenance of a spatially extensive lithic technological tradition. Rock art and lithic technology provides evidence of a regionalisation process, possibly accompanied by the abandonment of some places. In Amazonia, there is evidence of denser occupation of the Serra dos Carajás. In the Atlantic Forest region, we can observe the expansion of Umbu Tradition sites throughout the area, accompanying the expansion of this biome. The only region where evidence suggests greater cultural continuity with the previous millennium is the inland semi-deciduous (mesophytic) Atlantic forest zone, where change however does come a few centuries later.

5. Discussion

Between 13,000 and 8000 ^{14}C BP, eastern South America was settled by a stable and diversified population of hunter–gatherers.

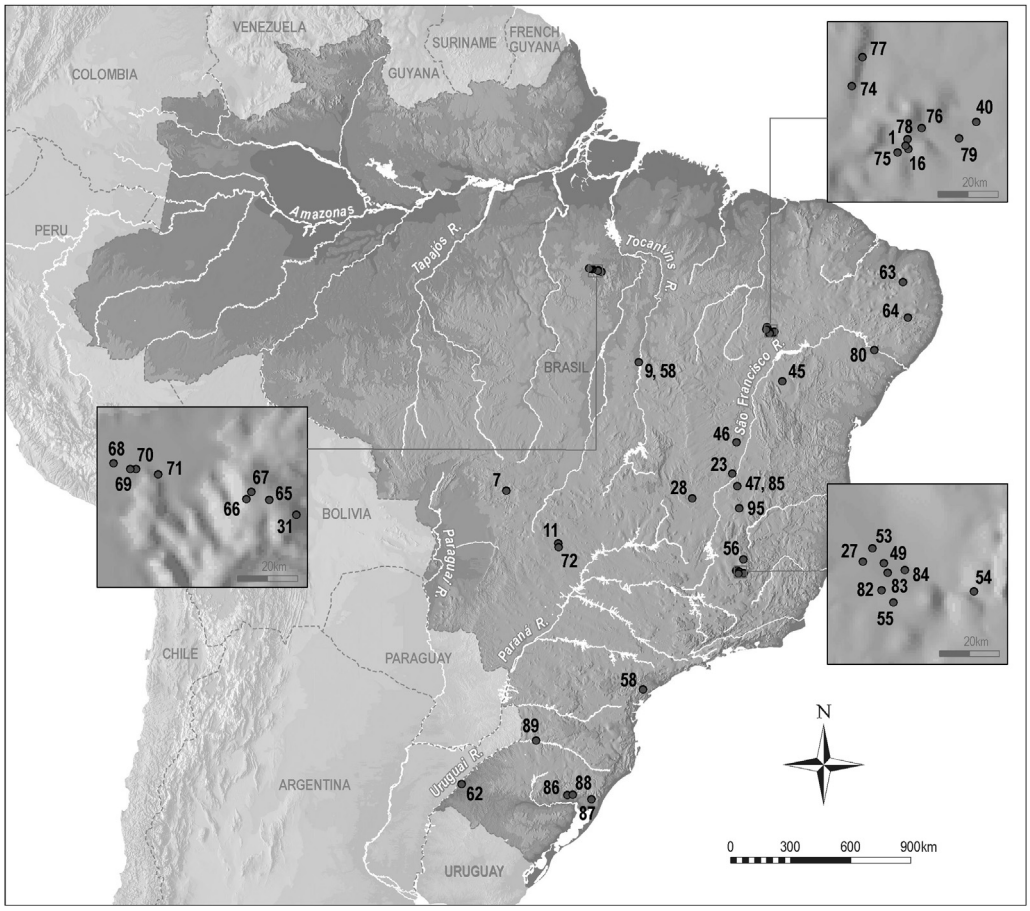

Fig. 6. Sites dated to the 9th millennium in ^{14}C years, superimposed on a map of surface relief and the major rivers of Brazil.

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The predominance of generalist subsistence systems and the great variability of regional styles of lithic industry in this period highlight the limits of classical 'overkill' and 'Clovis-first' models of the peopling of the Americas. In chronological terms, archaeological excavation in the past thirty years has yielded increasingly consistent evidence of occupation in different regions of Brazil since the end of the Pleistocene, with dates at least contemporary to the Clovis Horizon in North America (cf. Faught, 2008; Goebel et al., 2008). On the other hand, the diversity of adaptive strategies suggests that the initial colonization of extra-Andean South America should be characterized as a cultural radiation with multiple dispersal trajectories (e.g. Miotti and Salemme, 2003; Dias, 2004; Borrero, 2006; Lanata et al., 2008; Steele and Politis, 2009; Bueno, 2011). Not all areas were settled simultaneously, and there are geographical areas with little or no evidence of human exploitation throughout the Holocene.

As one hypothesis, we propose that initial populations may have dispersed preferentially along the valleys of large rivers, finding thereby a route inland (Kelly, 2003). This dynamic can promote rapid displacement over long distances, which, in some cases, may explain the existence of almost contemporary sets of sites with similar lithic technologies and rock art styles in both northeastern and mid-western Brazil, as found for example in São Raimundo Nonato and in the Peruaçu Valley (Bueno et al., in press). The existence of such an axial displacement network may have been paralleled by expansion outwards from these axes, but we might expect this to be focused at hot spots in certain areas, which would have been continually re-occupied. This riverine colonization model is a suitable hypothesis in the geographical context of central and northeastern Brazil, and also in south Brazil, where dispersing population may have been channeled along the valleys of the Paraná and Uruguay rivers and their main tributaries, moving both upstream within, and outwards from, those valleys until reaching the Atlantic coast.

We suggest that during the Late Pleistocene in the pioneer phase of human colonization, there would have been a preference for recurrent activity at salient landmarks or orientation points in a landscape that was still being explored, 'mapped' and encoded into knowledge systems. Such a preference would have facilitated navigation, social aggregation, and dispersal into sparsely inhabited or uninhabited landscapes. The valleys of large rivers in the northeastern and central Brazil, in the Amazon, and in the south, seem to have played a key role in this period, concentrating and directing an expansion that quickly reaches new and distant areas without completely filling the vast territory surrounding those known early settlement points. Besides representing key axes of movement and reference points in the landscape, easily located and recognized, these river valleys also provided diverse and abundant resources for subsistence and technology, which would have be very valuable in situations of little or low knowledge of the larger area.

Regarding rates of population expansion and of regional cultural diversification in Brazil's interior, there seems to be an archaeological threshold reached in all occupied regions at ca. 10,500 ^{14}C BP. Numbers of sites increase, there is evidence of settlement of all biomes (except the humid coastal Atlantic Forest) and, most importantly, there is clear evidence of inter-regional cultural diversity. In this sense, the 11th millennium ^{14}C BP represents a transitional period in the first peopling of Brazil. In contrast, from the beginning of the Holocene, human dispersal expands radially along branching routes and in an increasing range of locations, as part of a process of social and cultural construction of a landscape whose geographical structure was now familiar and incorporated into knowledge systems. There is cultural evidence of regional variation, possibly associated with the definition of smaller territories, with greater local density of occupation and (we may infer) regular cycles of annual mobility. In this sense, the Early Holocene was the first phase of established settlement of Brazil's interior.

As noted at the beginning of this paper, we are interested in understanding and modelling large-scale dispersal and settlement processes. This does not involve an archaeological competition to identify the oldest site. The preference is to build a robust and solid corpus of data that makes it possible to discuss how human groups perceived and settled different kinds of environments; how they obtained information when entering unfamiliar landscapes, previously uninhabited; and how they interacted with other groups in moments when environmental stress caused the breakdown of established territorial boundaries. This database is the first step for this discussion and it is being complemented with collations of dates and data from other countries (this volume), to start filling in the gaps in understanding of early human dispersals and settlement history in South America.

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Appendix. Key to Figs. 3–6

ID	Name
1	Toca do Sitio do Meio
2	Toca do Gordo do Garrincho
3	Lapa do Boquete
4	Lapa do Dragao
5	Caverna da Pedra Pintada
6	Santa Elina
7	MT-SL-31 – Morro da Janela
8	Miracema do Tocantins 1
9	Capivara 5
10	Lajeado 18
11	GO-JA-01
12	GO-JA-02
13	GO-JA-14
14	GO-NI-49
15	MS-PA-02
16	Boqueirao da Pedra Furada
17	Toca de Cima do Pilao
18	Toca do Elias
19	Toca do João Leite
20	Sitio Toca dos Coqueiros
22	Boa Vista I
23	Lapa dos Bichos
24	Lapa do Caboblo
25	Lapa do Peixe Gordo
26	Coqueirinho
27	Lapa das Boleiras
28	MG-RP-6 – Lapa do Gentio
29	RS-I-66/Milton Almeida
30	RS-I-69/Laranjito
31	Gruta do Pequiá
32	Breu Branco 1
33	Breu Branco 2
34	Dona Stella

(*continued on next page*)

(*continued*)

ID	Name
35	Miracema do Tocantins 2
36	Mares 2
37	GO-JA-03
38	Toca da Janela da Barra do Antoniao
39	Toca do Morcego
40	Toca do Bojo
41	Caldeirao do Rodrigues
42	Toca do Zé Luis
43	Baixao do Perna I
44	Boa Vista II
45	Abrigo do Pilão
46	Morro Furado (BA-RC-28)
47	MG-VG-11 – Boqueirão Soberbo
48	Lapa Vermelha IV
49	Cerca Grande 6
50	Cerca Grande 7
51	Lapa das Boleiras
53	Lapa do Santo
54	Lapa Grande de Taquaruçu
55	Lapa Mortuária de Confins
56	Santana do Riacho (Abrigo Grande de Santana do Riacho)
57	Gruta do Marinheiro
58	Capelinha
59	Batatal I
60	RS-I-67/Touro Passo I
61	RS-I-72/Palmito 2
62	RS-IJ-67/Pessegueiro
63	Pedra do Alexandre
64	Furna do Estrago
65	Gruta do Gavião
66	Gruta do Rato
67	Gruta da Guarita
68	NV-V
69	N4-WS-017
70	N4-WS-012
71	N4-WS-005
72	GO-JA-26
74	Toca da Ema do sítio do Brás
75	Toca do vento
76	Toca da Baixa da Cabaceira
78	Toca do Fundo do Baixão da Pedra Furada
80	Justino
82	Lapa da Lagoa Funda
83	Lapa do Baú 2
84	Lapa do Sumidouro
85	MG-VG-19 – Barreirinho
87	RS-S-327/Sangão
88	RS-C-61/Adelar Pilger
93	Toca do Pau Dóia
95	Lapa Pequena

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