REPORTS

LAGOA SANTA REVISITED: AN OVERVIEW OF THE CHRONOLOGY, SUBSISTENCE, AND MATERIAL CULTURE OF PALEOINDIAN SITES IN EASTERN CENTRAL BRAZIL

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Lagoa Santa, a karstic area in eastern Central Brazil, has been subject to research on human paleontology and archaeology for 175 years. Almost 300 Paleoindian human skeletons have been found since Danish naturalist Peter Lund's pioneering work. Even so, some critical issues such as the role of rockshelters in settlement systems, and the possible paleoclimatic implications of the peopling of the region have yet to be addressed. We present some results obtained from recent excavations at four rockshelters and two open-air sites, new dates for human Paleoindian skeletons, and a model to explain the cultural patterns observed so far. It is also argued that the Paleoindian subsistence system at Lagoa Santa was similar to other locations in South America: generalized small-game hunting complemented by fruits, seed, and root gathering.

Lagoa Santa, un área kárstica en Brasil Central, ha sido objeto de investigación en paleontología humana y arqueología durante 170 años. Casi 300 esqueletos humanos paleoindios se han encontrado desde que el naturalista dinamarqués Peter Lund empezó su trabajo pionero en la mitad del siglo XIX. Sin embargo, problemas críticos como el papel de las cuevas en los patrones de asentamiento y las posibles implicaciones paleoclimáticas en el poblamiento del área todavía tienen que ser mejor estudiados. Nosotros presentamos los resultados obtenidos de las recientes excavaciones de cuatro cuevas y dos yacimientos a cielo abierto, nuevas feches de esqueletos humanos paleoindios, y un modelo para explicar los patrones culturales observados. También propone mas que el sistema de subsistencia paleoindio en Lagoa Santa fue, así como en otros sitios de Sudamérica, bastante generalizado, incluyendo la caza de pequeños animales y la recolección de frutos, semillas y raíces.

The Lagoa Santa region is a karstic area encompassing several counties near the city of Belo Horizonte, State of Minas Gerais (Figure 1). The geological setting comprises mainly Upper Pre-Cambrian metasedimentary rocks of the Bambuí Group (Instituto Brasileiro do Meio Ambiente and Centro de Pesquisas de Recursos Minerais [IBAMA/CPRM] 1998). The Bambuí Group is composed of a basal metacalcareous body—Sete Lagoas Formation—and an upper metapelitic formation called Serra de Santa Helena Formation. Hydrothermal solutions cutting the Pre-Cambrian rock bodies produced siliceous veins and geodes, many of them with hyaline quartz that were heavily used as raw materials by the local Paleoindians. Weathering of Serra de Santa Helena Formation produces most oxisols found in the region (Piló 1998), whereas the Sete Lagoas Formation limestones, because of their purity, are almost completely leached, forming caves, dolines, and other karstic features.

Vegetation today comprises patches of savanna ("cerrado"), and deciduous ("mata seca") and semideciduous forests (Instituto Brasileiro de Geografia e Estatística [IBGE] 1992).

This is one of the most widely known archaeological regions of Brazil, and a key area for understanding the peopling of the Americas. Thanks to the Danish naturalist Peter W. Lund, who visited several hundreds and excavated many dozens of rockshelters and caves during the mid-nineteenth century, Lagoa Santa became internationally

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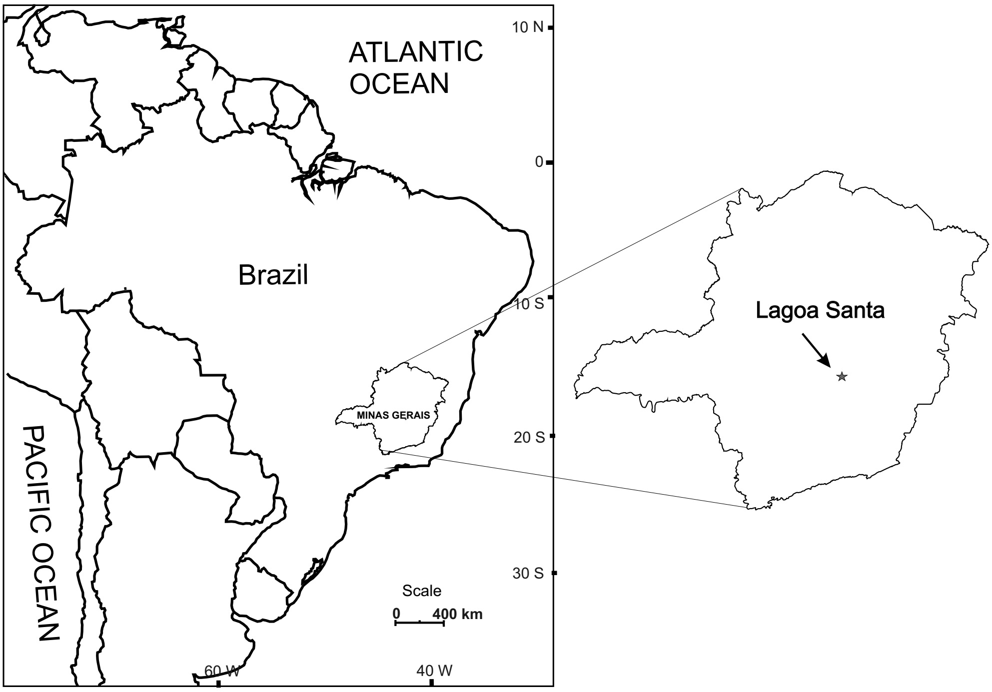

Figure 1. Lagoa Santa area and its location in Brazil.

known as the first place in the Americas where the co-occurrence of humans and extinct animals was thought to deserve further investigations (Walter 1948:21, 1958:106).

Lund also realized that the human skeletons found in Sumidouro cave were not "typical Amerindians," now a well-accepted assertion among biological anthropologists (Chatters et al. 1999; Hubbe et al. 2010; Jantz and Owsley 2001; Neves and Hubbe 2005; Neves et al. 2007; Neves, Powell, and Ozolins 1999; Neves and Pucciarelli 1989, 1991; Powell and Neves 1999; Steele and Powell 1992).

After Lund's death in 1880, the interest in the region decreased somewhat, with excavations being resumed only in the beginning of the twentieth century, mostly by other naturalists and amateurs (see Mello e Alvim et al. 1977 and Neves and Piló 2008 for a more detailed account of previous research in the region).

In the 1950s, Wesley Hurt and Oldemar Blasi carried out the first professional diggings in Lagoa Santa. Their primary goal was to test the long-held idea of the co-occurrence in time of humans and megafauna in the region, as suggested by Lund in 1844, using standard archaeological procedures for the first time.

Lapa das Boleiras and Cerca Grande VI rockshelters were the most prominent sites excavated by Hurt and Blasi (1969). In Cerca Grande VI, they generated the first absolute dates for the region (around 9700 B.P., or 11,200 cal B.P.), which corroborated the hypothesis that humans were in Lagoa Santa at least since the beginning of the Holocene. However, by the end of their research, both scholars were very skeptical about the contemporaneity between humans and megafauna in Lagoa Santa, because no skeletal remains of extinct animals were found in the sites they excavated.

Between 1971 and 1976, a French Brazilian team carried out large scale archaeological investigations in Lagoa Santa. Anette Laming-Emperaire and associates were responsible for the excavation at Lapa Vermelha IV rockshelter (Laming-Emperaire et al. 1975). It was only with the excavations at Lapa Vermelha IV that a human occupation extending back to the Late Pleistocene was formally suggested for Lagoa Santa. Furthermore, the issue regarding the contemporaneity between humans and extinct fauna in the region was resurrected by the French Brazilian mission: bones and dung of a small ground sloth (*Catonyx cuvieri*) were found at Lapa Vermelha IV at levels dating back to 9580 ± 200 (GIF 3208; wood charcoal; 11,450 to 10,250 cal B.P.), while a human skeleton (Lapa Vermelha IV Hominid 1, or "Luzia") was found in layers dating to between 10,220 ± 220 and 11,680 ± 500 radiocarbon years B.P. (11,264 to 15,145 cal B.P. [Laming-Emperaire et al. 1975; Prous 1986; Prous and Fogaça 1999]). Later the "Luzia" human remains were directly dated (bone collagen) by AMS, resulting in a minimum age of 9330 ± 60 (Beta 84439; bone collagen; 10,298 to 10,701 cal B.P.—Neves et al. 1998; Neves, Powell, and Ozolins 1999; Neves, Powell, Prous, et al. 1999). Since then, despite the capital importance of Lagoa Santa for the understanding of the peopling of the Americas, no large-scale archaeological operation was carried out in the region (but see Prous et al. 1998 for a more recent comprehensive site inventory for the area).

In 2000, a long-term paleoanthropological project headed by one of us (WAN), was initiated in the region. Three limestone rockshelters, Lapa das Boleiras, Cerca Grande VI, and Lapa do Santo were chosen as focal sites, with excavations beginning in 2001; the first two because the work carried out by Hurt and Blasi (1969) revealed the occurrence of early human skeletal remains; the third because of its excellent preservation (most archaeological sites in Lagoa Santa are seriously damaged by amateur excavations and/or limestone commercial mining). A fourth limestone rockshelter, Lapa Grande de Taquaraçu, was excavated later, starting in 2003, to assess the role of water availability in the human settlement choices.

In 2004, we started the excavation of a paleontological site, named Cuvieri Cave, to have a better grasp of the faunal response to climatic changes, and assess the chronology and relationship between humans and megafauna. After 2005, our efforts were also directed toward finding and characterizing early open-air sites, because the well-established chronology obtained inside the rockshelters had no correlate outside. By means of an intensive subsurface prospection program, we were able to detect two Paleoindian sites on the shores of Sumidouro Lake, named Sumidouro and Coqueirinho.

In this article, we present the results of our investigations and elaborate on their implications for long-held discussions about the Paleoindians[1] of Lagoa Santa. A tentative model, relating cultural, biological, and environmental pieces of evidence, is also suggested as a framework to help the organization of future work in the area, and as a heuristic device to advance the interpretation of the local archaeological record.

Lapa das Boleiras Rockshelter

Lapa das Boleiras is part of a limestone outcrop facing two sinkholes, one of them active today as a swallet of an intermittent stream. The sheltered area is 43 m long and 12 m wide, aligned roughly north–south, with an area of 280 m^2 (Figure 2). The shelter's mouth faces west, and its floor is slightly inclined (12 percent) toward the north. A colluvial fan can be observed to bring red colluvial material from above the outcrop into the southern portion of the sheltered area.

The site was first excavated by avocational archaeologists in the early twentieth century and later by a team of professional archaeologists in 1956 (Hurt and Blasi 1969). Between 2001 and 2003, our team excavated a total of 21 m^3. Excavations detected generally well-stratified human burials, abundant lithic and bone artifacts, and common faunal and plant remains. The stratigraphy, chronology, and formation processes at the site are discussed at length elsewhere (Araujo et al. 2008). The Paleoindian occupation was dated both by radiocarbon and OSL, with ages ranging between 10,150 ± 130 B.P. (Beta 168451; wood charcoal; 12,380 to 11,240 cal B.P.) and 7560 ± 110 B.P. (Beta 159243; wood charcoal; 8560 to 8160 cal B.P.) (see Table 1 for details).

Lapa do Santo Rockshelter

Lapa do Santo is a sheltered entrance of a cave, 70 m long and 20 m wide, with its mouth opening toward the west, and comprising an area of 1,300 m^2 (Figure 3). The site is very well preserved, because treasure hunters, naturalists, amateurs, and professional archaeologists never carried out any kind of intrusive activities inside the rockshelter. At the time of our first visit to the Lapa do Santo, fragmented human bones could be found at the surface, exposed by water dripping from the roof. The site began to be excavated in 2001, and works terminated in 2009.

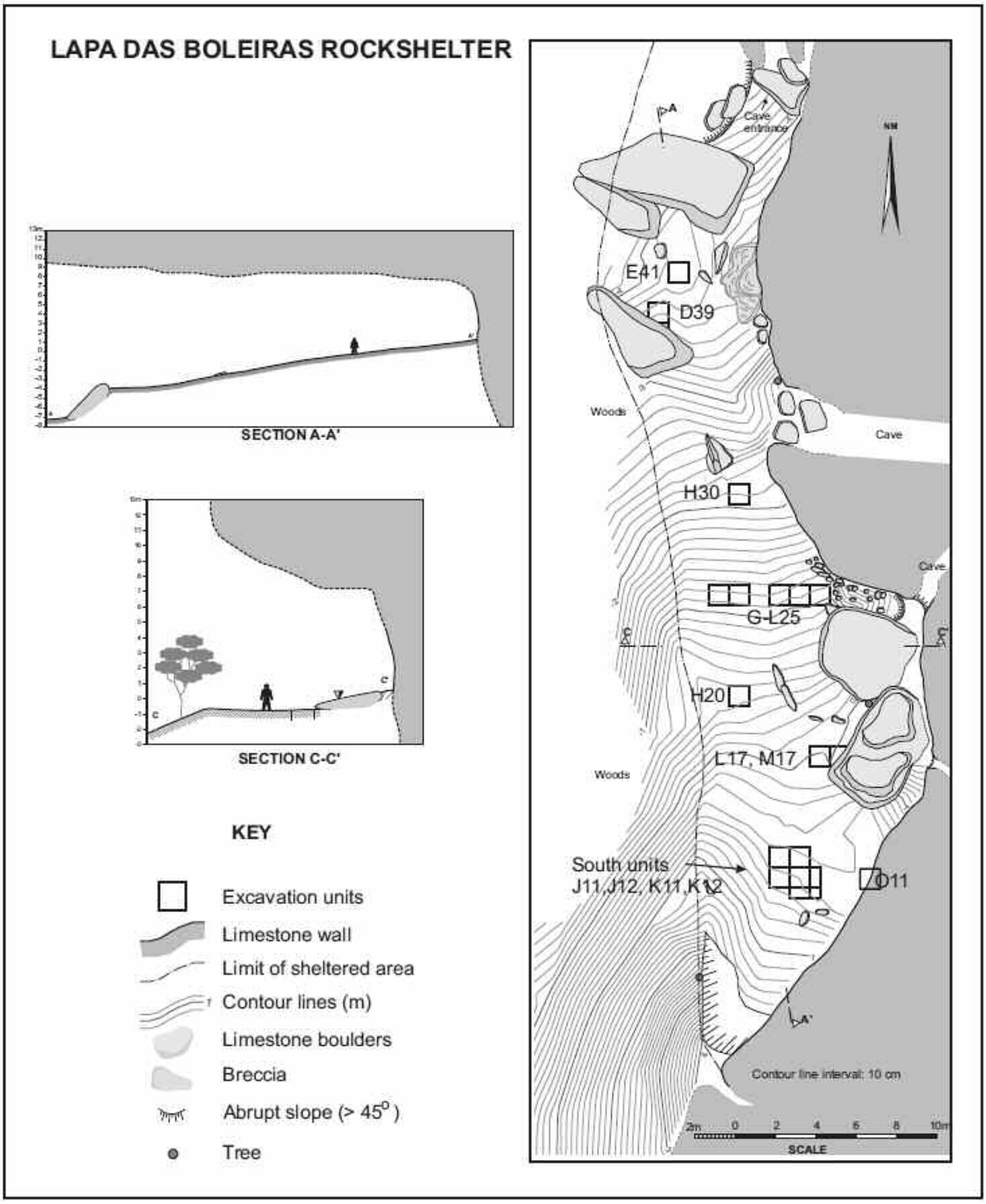

Figure 2. Lapa das Boleiras rockshelter.

An area of 44 m^2 was excavated. The site showed a deep stratigraphy, reaching more than 4 m in its deepest portion. The sediments, although not yet subject to more detailed geochemical and micromorphological studies, bear a strong resemblance to those of Lapa das Boleiras. In both cases the archaeological package is composed mainly of debris related to anthropogenic activities (mostly wood ash, see Araujo et al. 2008). Sixty-two radiocarbon ages were obtained for this site. Ages for the Paleoindian occupation range between 10,490 ± 50 B.P. (Beta 280489; wood charcoal; 12,680 to 12,350 cal B.P., 12,320 to 12,240 cal B.P.) and 7890 ± 40 B.P. (Beta 214142; wood charcoal; 8970 to 8910 cal B.P., 8870 to 8830 cal B.P., and 8790 to 8590 cal B.P.) (Table 2).

Table 1. Radiocarbon Ages for Lapa das Boleiras.

Sample	Lab number (Beta)	Material	Conventional ^{14}C age (years B.P.)	^{13}C / ^{12}C ratio (‰)	Calibration 2σ[a]
BL-H20-C1	162529	plant material	140 ± 40	−28,3	290 to 0 cal B.P.
BLD39NO.07	159237	charred material	160 ± 70	−25,0	310 to 0 cal B.P.
BLL25NO.01	159231	charred material	180 ± 40	−26,3	300 to 240 cal B.P.,
					230 to 70 cal B.P.,
					40 to 0 cal B.P.
BLE41NO.04	159234	charred material	210 ± 60	−25,0	430 to 380 cal B.P.,
					320 to 60 cal B.P.,
					40 to 0 cal B.P.
BL-M17-G	162530	organic sediment	810 ± 40	−16,4	780 to 670 cal B.P.
BLE41NO.05	159235	charred material	3830 ± 60	−25,0	4420 to 4080 cal B.P.,
					4030 to 4010 cal B.P.
BLK10NO.13	159243	charred material	7560 ± 110	−25,0	8560 to 8160 cal B.P.
BOLOSSO-S3	178554	Human bone	8190 ± 40	−19,1	9270 to 9020 cal B.P.
BLL25NO.02	159232	charred material	8240 ± 50	−25,3	9410 to 9030 cal B.P.
BOLSEP3DENTE	179815	Human tooth	8280 ± 50	−23,4	9440 to 9115 cal B.P.
MN 1390 (SEP 1)	155659	Human bone	8300 ± 50	−20,8	9460 to 9130 cal B.P.
BLK12NO.14	159244	charred material	8360 ± 50	−25,4	9490 to 9270 cal B.P.
MN1389 (SEP 2)	155658	Human bone	8420 ± 100	−17,9	9180 to 9140 cal B.P.
BLO116	221456	charred material	8510 ± 60	−26.7	9550 to 9450 cal B.P.
BLO113	221453	charred material	8530 ± 60	−25.9	9560 to 9460 cal B.P.
BLO114	221454	charred material	8570 ± 60	−27.2	9600 to 9490 cal B.P.
BL011NO.15	159245	charred material	8730 ± 110	−25,0	10,170 to 9520 cal B.P.
BLO109	221452	charred material	8730 ± 70	−23.5	10,110 to 10,080 cal B.P.,
					9930 to 9540 cal B.P.
BL-101	183563	charred material	8750 ± 50	−25,6	9920 to 9560 cal B.P.
BL-102/105	183564	charred material	8750 ± 50	−25,9	9920 to 9560 cal B.P.
BLO166	221459	charred material	8810 ± 60	−24.8	10150 to 9600 cal B.P.
BLK10NO.12	159242	charred material	8820 ± 150	−25,0	10240 to 9520 cal B.P.
BLO106	221451	charred material	8980 ± 60	−26.5	10,230 to 10,100 cal B.P.,
					10,090 to 9920 cal B.P.
BLO117	221457	charred material	9060 ± 60	−26.9	10,260 to 10,160 cal B.P.
BLH20NO.03	159233	charred material	9210 ± 130	−25,0	10,700 to 10,170 cal B.P.
BLO167	221460	charred material	9420 ± 60	−26.7	11,030 to 10,980 cal B.P.,
					10,750 to 10,510 cal B.P.
BLL17NO.06	159236	charred material	9600 ± 60	−25,8	11,170 to 10,710 cal B.P.
DENTO3-SEPBL	178556	Human tooth	9640 ± 50	−23,5	10,980 to 10,750 cal B.P.
BLO118	221458	charred material	9650 ± 60	−26.4	11,190 to 10,750 cal B.P.
BLK11N.1	168449	charred material	9850 ± 40	−24,3	11,270 to 11,190 cal B.P.
BLK12N.1	168451	charred material	10,150 ± 130	−25,0	12,380 to 11,240 cal B.P.
BLL11N.3	168457	charred material[b]	12,240 ± 50	−25,2	15,310 to 14,640 cal B.P.,
					14,370 to 14,090 cal B.P.,
					13,880 cal B.P.

[a]INTCAL 04 Radiocarbon Age Calibration.

[b]Charcoal fragment not directly associated with archaeological material.

Cerca Grande VI Rockshelter

Cerca Grande VI, another large rockshelter, with its mouth opening toward the north, is 35 m long and 30 m wide, with a sheltered area of 1,040 m^2. When excavated by Hurt and Blasi in 1956, the rockshelter was already partially destroyed by mining operations (Hurt 1960:579). The authors found a large number of human skeletons, most of them fragmentary, but could differentiate at least 11 human burials. They published two radiocarbon ages for the site: 9028 ± 120 B.P. (10,500 to 9700 cal B.P.) and 9720 ± 128 B.P. (11,500 to 10,650 cal B.P.) (Hurt and Blasi 1969:31), both of them on charcoal. More recently, we were able to date bone collagen from two of the skeletons recovered by

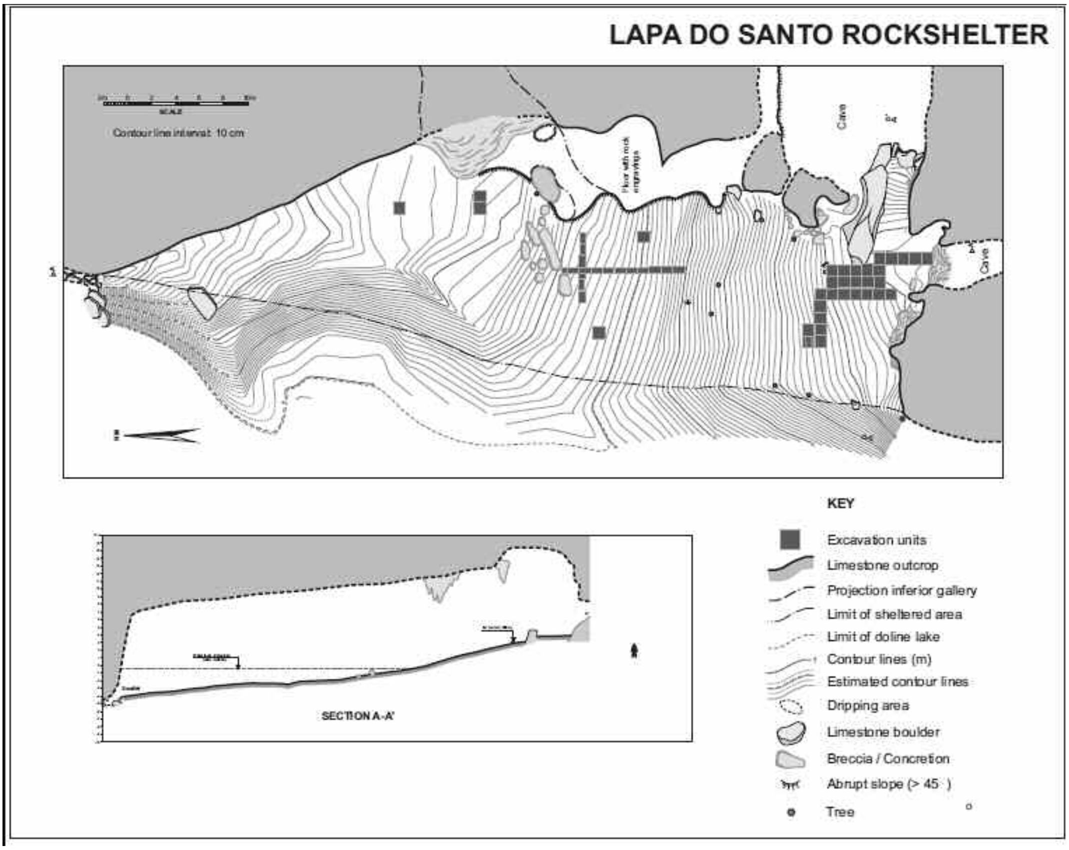

Figure 3. Lapa do Santo rockshelter.

Hurt and Blasi: 8230 ± 50 B.P. (Beta 161666; bone collagen; 9400 to 9340 cal B.P. and 9320 to 9030 cal B.P.) and 8240 ± 40 B.P. (Beta 161668; bone collagen; 9400 to 9360 cal B.P. and 9310 to 9050 cal B.P.) (Table 3; see also Neves et al. 2004).

At the time of our intervention, the sediment at the rockshelter seemed to have been completely removed, with the possible exception of a small parcel underneath a limestone boulder. Four units were dug inside the shelter, another three outside the sheltered area. Our excavations confirmed that the original stratigraphy of the site had been seriously disturbed, and deserved no further excavations. The only sign of human occupation found outside the sheltered area was a unifacial tool ("limace"), on the surface, with no stratigraphic context.

Lapa Grande de Taquaraçu Rockshelter

This rockshelter is located in a somewhat different setting, in an isolated limestone outcrop, outside the main karstic area, and close to a major river. The site is 30 m long and 9 m wide, opening toward the west, with a sheltered area of 255 m^2. The excavated area comprises 7 m^2. The archaeological sediments at Taquaraçu showed the same pattern observed both at Lapa das Boleiras and Lapa do Santo: they are mainly anthropogenic, composed almost totally of wood ash, albeit in some levels with a very small silt and clay contribution from the adjacent river. The archaeological stratigraphy reaches a maximum depth of 1 m. Ages obtained for the Paleoindian levels range between 9990 ± 60 B.P. B.P. (11,750 to 11,250 cal B.P.) and 8080 ± 40 B.P. (9050 to 8990 cal B.P.) (Table 4).

Sumidouro and Coqueirinho Sites

Sumidouro and Coqueirinho are the only open-air sites ever found in Lagoa Santa whose ages fell within the Paleoindian chronological interval. Both sites are located on the shores of Sumidouro

Table 2. Radiocarbon Ages for Lapa do Santo.

Sample	Lab number (Beta)	Material	Conventional ^{14}C age (years B.P.)	$^{13}C/^{12}C$ ratio (‰)	Calibration 2σ[a]
Sep 2	253497	Human bone	790 ± 40	−19.2	780 to 670 cal B.P.
LST45	202764	charred material	910 ± 50	−25.6	930 to 710 cal B.P.
ST-47	183572	charred material	960 ± 70	−25.0	980 to 720 cal B.P.
ST-A1753	280491	charred material	1080 ± 40	−26.6	1060 to 930 cal B.P.
LST59	202766	charred material	3810 ± 50	−26.0	4400 to 4080 cal B.P., 4030 to 4010 cal B.P.
LST58	202765	charred material	3820 ± 100	−25.7	4510 to 4480 cal B.P., 4440 to 3910 cal B.P.
ST-10	183570	charred material	3830 ± 40	−25.5	4400 to 4100 cal B.P.
LSt04	216517	charred material	3930 ± 40	−24.9	4500 to 4480 cal B.P., 4440 to 4250 cal B.P.
359	243393	charred material	3950 ± 40	−23.4	4520 to 4460 cal B.P., 4450 to 4290 cal B.P.
LST6	214129	charred material	3960 ± 40	−26.7	4520 to 4290 cal B.P.
ST-72	183574	charred material	4010 ± 130	−25.0	4840 to 4100 cal B.P.
LSt50	216521	charred material	4070 ± 60	−25.0	4820 to 4420 cal B.P.
335	243392	charred material	4140 ± 40	−26.3	4830 to 4530 cal B.P.
LST73	202768	charred material	4290 ± 90	−25.7	5050 to 4580 cal B.P.
Santo - 1431	248891	charred material	4470 ± 40	−24.5	5300 to 4960 cal B.P.
Sep 11	215195	Human bone	5990 ± 40	−20.6	6900 to 6730 cal B.P.
Sep 7B	215194	Human bone	7400 ± 40	−18.9	8330 to 8160 cal B.P.
Sep 19	215200	Human bone	7700 ± 40	−18.6	8560 to 8400 cal B.P.
LST760	214142	charred material	7890 ± 40	−25.1	8970 to 8910 cal B.P., 8870 to 8830 cal B.P., 8790 to 8590 cal B.P.
LSF13NO.16	159246	charred material	7940 ± 50	−26.5	8990 to 8630 cal B.P.
Santo - 1696	248893	charred material	8170 ± 50	−25.2	9280 to 9010 cal B.P.
ST-62	183573	charred material	8230 ± 50	−25.8	9400 to 9340 cal B.P., 9320 to 9030 cal B.P.
Sep 14	215196	Human bone	8230 ± 40	−22.4	9380 to 9370 cal B.P., 9300 to 9040 cal B.P.
LST63	202767	charred material	8530 ± 40	−26.5	9550 to 9490 cal B.P.
Sep26	253511	Human bone	8540 ± 50	−19.8	9550 to 9480 cal B.P.
Sep 17	265182	Human bone	8580 ± 50	−19.0	9590 to 9490 cal B.P.
ST-40	183571	charred material	8600 ± 160	−25.0	10,150 to 9280 cal B.P.
LST15	202763	charred material	8600 ± 50	−26.8	9660 to 9510 cal B.P.
LSt736	216523	charred material	8620 ± 40	−26.0	9660 to 9530 cal B.P.
Sep 17	253507	Human bone	8660 ± 50	−19.0	9710 to 9540 cal B.P.
LST89	214131	charred material	8670 ± 40	−26.8	9720 to 9540 cal B.P.
LSt21	216519	charred material	8690 ± 40	−26.2	9740 to 9550 cal B.P.
LST100	214133	charred material	8700 ± 40	−26.0	9760 to 9550 cal B.P.
LSt759	216524	charred material	8710 ± 40	−24.8	9860 to 9860 cal B.P., 9780to 9550 cal B.P.
LST726	214136	charred material	8710 ± 80	−25.8	10,110 to 10,080 cal B.P., 9930 to 9530 cal B.P.
Sep 14	253505	Human bone	8730 ± 50	−19.6	9900 to 9550 cal B.P.
LST712	214135	charred material	8750 ± 40	−25.4	9900 to 9570 cal B.P.
LST94	214132	charred material	8790 ± 40	−24.8	10,120 to 10,070 cal B.P., 9920 to 9670 cal B.P.
ST-A1751	280490	charred material	8790 ± 40	−26.2	10,120 to 10,070 cal B.P., 9920 to 9670 cal B.P.
LSt71	216522	charred material	8800 ± 40	−26.3	10,120 to 10,070 cal B.P., 9940 to 9690 cal B.P.
LSt48	216520	charred material	8810 ± 90	−26.3	10,190 to 9550 cal B.P.

Table 2 (continued). Radiocarbon Ages for Lapa do Santo.

Sample	Lab number (Beta)	Material	Conventional ^{14}C age (years B.P.)	$^{13}C/^{12}C$ ratio (‰)	Calibration 2σ[a]
LST731	214137	charred material	8820 ± 40	–26.3	10,140 to 10,000 cal B.P., 9960 to 9710 cal B.P.
Sep 1	271249	Human bone	8840 ± 60	–18.1	10,180 to 9680 cal B.P., 8230 to 7730 cal B.P.
LST711	214134	charred material	8870 ± 100	–24.1	10,220 to 9570 cal B.P.
ST-A1734	280487	charred material	8890 ± 40	–24.2	10,180 to 9890 cal B.P.
LSF13NO.17	159247	charred material	8880 ± 50	–26.4	10,190 to 9770 cal B.P.
364	246246	charred material	8900 ±40	–24.9	10,190 to 9900 cal B.P.
LST738	214139	charred material	8930 ± 40	–25.9	10,200 to 9920 cal B.P.
LST744	214140	charred material	8930 ± 40	–25.2	10,200 to 9920 cal B.P.
LST751	214141	charred material	8980 ± 40	–26.1	10,220 to 10,140 cal B.P., 10,000 to 9960 cal B.P.
LSt19	216518	charred material	9100 ± 40	–24.1	10,260 to 10,200 cal B.P.
LST762	214143	charred material	9150 ± 40	–24.8	10,400 to 10,220 cal B.P.
ST-A1740	263885	charred material	9370 ± 40	NA	10,700 to 10,500 cal B.P.
ST-A1737	263883	charred material	9470 ± 50	NA	11,060 to 11,020 cal B.P., 11,010 to 10,960 cal B.P., 10,800 to 10,580 cal B.P.
LS1475	256223	charred material	9520 ± 60	–24.9	11,150 to 10,550 cal B.P.
ST-A1724	263882	charred material	9650 ± 50	–25.6	11,200 to 11,050 cal B.P., 11,040 to 10,780 cal B.P.
ST-A1738	263884	charred material	9680 ± 50	–23.1	11,210 to 11,070 cal B.P., 10,960 to 10,860 cal B.P., 10,840 to 10,810 cal B.P.
ST-A1739	280488	charred material	9720 ± 40	22.2	11,220 to 11,100 cal B.P.
LST77	214130	charred material	9900 ± 40	–23.7	11,320 to 11,210 cal B.P.
LST734	214138	charred material	10,070 ± 100	–23.0	12,310 to 11,230 cal B.P.
LS1488	256224	charred material	10,130 ± 60	–28.0	12,050 to 11,400 cal B.P.
ST-A1745	280489	charred material	10,490 ± 50	–23.2	12,680 to 12,350 cal B.P., 12,320 to 12,240 cal B.P.

[a]INTCAL 04 Radiocarbon Age Calibration.

Table 3. Radiocarbon Ages for Cerca Grande VI.

Sample	Lab number	Material	Conventional ^{14}C age (years B.P.)	$^{13}C/^{12}C$ ratio (‰)	Calibration 2σ[a]
MN-1329	Beta 161666	Human bone	8230 ± 50	–20.8	9400 to 9340 cal B.P., 9320 to 9030 cal B.P.
MN-1369	Beta 161668	Human bone	8240 ± 40	–25.7	9400 to 9360 cal B.P., 9310 to 9050 cal B.P.
Level 2 and 3	P 519b	charcoal	9028 ± 120	NA	10,500 to 9700 cal B.P.
Level 6 and 7	P 521b	charcoal	9720 ±128	NA	11,500 to 10,650 cal B.P.

[a]INTCAL 04 Radiocarbon Age Calibration. b Applied Center for Archaeology, University of Pennsylvania.

Lake, a karstic depression ("polje"). Coqueirinho was found during a surface survey, and Sumidouro by means of deep augering. Both sites were excavated by means of several 1-m^2 units, and their stratigraphy is the result of a complex interplay between tropical soil processes and bioturbation. Radiocarbon ages obtained for the Paleoindian occupation were 10,460 ± 60 B.P. (Beta 237346; wood charcoal; $\delta^{13}C$ = –25.1 ‰; 12,690 to 12,090 cal B.P.) for Coqueirinho, and 8310 ± 40 B.P. (Beta 205351; wood charcoal; $\delta^{13}C$ = –25.3 ‰; 9450 to 9240 cal B.P.) for Sumidouro. We also obtained

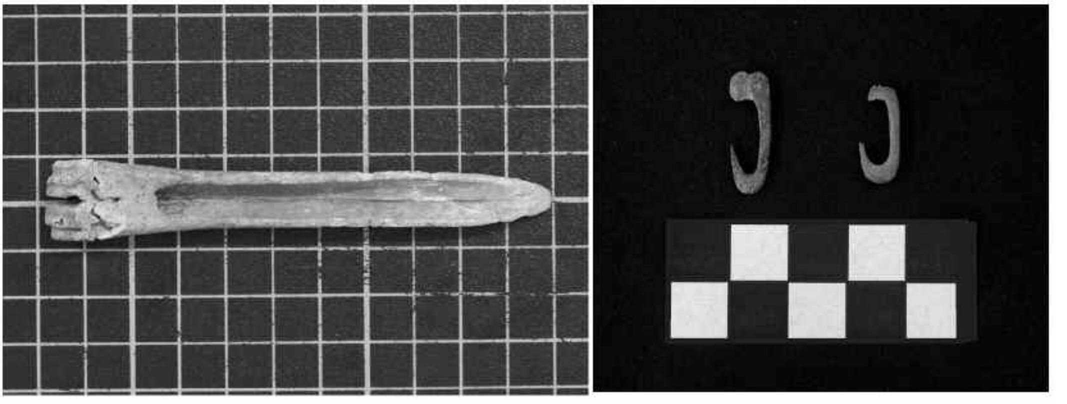

Figure 4. Examples of bone artifacts associated to Paleoindian occupations (Lapa das Boleiras): Left: spatula; right: fish hooks.

OSL ages for the Paleoindian levels of Sumidouro to 9.9 ± .7 ka (1.37-m depth), 10.1 ± .7 ka (1.60-m depth), and 12.5 ± .9 ka (1.96-m depth) (Araujo and Feathers 2008).

Material Culture, Burial Practices, and Subsistence: An Overview

All Paleoindian sites showed a similar lithic industry. In the case of rockshelters, the similarity also extends to bone artifacts, burial practices, and subsistence. Cerca Grande VI, because of its destruction, did not provide a reliable sample, and will not be considered here, although the data published by Hurt (1960; Hurt and Blasi 1969) confirms the pattern.

Lithics and Bone Artifacts

The lithic industry found at the sheltered sites of Lapa das Boleiras, Lapa do Santo, and Lapa de Taquaraçu shows mainly a generalized core technology (sensu Teltser 1991). Beltrão (1975:130) undertook an analysis of lithics found in a 1971 fieldwork, and described the industry as "poor both from the technological and functional points of view." The industry comprises mainly unretouched, small-sized quartz flakes (mean length around 22 mm), the older levels showing a discrete contribution of chert as well. Less than 1 percent of the flakes were retouched, and less then 5 percent showed macroscopic use-wear. Although an amateur archaeologist supposedly found some formal artifacts (bifacial points) in the region (Walter 1948, 1958), after eight years of intensive work we found only one broken tip of a bifacial point at the lower level of Coqueirinho Site, and a single "limace" in the lower level of Taquaraçu. We therefore have reasons to believe that these extremely rare formal artifacts derive from early Paleoindian forays into the area, perhaps unrelated to the massive occupation that took place after 12,000 years B.P.[2]

Milky, translucent, and hyaline quartz were used during the whole Paleoindian occupation. At Lapa das Boleiras, 91 percent of the lithics were made of quartz, and at Lapa do Santo, 86 percent (Pugliese 2007). The chert is of very good quality, always heat-treated, but never used to make formal artifacts, and its frequency in the industries lies between 5 and 7 percent. Polished stone blades were also part of the toolkit, made of igneous and metamorphic rocks, some of them of iron ore. The polishing was usually careful along the edges, but very rough in the body of the blade (see Beltrão 1975:126; Evans 1950:342).

Besides lithic tools and debitage, bone artifacts were also found inside the rockshelters, albeit in very low frequencies. At least three types of bone artifacts could be clearly defined: perforators, spatulas, and fish hooks (Figure 4) (Kipnis et al. 2009). No projectile points made on bone were found; the bone artifacts Evans (1950:352) and Hurt (1960:583) call "points" are most probably perforators and spatulas.

The lithic industries of the two open-air sites, Sumidouro and Coqueirinho, are still under analysis but their general characteristics are very similar to what we have found at the rockshelters.

Figure 5. One of the Paleoindian secondary burials from Lapa do Santo: Burial 17, showing a human skull filled with hand, scapula and sawed long bones, dated at 8660 ± 50 B.P. (9710 to 9540 cal B.P., Beta 253507).

Human Burial Practices

For reasons still unknown, Paleoindians started to bury their dead systematically in the rockshelters of Lagoa Santa only about 8500 ^{14}C years B.P. (around 9500 years cal B.P.). The destination of the dead before that is completely unknown. Luzia (from Lapa Vermelha IV), whose estimated age is around 11,000 years cal B.P., was not formally buried but, at best, only deposited in a natural protected niche. If Luzia can be used as a standard to infer burial practices before 9500 years B.P., it is possible that the use of naturally protected niches within caves and fissures to dispose the corpses could have been regularly used by early humans in the region. Thousands of these niches are available in Lagoa Santa, and looking for early human skeletons would be like searching for a needle in a haystack.

Information about burial practices post dating 9500 years B.P. has been available for Lagoa Santa since the beginning of the twentieth century. Naturalists, amateurs, and professional archaeologists and paleontologists working in the region have recovered at least 300 human skeletons from the local rockshelters and caves. Nearly all sites tested and/or excavated in Lagoa Santa revealed ancient human skeletal remains, mostly in a good state of preservation. This vast material shows a diversity of funerary practices. However, some common characteristics can be emphasized: high frequency of secondary burials (Figure 5); highly flexed bodies in the case of primary burials; small limestone slabs used to cover (and probably to mark) the burial pits; shallow graves; frequent disturbance of previous burials to accommodate new corpses; extensive use of red ocher; intentional removal of long bone epiphyses (and sometimes diaphyses) for unknown purposes; partial burning of bones, with complete cremation rarely found; and meager (if any) deposition of objects of personal use and mortuary offers in the graves (primary and secondary) (see Strauss 2010 for a comprehensive analysis of mortuary practices). Another common practice during the late Paleoindian occupation of Lagoa Santa was to bury the dead around large slabs or boulders collapsed from the rockshelter's roof (Prous 1991), if available. For a case of a highly elaborated secondary burial see Neves et al. (2002).

Subsistence

Recent zooarchaeological analyses carried out at Paleoindian sites throughout eastern South America tend to show the same pattern of heavy reliance on medium to small-sized prey, such as cervids, peccaries, armadillos, turtles, lizards, rodents, birds, fish, amphibians, and terrestrial gastropods (Jacobus 2004; Kipnis 2002, 2009; Rosa 2004).

At Lagoa Santa, the same pattern was observed. The most abundant species found at Lapa das Boleiras and Lapa do Santo rockshelters were small-sized mammals (*Cavia aperea, Agouti paca,* and *Kerodon rupestris*), amphibians, reptiles (mainly *Tupinambis* sp.) , and armadillos. Among the larger mammalians, cervids (*Mazama* sp.) were the most abundant, and to a lesser extent, peccaries (*Tayassu* sp.). It is important to note the virtual absence of the largest extant South American herbivore, the tapir (*Tapirus terrestris*) in the Lagoa Santa Paleoindian archaeological record (Bissaro Junior 2008). The tapir was definitely present in Lagoa Santa since, at least, the Pleistocene/Holocene transition (Hubbe 2008), being much larger than the *Mazama* sp. cervid (mean *T. terrestris* weight is 150 kg vs. 26 kg for *Mazama* sp.) and its meat is highly appreciated by native hunters (e.g., Souza-Mazurek et al. 2000). This suggests that Paleoindians were deliberately avoiding larger prey.

Paleoindian subsistence at Lagoa Santa was also strongly dependent on vegetables. The most ubiquitous plant species in the archaeological record are fruit-bearing trees, such as jatobá (*Hymenaea* sp.), pequi (*Caryocar brasiliense*), araticum (*Annona crassiflora* Mart.), and small coconuts (*Syagrus*

Table 4. Radiocarbon Ages for Lapa Grande de Taquaraçu.

Sample	Lab number (Beta)	Material	Conventional ^{14}C age (years B.P.)	$^{13}C/^{12}C$ ratio (‰)	Calibration 2σ[a]
TQ-421	216528	charred material	1160 ± 60	–29.9	1240 to 950 cal B.P.
TQ-417	216527	charred material	8080 ± 40	–25.1	9050 to 8990 cal B.P.
TQ-402	183576	charred material	8230 ± 50	–23.9	9319 to 9356, cal B.P., 9356 to 9400 cal B.P.
TQ-430	216529	charred material	8310 ± 40	–25.8	9450 to 9240 cal B.P.
TQ-441	216530	charred material	8730 ± 40	–23.7	9890 to 9560 cal B.P.
TQ-404	183577	charred material	8730 ± 50	–26.0	9553 to 9890 cal B.P.
TQ-454	216531	charred material	8910 ± 40	–25.8	10,190 to 9900 cal B.P.
TQ-459	216532	charred material	9040 ± 40	–24.9	10,240 to 10,170 cal B.P.
TQ-268	183575	charred material	9550 ± 60	–24.3	10,691 to 11,132 cal B.P.
TQ-297	216526	charred material	9540 ± 90	–25.5	11,170 to 10,560 cal B.P.
TQ-295	216525	charred material	9620 ± 40	–26.3	11,160 to 11,030 cal B.P., 10,980 to 10,750 cal B.P.
TQ- 544	242715	charred material	9900 ± 60	–27.1	11,600 to 11,560 cal B.P., 11,470 to 11,440 cal B.P., 11,410 to 11,210 cal B.P.
TQ-536	242714	charred material	9990 ± 60	–23.1	11,750 to 11,250 cal B.P.

[a]INTCAL 04 Radiocarbon Age Calibration.

sp.) (Nakamura et al. 2010). The high carbohidrate content of these fruits can partially explain the high frequency of cavities in the Paleoindian teeth (see "Skeletal Biology" below).

Skeletal Biology

The first Lagoa Santa human skeletal remains were recovered by Peter Lund from the inner chambers of Sumidouro Cave in the mid-nineteenth century (Lund 1844). Synthetic overviews about the subject can be found in Mello e Alvim et al. (1977) and Neves and Atui (2004). The idea that the human occupation of Lagoa Santa was of great antiquity was only empirically demonstrated a century after Lund's proposition, by Hurt and Blasi (1969). However, the contemporaneity of humans and extinct megafauna in the region was proved only very recently (Piló and Neves 2003).

As mentioned above, nearly all sites tested or excavated within the karst of Lagoa Santa have provided human skeletal remains of potentially great antiquity. As such Lagoa Santa is probably one of the few areas in the Americas that allows for the investigation of those who were the first Americans and how they lived, from a true populational perspective (suffice to say that in the whole of North America only half a dozen human skeletons older than 8000 ^{14}C years B.P. are available).

Unfortunately, until the end of the 1980s the accumulated literature concerning the human skeletons found at Lagoa Santa was primarily descriptive in nature (e.g., Mello e Alvim 1992–93; Mello e Alvim et al. 1977; Messias and Mello e Alvim 1962) and published in Portuguese. During this period, the human skeletons found in Lagoa Santa were scarcely explored to provide information about who the first Americans were and what their skeletal biology could inform about local adaptation, subsistence patterns, lifestyles, and biological quality of life. However, since the end of the 1980s a growing literature about the intra and extracontinental biological affinities of the early population of Lagoa Santa, based on appropriate quantitative treatments, has been accumulated (for the first example see Neves and Pucciarelli 1989, 1991). Accordingly, the cranial morphology of these first South Americans shows a remarkable similarity to modern Australians and Africans, and none whatsoever to present-day Native Americans and East Asians (see Neves and Hubbe 2005 for a comprehensive cranial analysis). These unexpected morphological affinities led Neves and associates to propose that the Americas were settled by two different human populations coming from Northeast Asia: one characterized by the generalized cranial pattern of the first modern humans that left

Table 5. Radiocarbon Ages of Human Remains from Lagoa Santa Area.

Site / Collection	Sample	Lab number (Beta)	Material	Conventional ^{14}C age (years B.P.)	$^{13}C/^{12}C$ ratio (‰)	Calibration 2σ[a]
Cerca Grande VI	MN-1329	Beta 161666	bone	8230 ± 50	−28	9400 to 9340 cal B.P., 9320 to 9030 cal B.P.
Cerca Grande VI	MN-1369	Beta 161668	bone	8240 ± 40	−25.7	9400 to 9360 cal B.P., 9310 to 9050 cal B.P.
Harold Walter	HW-6	Beta 220426	tooth	8590 ± 40	−20.1	9570 to 9520 cal B.P.
Harold Walter	HW-13	Beta 220429	tooth	8730 ± 40	−19.0	9890 to 9560 cal B.P.
Harold Walter	HW-293	Beta 220432	tooth	8020 ± 40	−19.4	9020 to 8760 cal B.P.
Harold Walter	HW-294	Beta 220433	tooth	8800 ± 40	−18.9	10,120 to 10,070 cal B.P., 9940 to 9690 cal B.P.
Harold Walter	HW-2520-1	Beta 220434	tooth	8320 ± 40	−18.8	9460 to 9250 cal B.P.
Harold Walter	HW-2520-4	Beta 220437	tooth	7700 ± 60	−21.1	8600 to 8380 cal B.P.
Harold Walter	HW-2520-7	Beta 220440	tooth	8570 ± 40	−19.0	9560 to 9510 cal B.P.
Harold Walter	HW-2520-9	Beta 220442	tooth	8480 ± 40	−19.1	9530 to 9460 cal B.P.
Harold Walter	HW-2520-10	Beta 220443	tooth	7850 ± 40	−20.1	8740 to 8550 cal B.P.
Lapa da Amoreira	MN-815	Beta 161657	bone	7070 ± 40	n/a	7960 to 7800 cal B.P.
Lapa da Amoreira	MN-821	Beta 205340	bone	8140 ± 40	−18.9	9220 to 9180, 9140 to 9010 cal B.P.
Lapa da Lagoa Funda	MNH-HW294	Beta 208077	bone	7870 ± 40	−19.5	9600 to 9520 cal B.P.
Lapa das Boleiras	Boleiras Sep 3	Beta 178554	tooth	8190 ± 40	−19.1	9270 to 9020 cal B.P.
Lapa das Boleiras	Boleiras Sep 3	Beta 178556	bone	9640 ± 50	−23.5	10,980 to 10,750 cal B.P.
Lapa das Boleiras	Boleiras Sep 3	Beta 179815	tooth	8280 ± 50	−23.4	9440 a 9115 cal B.P.
Lapa das Boleiras	MN-1389	Beta 155658	bone	8420 ± 100	−17.9	9180 to 9140 cal B.P.
Lapa das Boleiras	MN-1390	Beta 155659	bone	8300 ± 50	−20.8	9460 to 9130 cal B.P.
Lapa de Carrancas	MN-627	Beta 161656	bone	7970 ± 40	−21.8	9000 to 8640 cal B.P.
Lapa de Escrivânia 3	ZMUCESC3HS	Beta 174734	bone	7740 ± 80	−19.6	8650 to 8380 cal B.P.
Lapa do Baú 2	ZMUC-2358	Beta 174735	bone	8830 ± 50	−19.2	10,150 to 9700 cal B.P.
Lapa do Braga	ZMUC-4725	Beta 174736	bone	9780 ± 70	−19.2	11,260 to 11,110 cal B.P.
Lapa do Caetano	MN-856	Beta 155657	bone	2200 ± 50	−21.8	2340 to 2060 cal B.P.
Lapa do Caetano	MN-865	Beta 161660	bone	1760 ± 40	n/a	1800 to 1560 cal B.P.
Lapa do Caetano	MN-892	Beta 174682	bone	2290 ± 60	−19.9	2370 to 2150 cal B.P.
Lapa do Santo	Sep 07	Beta 215194	bone	7400 ± 40	−18.9	8330 to 8160 cal B.P.
Lapa do Santo	Sep 11	Beta 215195	bone	5990 ± 40	−20.6	6900 to 6730 cal B.P.
Lapa do Santo	Sep 14	Beta 215196	bone	8230 ± 40	−22.4	9380 to 9370 cal B.P., 9300 to 9040 cal B.P.
Lapa do Santo	Sep 19	Beta 215200	bone	7700 ± 40	−18.6	8560 to 8400 cal B.P.
Lapa do Santo	Sep2	Beta 253497	bone	790 ± 40	−19.2	780 to 670 cal B.P.
Lapa do Santo	Sep14	Beta 253505	bone	8730 ± 50	−19.6	9900 to 9550 cal B.P.
Lapa do Santo	Sep17	Beta 253507	bone	8660 ± 50	−19.0	9710 to 9540 cal B.P.
Lapa do Santo	Sep26	Beta 253511	bone	8540 ± 50	−19.8	9550 to 9480 cal B.P.
Lapa Mortuária	MN-834	Beta 161658	bone	8810 ± 50	−18.6	10,140 to 9680 cal B.P.
Lapa Mortuária	MN-847	Beta 161659	bone	7190 ± 50	−19.1	8110 to 8090 cal B.P., 8060 to 7940 cal B.P.
Lapa Mortuária	MN-902	Beta 161661	bone	1700 ± 40	−19.2	1830 to 1610 cal B.P.
Lapa Mortuária	MN-923	Beta 161662	bone	8290 ± 40	−19.2	9450 to 9120 cal B.P.
Lapa Mortuária	MN-928	Beta 161663	bone	8350 ± 40	−19.4	9480 to 9270 cal B.P.
Lapa Mortuária	MN-932	Beta 161664	bone	1680 ± 40	−19.3	1810 to 1570 cal B.P.
Lapa Mortuária	MN-933	Beta 161665	bone	1880 ± 40	−19.8	2000 to 1840 cal B.P.
Lapa Mortuária (Cave)	MHN-Confins	Beta 174680	bone	11990 ± 50b	−33.4	15,070 to 14,830 cal B.P., 14,270 to 14,210 cal B.P.
Santana do Riacho	SR1-Va	Beta 96759	bone	12760 ± 70b	−33.2	14,711 cal BP to 15,617 cal BP
Santana do Riacho	SR1-IX	Beta 162005	bone	3940 ± 50	n/a	4520 to 4240 cal B.P.
Santana do Riacho	SR1-XI	Beta 162007	bone	110 ± 0,7	n/a	n/a
Santana do Riacho	SR1-XX	Beta 162014	bone	8280 ± 40	−24.9	9420 to 9130 cal B.P.
Santana do Riacho	—	Beta 104292	bone	7840 ± 60	n/a	8790 cal B.P. to 8506 cal B.P.

Table 5 (continued). Radiocarbon Ages of Human Remains from Lagoa Santa Area.

Site / Collection	Sample	Lab number (Beta)	Material	Conventional ^{14}C age (years B.P.)	$^{13}C/^{12}C$ ratio (‰)	Calibration 2σ[a]
Santana do Riacho	—	Beta 96760	bone	5740 ± 70[b]	−28.3	7630 to 6310 cal B.P.
Santana do Riacho	SR1-II	Beta 96758	bone	5340 ± 60[b]	−24.5	6285 to 5950 cal B.P.
Santana do Riacho	—	Beta 104291	bone	2270 ± 50[b]	n/a	2352 to 2285 cal B.P., 2280 to 2152 cal B.P.
Santana do Riacho	SR1 – XIII	Gif 4508	assoc. charcoal	9460 ± 110	n/a	11155 to 10481 cal B.P.
Santana do Riacho	SR1 – XXIII	Gif 5088	assoc. charcoal	8230 ± 150	n/a	9525 to 8773 cal B.P.
Santana do Riacho	SR1 – IV	Gif 5087	assoc. charcoal	8150 ± 150	n/a	9449 to 8646 cal B.P.

[a]INTCAL 04 Radiocarbon Age Calibration.
[b]Ages probably contaminated.

Africa around 50,000 ^{14}C years B.P., and one characterized by the derived cranial morphology seen today among East Asians and Native Americans, referred to in the classical literature as Mongoloid (see Powell 2005 and González-José et al. 2008 for alternative interpretations).

A well-established chronology for the Lagoa Santa human skeletons was also generated over the last 15 years. More than 130 samples have been submitted to AMS dating in reputed international laboratories. Most of these samples preserved no collagen. Those containing enough collagen for dating (40) partially confirmed the alleged antiquity of the material. With the exception of Luzia, whose skeleton is estimated to be dated ca. 11,000 ^{14}C years B.P., the vast majority of the sample is bracketed between 8500 and 7500 ^{14}C years B.P. (Table 5).

As to lifestyle and biological quality of life, little has been recovered so far from the Lagoa Santa early human skeletons. This kind of analysis is hampered by the fact that most of the postcranial bones are not separated by individuals, because the great majority of the skeletons were found during prescientific excavations. Mendonça de Souza (1992–93) carried out the first comprehensive descriptive report about the paleopathological conditions found in the skeletons recovered by André Prous (1991; Prous et al. 1991) at Santana do Riacho in the late 1970s, a rockshelter located on the boundaries of the Lagoa Santa carst (Santana do Riacho is one of the few local collections excavated in modern times). Neves and Cornero (1997; but see also Cornero 2005) have more recently reported a frequency of dental cavities of around 9 percent for the skeletons from the same site, a very high incidence for a hunter-gatherer group (see also Neves and Kipnis [2004] for a similar conclusion based on other human skeletal collections from Lagoa Santa). As an explanation for this high incidence of dental caries in Santana do Riacho (which indicates a high consumption of carbohydrates), these authors have suggested a subsistence pattern based primarily on the gathering of fruits, seeds, and tubers, a hypothesis recently confirmed by Hermenegildo (2009) based on bone isotopic analysis.

The three rockshelters excavated by us at Lagoa Santa over the last nine years (Lapa das Boleiras, Lapa do Santo and Lapa Grande de Taquaraçu) have uncovered around 30 new human skeletons. Following the regional trend, they are mostly dated to between 8500 and 7500 ^{14}C years B.P. With the exception of the isotopic assessment carried out by Hermenegildo (2009), this material has not been analyzed and published so far. Taking into account its excellent degree of conservation and the high quality of the excavations involved in their recovering, important information about the burial practices and skeletal biology of the first humans who settled eastern Central Brazil can be already foreshadowed.

Discussion

The chronology obtained for the sites shows a very clear scenario: in spite of some early evidence of humans crossing the region ("Luzia," stratigrapically bracketed by dates ranging from 11,264 to 15,145 cal. B.P. is the strongest evidence), the bulk of human occupation at Lagoa Santa started, rather abruptly, around 10,000 ^{14}C years B.P. (11,200 ~ 12,300 cal B.P.). A factor that could be invoked to explain this phenomenon would be climatic changes that marked the beginning of the Holocene in the inland areas of Brazil (Cruz et al. 2006; Ledru et al. 2005), bringing more favorable moisture and temperature conditions to human settlement. At the same time, it is possible that geomorphic factors, commonly related to abrupt climate change (Thomas 2001, 2008) could have introduced a strong bias in this scenario, destroying or deeply burying older open-air sites. In any case, given the available data, we can summarize the main aspects relating to Paleoindian material culture, subsistence, chronology, and human biology below.

Chronology and material culture. At about the same time Lagoa Santa began to be densely occupied, Paleoindian sites are found in several inland areas across Brazil. However, most of these sites show completely different lithic industries. Toward the north, the industries are assigned to the "Itaparica Tradition," characterized by unifacial flaking, with distinctive formal artifacts ("limaces"). Toward the south, the lithic industry is called the "Umbu Tradition," showing a higher frequency of formal artifacts when compared to Itaparica, including bifacial points (see Araujo and Pugliese 2009 for an overview; also Roosevelt et al. 1996). This information suggests a strong cultural differentiation already established in eastern South America as early as the beginning of the Holocene, a point already made by several authors (e.g., Dillehay 2000).

Human biology. In spite of the clear regional differences in material culture during the Pleistocene/Holocene transition, from the biological point of view Paleoindian human skeletal remains, when available, are remarkably different from later and present native Americans (Neves and Hubbe 2005), tending to cluster with Australo-Melanesians and sub-Saharan Africans in comparative multivariate analysis. This strongly suggests at least two different populations entering the Americas through the Behring Strait, or an extreme in situ microevolutionary process. The human skeletal remains found so far in Lagoa Santa are also remarkable in showing a frequency of dental cavities (around 10 percent) higher than the ones found in other hunter-gatherer societies.

Humans and extinct mammals. The beginning of the human occupation at Lagoa Santa is probably contemporaneous with the last megafauna. Besides the already mentioned radiocarbon age of 9580 ± 200 for a *Catonix cuvieri* (giant sloth) at Lapa Vermelha IV (Prous 1986), at Cuvieri Cave we obtained radiocarbon ages of 9990 ± 40 B.P. (Beta 165398; bone collagen; 11,570 to 11,250 cal B.P.) for another specimen of *C. cuvieri* and 10,790 ± 60 B.P. (Beta 234519; bone collagen; 12,880 to 12,720 cal B.P.) for a *Smilodon populator* (saber-toothed tiger—Piló and Neves 2003). Yet like all other researchers who worked in the region, we did not find the slightest evidence that humans were hunting these animals, or even bringing parts of them inside the rockshelters.[3] As noted previously, hunting was based exclusively on medium-sized or smaller extant animals (the larger hunted mammal being the *Mazama* sp. cervid). Even the tapir was avoided. We do acknowledge that "contemporaneity" is an elusive concept when dealing with radiocarbon ages, but nevertheless the dates mentioned above cannot be ignored.

Conclusions and Implications for the Settlement of the Americas

Since its inception, the model defended by Neves and associates (The Two Main Biological Components Model) never invoked any kind of transoceanic migrations to explain the cranial similarities between the first South Americans and recent Africans/Australians (for misunderstandings about this issue see Fiedel 2004a; Roosevelt et al. 2002). By the mid-1980s, it was already clear in the anthropological literature that the few human skulls of Pleistocene antiquity found in East Asia (Zhoukoudian Upper Cave/Liugiang) exhibited a generalized morphology (Kamminga and Wright 1988; Wright 1995; but see also Cunningham and Jantz 2003 and Neves, Powell, and Ozolins 1999 for more recent contributions to the subject), showing no particular affinity with the human population that has occupied the region since the Early/Middle Holocene (Mongoloids). In other words, Northeast Asia is perfectly feasible as source of both morphological patterns that entered the New World.

The data obtained at Lagoa Santa, together with archaeological information derived from other settings in Brazil, strongly suggest an abrupt and simultaneous appearance of Paleoindians at about 11,700 years B.P., inside a polygon whose (minimum) dimensions are about 800 km east–west and 2,300 km north–south, and already showing a very diverse material culture.

We do not believe the differences in lithic industries can be explained solely by raw material variation, mobility, or subsistence. Rather, the differences observed appear to be three different ways of meeting basic needs, rooted in a variation that developed much earlier (Araujo and Pugliese 2009). Zooarchaeological data from Southern and Central Brazilian Paleoindian sites (Jacobus 2004; Kipnis 2002; Schmitz et al. 1996; Schmitz et al. 2004) indicate very similar faunal contents in the sites associated with Umbu and Itaparica traditions, and the same can be said for the Lagoa Santa Paleoindians. All groups relied strongly on cervids (*Mazama americana*, *Ozotocerus bezoarticus*) and peccaries (*Pecari tajacu*, *Tayassu pecari*), as well as terrestrial gastropods (*Megalobulimus oblongus*, *Drymaeus sp*.). Thus, subsistence-based explanations to account for the differences among these traditions should be rejected. Also, it is very unlikely that these differences represent only regional variations within a supposedly "recently-split" hunter-gatherer population directly derived from Clovis, whose industries happen to have been modified over a short time interval because of mobility strategies and/or raw material availability. Rather, we propose that these industries differ so significantly because of cultural drift (sensu Neiman 1995:9), operating over a long time frame. The idea of a Clovis-derived expansion into South America is at odds with a basic tenet of transmission (be it cultural or genetic), namely, that rates of innovation are positively correlated with population numbers (Neiman 1995; Shennan 2001). Otherwise, we would have to accept that Clovis hunters moved southward reproducing themselves at extremely high rates (e.g., Fiedel 2000, 2004b; Haynes 2006), promoting a boom in demography and in cultural innovation, leading to the appearance of all kinds of lithic industries, from flake-based to Fishtail, Fell, or El Jobo points, and all this in less than a thousand years. As a point of comparison, by the time Dalton points were being produced in North America, the aforementioned Lagoa Santa flake industries, the Umbu bifacial points, and the Itaparica "limaces" were fully developed and occupied the whole of eastern South America. If we take into account comprehensive data about North American Paleoindian bifacial points (O'Brien et al. 2001), it becomes clear that their morphological (and hence, typological) variability implies rates of change that are extremely unlikely, unless we think about a "Clovis-turning-into-Itaparica," or even a "Clovis-turning-into Umbu" scenario.

In our view, the amassed data is best explained by a model of early coastal expansion (Dixon 1999, 2001; albeit with some modifications—see Araujo 2004), followed by inland migration and cultural drift after the improvement of climatic conditions in the Pleistocene/Holocene boundary. Population pressure on the coast, probably resulting from a conjunction of net population growth and the rapid rise of the sea level operating since the Last Glacial Maximum, may also have enhanced this population expansion toward inland settings. In short, both the Paleoindian chronology and cultural diversity in eastern South America are at odds with the idea of a rapid southward expansion by Clovis hunters.

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Notes

1. In most countries of South America, the term "Paleoindian" was originally used as a chronological marker, rather than attached to technological or subsistence issues, mainly because archaeologists soon realized that many of the oldest sites lacked bifacial points or evidence of megafauna exploitation. More recently, especially in Brazil, the term is being used with a strong biological meaning, because craniometric studies suggest that there is a marked difference between Early Holocene human skulls and the more recent, mongoloid Amerindian populations.

2. A single bifacial point was found at Lapa do Santo, in a heavily disturbed context, and a very dubious "point preform" was found at Boleiras.

3. The *Catonix cuvieri* bones and coprolites found at Lapa Vermelha IV rockshelter are not associated with archaeological materials.

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