



A new early Holocene human skeleton from Brazil: implications for the settlement of the New World

Walter A. Neves^{a,*}, Mark Hubbe^a, Maria Mercedes M. Okumura^a,
Rolando González-José^b, Levy Figuti^c, Sabine Eggers^d,
Paulo Antonio Dantas De Blasis^c

^a*Laboratório de Estudos Evolutivos Humanos, Departamento de Biologia, Instituto de Biociências,
Universidade de São Paulo, CP 11461, 05422-970, São Paulo, SP, Brazil*

^b*Centro Nacional Patagónico-CONICET, Bvd. Brown 3500. U9120ACV Puerto Madryn, Argentina*

^c*Museu de Arqueologia e Etnologia, Universidade de São Paulo, Av. Prof. Almeida Prado, 1466, 05508-900, SP, Brazil*

^d*Laboratório de Antropologia Biológica, Centro de Estudos do Genoma Humano, Departamento de Biologia,
Instituto de Biociências, Universidade de São Paulo, Rua do Matão, 277, 05508-090, São Paulo, SP, Brazil*

Received 30 June 2004; accepted 14 December 2004

Abstract

Increasing skeletal evidence from the U.S.A., Mexico, Colombia, and Brazil strongly suggests that the first settlers in the Americas had a cranial morphology distinct from that displayed by most late and modern Native Americans. The Paleoamerican morphological pattern is more generalized and can be seen today among Africans, Australians, and Melanesians. Here, we present the results of a comparative morphological assessment of a late Paleoindian/early archaic specimen from Capelinha Burial II, southern Brazil. The Capelinha skull was compared with samples of four Paleoindian groups from South and Central America and worldwide modern groups from W.W. Howells' studies. In both analyses performed (classical morphometrics and geometric morphometrics), the results show a clear association between Capelinha Burial II and the Paleoindians, as well as Australians, Melanesians, and Africans, confirming its Paleoamerican status.

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Keywords: Settlement of the Americas; Craniometrics; Riverine shellmidden

* Corresponding author. Tel.: +55 11 30917725; fax: +55 11 30917553.
E-mail address: waneves@ib.usp.br (W.A. Neves).

Introduction

In the last two decades, craniofacial comparisons of early human skeletal remains from North, Central, and especially South America with global human morphological variation has generated important new information about the settlement of the Americas. Traditional ideas about the number of migrations entering the New World in prehistoric times have been extensively questioned by these results (Neves and Pucciarelli, 1989, 1991, 1998; Steele and Powell, 1992, 1993, 2002; Munford et al., 1995; Neves et al., 1998, 1999a; Powell and Neves, 1999; González-José et al., 2001; Jantz and Owsley, 2001, 2003).

In a recent paper (Neves et al., 2003), some of us presented supplementary evidence from Lagoa Santa, central Brazil, that the Paleoamerican cranial morphology is very different from that normally found among late prehistoric and modern Native Americans. While the latter resemble modern northeastern Asians, the former resembles Australo-Melanesians and Africans.

Although a rich literature about the morphology of the first Americans has been assembled over the last two decades, some scholars still feel uneasy with these findings, because most of them are said to have been based on single skulls and/or on poorly dated material (Dillehay, 1989, 1997; Roosevelt et al., 1996; Van Vark et al., 2003; but

see Neves et al., 2003, for a response). Indeed, with the exception of Lagoa Santa (central Brazil), early human skeletal remains are scant in the archaeological record of the New World.

In order to overcome this limitation, one of us (WAN) has adopted the strategy of analyzing and comparing the morphological affinities of isolated early American human skeletons deriving from very different regions of the continent (Powell and Neves, 1998, 1999; Neves et al., 1999a,b). The greater the number of these isolated skulls showing the same morphological pattern, the more acceptable is the idea that the non-Mongoloid cranial morphology of the first Americans is a real biological entity, and not just the result of outliers or aberrant specimens (Van Vark et al., 2003). Here we present the results of a comparative morphological analysis based on an early Holocene human skeleton recently recovered at Capelinha, a riverine shell midden located at the Ribeira do Iguape Valley, southern Brazil.

The Ribeira do Iguape Valley is located in the southeastern region of the state of São Paulo, southern Brazil (Fig. 1). Shell middens and mounds of this region have been known since the beginning of the 20th century (Krone, 1914), and were occasionally explored by Kiju Sakai, an amateur archaeologist, during the 1930s (Sakai, 1981). Only during the last two decades of the last century were professional excavations carried out

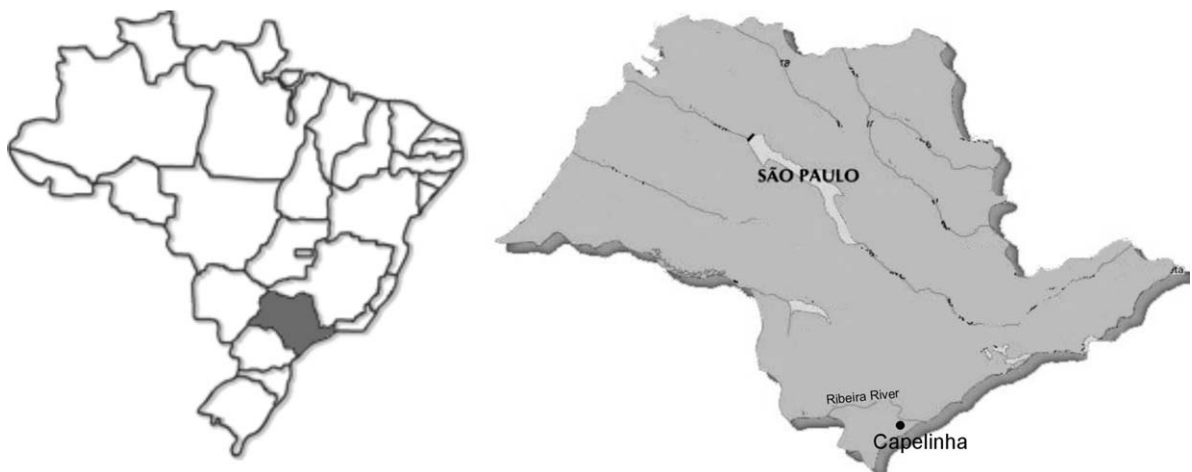


Fig. 1. Location of Capelinha in the Valley of the Ribeira do Iguape River.

at these sites (Barreto et al., 1982; Collet, 1985; Barreto, 1988; Collet and Loebel, 1988; De Blasis, 1988; Robrahn, 1988; Robrahn-González and De Blasis, 1998; Robrahn-González, 1999).

Two distinct early Holocene prehistoric human occupations have been identified in the region. The oldest occupation was detected in Maximiano Rockshelter, dated to $9,810 \pm 150$ years BP (GIF-7493, uncalibrated) (Collet, 1985). Except for the date, nothing else is known about these very early Holocene groups. They are succeeded in time by the establishment of several shell-mounds and shell-middens along the Ribeira do Iguape River, with dates ranging from 8,800 to 1,200 years BP, but with gaps between 7,000–5,900 years BP, and 3,500–1,600 years BP (uncalibrated).

Archaeological context

Capelinha (latitude $24^{\circ}50'80,7$ longitude $48^{\circ}14'38,1$) is a shell midden comprising shells of the genus *Megalobulinus*, and is located on the highest part of the Capelinha stream, an affluent of Jacupiranguinha River that drains directly to the Ribeira de Iguape River (Fig. 1). The site was first explored by amateurs in the mid-1980s, and yielded calibrated dates of 10,500 years BP and 9,890 years BP (Collet, 1985; Collet and Loebel, 1988; uncalibrated dates not reported). Recent AMS dating of bone collagen from one of the human skeletons recovered from the site yielded an uncalibrated date of $8,860 \pm 60$ years BP (Beta 153988, C13/C12 = -19.7 , Cal BP 10,180 to 9,710), confirming the early Holocene antiquity of the site. Other similar dates were obtained from charcoal ($8,795 \pm 100$ years BP – A11239,¹ C13/C12 = -27.0 ; calibrated dates not reported) coming from the base of one of the middens, and from a shell fragment ($8,500 \pm 100$ years BP – A11236, C13/C12 = -12.7 , calibrated dates not reported) collected 10 cm above the charcoal sample.

Six human burials were recovered from Capelinha. With the exception of Burial II, the human skeletal remains were very fragmented.

Orange-reddish clay demarcated the pit of Burial II, which was an articulated primary interment.

The skeleton of Burial II was diagnosed as male based on the robust features of the skull and the morphology of the pelvis (Buikstra and Ubelaker, 1994). This individual exhibits a craniosynostosis developed after he had reached adulthood, which did not result in any cranial deformation, such as asymmetry or aberrant size and shape. Due to this craniosynostosis, the age estimation relied primarily on the postcranial skeleton. The Capelinha Burial II skull can be seen in Fig. 2. The general aspect of the auricular surface (Lovejoy et al., 1985) and the recent fusion of the iliac crest (Bass, 1987) indicate an adult ranging from 25 to 30 years. Little degenerative joint changes and a mild degree of dental wear indirectly support this age estimation.

Material and methods

The comparative analysis of the specimen was performed using both classical morphometrics and geometric morphometrics. Principal components analysis (PCA) (Manly, 1994) was used in order to explore the morphological affinities of Capelinha Burial II relative to a set of modern humans (Howells, 1973, 1989, 1995, 1996) and a set of Paleoindian reference samples (Lagoa Santa, Sumidouro, Tequendama, and Paleomexicans; sample size and dates listed in Table 1). Only males were included in the analysis. Principal components analysis was based on a set of 44 of Howells' variables. These variables were chosen in order to minimize the replacement of missing values (less than 30%) in the Paleoindian reference samples. All variables were observed in Capelinha Burial II. The variables used in the PCA, the measurements of Capelinha Burial II and the means of the Paleoindians series are shown in Table 2. Howells' samples used in the analyses and their geographic affiliation are listed in Table 3. Howells' databank can be found on the internet at www.konig.utk.la.edu/howells.htm (Howells, 1996). Missing values were replaced by multiple regression estimates. The analyses were performed on shape variation alone, after a Q-standardization by the geometric mean

¹ Laboratory of Isotope Chemistry, Department of Geosciences, University of Arizona.



Fig. 2. Frontal, superior, and lateral views of the Capelinha Burial II skull.

Table 1

Samples included in the analyses (Howells populations not shown)

Group/Specimen	Chronology	N	Code
Ainú, Japan	Modern	7	AIN
Califórnia, USA	Modern	27	ALC
Aborigins, Australia	Modern	20	AUS
Baja Califórnia Sur, México	Modern	12	BCS
Calama, Chile	Modern	10	CAL
Paltacalo, Ecuador	Modern	28	ECU
Eskimos, Greenland	Modern	18	ESK
Mapure, Venezuela	Modern	21	MAP
Ancon, Peru	Modern	17	PER
Ourga, Siberia	Modern	12	SIB
Patagonians	Modern	23	PAT
Portugal	Modern	9	POR
Basques	Modern	24	VAS
Capelinha, Brasil	8860 ± 60 yr BP	1	CAP
Liujiang Guangxi Zhuang, China	60000 yr BP?	1	LIU
Upper Cave 1, Zhoukoudian, China	10175 ± 360 yr BP	1	UC 101
Wizard Beach, USA	9225 yr BP	1	Wizard
Metro Balderas, Mexico	9000 yr BP	1	Metro
Cueva del Tecolote, Mexico	10500 yr BP	1	Teco
Chimalhuacán, México	10500 yr BP	1	Chima
Santana do Riacho, Brasil	8200–9500 yr BP	1	SR111
Lagoa Santa, Brasil ^a	8000–11000 yr BP	44	LAGO
Paleomexicans ^a	9000–10500 yr BP	4	PMEX
Sumidouro, Brasil ^a	> 8000 yr BP	29	SUMI
Tequendama, ^a	7000–9000 yr BP	15	TEQU
Total		328	

^a Samples included only in Principal components analyses. The others were used in the geometric morphometric analysis only.

(Darroch and Mosiman, 1985). Finally, the biological affinity of the individual from Capelinha was assessed by a cluster analysis (Ward's Method) applied to the scores of the first 13 principal components (eigenvalues > 1.0).² The principal components with eigenvalues lower than 1 were excluded because they could be excessively influenced by inter-observer error in the measurements (Roseman and Weaver, 2004). Clustering was chosen instead of bi-dimensional graphing because the first three principal components explained only 37.7% of the original information.

² UPGMA and Single linkage clustering techniques were also performed. However, in both trials the individual from Capelinha appeared as an outlier to all reference samples.

Table 2

Variables used in the Principal components analyses (measures from Capelinha Burial II and mean measures for each Paleoindian series)

Variables used	Capelinha Burial II	Lagoa Santa	Paleomexicans	Tequendama	Sumidouro
Glabella-occipital length (GOL)	180	183	199	185	187
Nasio-occipital length (NOL)	179	180	196	182	183
Maximum cranial breadth (XCB)	135	130	138	129	131
Maximum frontal breadth (XFB)	113	110	115	107	113
Bistephanic breadth (STB)	111	104	113	99	112
Bizygomatic breadth (ZYB)	130	131	138	136	135
Biauricular breadth (AUB)	114	123	128	121	121
Biasterionic breadth (ASB)	112	110	112	108	111
Nasion-prosthion height (NPH)	71	64	67	69	64
Nasal height (NLH)	51	48	49	50	47
Orbit height (OBH)	35	33	35	32	33
Orbit breadth (OBB)	40	40	42	39	40
Nasal breadth (NLB)	24	25	25	26	24
Palate breadth, external (MAB)	61	62	64	60	60
Mastoid height (MDH)	25	25	30	26	24
Mastoid breadth (MDB)	10	13	13	12	14
Bifrontal breadth (FMB)	99	101	104	97	100
Nasio-frontal subtense (NAS)	14	15	16	14	15
Interorbital breadth (DKB)	26	24	26	23	25
Malar length, inferior (IML)	34	37	38	36	42
Malar length, maximum (XML)	47	52	53	54	57
Malar subtense (MLS)	8	10	11	10	13
Cheek height (WMH)	20	24	24	25	24
Supraorbital projection (SOS)	8	7	8	6	8
Glabella projection (GLS)	3	4	5	3	4
Frontal cord (FRC)	107	110	118	110	112
Frontal subtense (FRS)	22	23	22	22	25
Nasion-subtense fraction (FRF)	53	48	50	47	51
Parietal cord (PAC)	127	114	120	114	119
Parietal Subtense (PAS)	28	25	24	24	26
Bregma-subtense fraction (PAF)	72	61	60	60	61
Occipital cord (OCC)	94	98	101	98	101
Occipital subtense (OCS)	21	30	33	30	31
Lambda-subtense fraction (OCF)	51	47	47	49	51
Vertex radius (VRR)	120	125	125	124	125
Nasion radius (NAR)	91	96	95	96	95
Subspinale radius (SSR)	91	97	98	102	98
Prosthion radius (PRR)	98	104	106	107	103
Dakrion radius (DKR)	81	85	84	85	82
Zygoorbitale radius (ZOR)	76	84	84	86	83
Frontomalare radius (FMR)	78	82	83	83	82
Ectoconchion radius (EKR)	67	76	75	76	75
Zygomaxillare radius (ZMR)	68	77	73	79	77
Molar alveulus radius (AVR)	69	84	83	86	85

Geometric morphometrics were used to visualize shape changes in lateral view as landmark deformations, and to perform multivariate analysis on landmark coordinates. Landmark coordinate data were available for populations listed in Table 1. The landmarks used were prosthion,

anterior subnasal spine, nasion, glabella, most inferiorposterior midline point above glabella (frontex), midline point of greatest elevation between nasion and bregma (metopion), bregma, vertex, midline point of greatest elevation between vertex and lambda, lambda, opisthocranion, inion,

Table 3
Howells' samples included in the Principal components analyses and their respective geographical affiliations

Series	Geographic Region	N
NORSE	Europe	55
ZALAVAR	Europe	53
BERG	Europe	56
TEITA	Africa	33
DOGON	Africa	47
ZULU	Africa	55
BUSHMAN	Africa	41
AUSTRALI	Australia	52
TASMANIA	Australia	45
TOLAI	Australia	56
ARIKARA	America	42
SANTA CR	America	51
PERU	America	55
ESKIMO	America	53
N JAPAN	Asia	55
S JAPAN	Asia	50
AINU	Asia	48
BURIAT	Asia	55
ANYANG	Asia	42
MOKAPU	Polynesia	51
EASTER I	Polynesia	49
MORIORI	Polynesia	57
HAINAN	Polynesia	45
ATAYAL	Polynesia	29
GUAM	Polynesia	30
ANDAMAN	Polynesia	35
Total		1368

porion, frontomale, and jugale. Again, only male individuals were considered. Major shape changes in projected lateral view were illustrated using thin-plate spline analysis (TPS) (Bookstein, 1989) after removing scale and positional and rotational effects on the skulls by generalized Procrustes superimposition (Goodall, 1991; Rohlf, 1999). The resulting weight matrix (Rohlf, 1993) was then used to explore shape change by means of a multivariate canonical variates analysis. Furthermore, the visual representation of shape differences described by canonical variates was produced by regressing the shapes (the weighted matrix of the partial warp scores) onto the specimen scores on the first two canonical vectors. This permitted the splines of the shape change to be associated with positive and negative values of a canonical vector.

Results

The first 13 principal components explain 76.6% of the original variation. Table 4 shows the scores obtained for each sample and the percentage of the total variance explained by each of the 13 principal components used here individually. Their scores were used to build the dendrogram of Fig. 3. The individual from Capelinha shows a close association with the four Paleoindian samples represented in the analysis. These samples form a major cluster with Australians, Tasmanians, and Tolais. The other American samples appear to be associated with some Polynesians (Buriat and Moriori) and the European samples on a first level, and with the remaining Asians, which cluster together, on a second level. All African samples appear clustered together, and distant to the Asian, European, and recent Amerindian samples. The cluster formed by Capelinha Burial II, Paleoindians, and Australians appears as the most distant cluster from all others.

The plot of the first and second roots of the canonical analysis applied to the geometric morphometric data is shown in Fig. 4. The scores of each sample in the roots obtained are shown in Table 5. The Capelinha Burial II is strongly associated with Paleoindians, as well as with the skull from Zhoukoudian Upper Cave, which has remarkably non-Mongoloid features (Kamminga and Wright, 1988; Wright, 1995; Neves and Pucciarelli, 1998; Cunningham and Jantz, 2003). All Paleoindian samples are located in the upper right corner of the graph, inside the ellipsis added to illustrate their dispersion. The Amerindian sample of Baja California Sur (BCS) also appears inside the ellipses, but as shown by González-José et al. (2003), they exhibit a strong association with non-mongoloid groups as well. The samples from Venezuela (MAP), California (ALC), and Ecuador (ECU) appear in the center of the graph, associated with the Liujiang skull, of older age. The remaining modern American samples are associated with the Portugal (POR), Basque (VAS), and Siberia (SIB) samples. In this analysis, the sample from Australia (AUS) appears as an outlier. Nonetheless, if only the first root is considered, the Australian sample presents values within the

Table 4

Eigenvalues and percentage of variance explained (inside parentheses) by each factor used in the construction of the dendrogram, and the values for each series

Series	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7	Factor 8	Factor 9	Fact. 10	Fact. 11	Fact. 12	Fact. 13
Eigenvalues	8.21 (18.66%)	5.04 (11.46%)	3.34 (7.60%)	2.86 (6.50%)	2.28 (5.18%)	1.91 (4.33%)	1.82 (4.13%)	1.69 (3.85%)	1.53 (3.48%)	1.44 (3.28%)	1.37 (3.11%)	1.19 (2.70%)	1.02 (2.32%)
Luzio	1.1481	-0.0673	-1.6883	-0.0284	-0.3908	1.4955	1.8847	-0.6799	-0.9349	1.0150	-0.2777	-0.3764	-1.9784
LAGO	0.0752	0.9535	-0.0526	-0.6224	0.3747	-0.2503	0.2368	-0.1819	-1.0174	1.2021	-0.2222	-0.2262	-0.4358
PMEX	-0.6770	0.2085	-1.0225	0.5258	1.4231	0.4107	0.2329	0.3673	-0.2287	1.0002	0.3536	0.3692	-0.3474
TEQU	-0.0594	1.2216	0.5307	-1.1492	0.5026	-0.2860	0.4090	-0.6696	-1.0292	1.3975	0.2601	0.3212	-0.8760
SUMI	-0.1832	0.8644	-0.6975	-0.4536	0.4171	0.0191	-0.8429	0.4314	0.0282	1.4810	-1.5112	-0.2290	-0.4312
NORSE	-0.0286	-0.4456	-0.6660	0.2700	0.4921	0.0594	0.5856	0.0004	0.3246	0.5994	-0.5959	0.8575	0.2574
ZALAVAR	0.1963	-0.3940	-0.7215	0.1462	0.4075	-0.0430	0.5621	0.2226	-0.2184	0.2522	-0.5315	0.4568	0.4217
BERG	0.2995	-1.1093	-0.6095	0.7197	-0.1930	-0.7664	0.4534	0.4454	-0.5138	0.3412	-0.8754	-0.0752	0.3322
TEITA	0.1729	1.1661	-0.4299	0.1665	-0.0570	-0.6835	0.1580	-1.3036	0.3738	0.0036	0.0748	0.5583	0.6273
DOGON	0.9942	0.2493	-0.6767	0.2827	-0.7808	0.1118	-0.4727	-0.7770	0.8789	-0.7139	0.8023	-0.3985	0.2005
ZULU	0.2740	0.5756	-1.0326	0.3894	-0.1411	-0.3935	0.1141	-0.9794	0.8608	-0.2738	0.7106	-0.6588	0.0034
BUSHMAN	1.4763	0.8941	-0.4408	0.0306	0.3490	-1.5865	-0.1619	0.7625	0.1293	-0.0320	0.1806	0.2923	0.8792
AUSTRALI	-0.2787	1.3960	-0.0044	0.9620	0.2873	0.4340	0.4009	1.2369	0.5549	0.0185	0.6522	0.1243	0.0367
TASMANIA	0.0558	0.9332	-0.3019	0.9807	0.0096	0.3007	-0.5260	1.4998	-0.4860	-0.0005	0.1765	-0.3655	-0.6078
TOLAI	-0.2327	1.4641	0.2386	0.3574	-0.0211	0.7352	-0.4428	0.3058	-0.2723	0.2570	-0.0313	-0.3740	-0.2431
MOKAPU	-0.8988	-0.3552	0.1060	-0.6428	0.2262	0.2521	-0.3915	-0.0667	-0.7695	-1.0105	-0.5290	-1.2862	0.3959
BURIAT	-1.0445	-1.6132	0.6065	0.1550	-1.2491	-1.2477	-0.1529	0.3013	-0.2867	0.6298	0.3773	0.4001	0.1076
ESKIMO	-1.0370	0.5227	1.0297	-1.5006	-0.2291	-0.0974	0.7572	0.2136	1.1123	0.9175	-0.4608	-0.2439	0.3939
PERU	0.9343	-0.7855	0.5625	0.1107	0.5796	0.5483	-0.0736	-0.3380	-0.1616	0.3039	-0.1357	0.4203	-0.3082
ANDAMAN	2.0245	0.2188	0.2215	-0.4712	-0.4909	0.1107	-0.0635	-0.1489	0.1944	-0.5137	-0.8489	-0.3117	-0.2906
ARIKARA	-0.2333	-0.2697	1.1168	0.5407	-0.6818	0.0556	0.5967	-0.0962	-0.4490	0.2399	-0.1991	-0.1113	-0.6059
AINU	-0.4884	-0.3556	-0.5704	-0.1070	0.3299	-0.0274	-0.0063	0.4224	-0.0021	0.1655	1.0849	-0.4758	0.5103
N JAPAN	-0.0342	-0.5306	0.0909	-0.5347	0.1073	0.1754	-0.3335	-0.1061	0.0317	0.0001	0.2888	0.0378	-0.6421
S JAPAN	0.1574	-0.3045	-0.1984	-0.8129	0.0569	0.0687	-0.1769	-0.7080	-0.0556	0.0186	0.1720	0.0178	-0.3942
HAINAN	0.5093	-0.3102	0.1660	-0.2669	-0.7676	0.3998	-0.4141	-0.7640	-0.3256	-0.2080	-0.0054	0.4262	-0.2948
ANYANG	0.0166	-0.4305	-0.0458	-0.7194	-0.3056	0.3018	-1.0281	-0.4218	-0.2488	-0.5980	0.4890	0.6734	-0.2096
ATAYAL	1.0185	-0.2118	-0.0604	-0.5001	-0.5857	-0.1013	-0.1697	0.0948	-0.1181	0.1413	0.6881	0.1947	0.0809
GUAM	-0.8203	-0.2652	-0.1902	0.0054	-0.5001	0.4124	-0.2704	-0.0481	0.7708	-0.2455	-0.3204	-0.0719	-0.0979
EASTER I	-1.1812	0.7567	-0.3535	-0.7405	0.4519	-0.1638	-0.0893	-0.3460	-0.8124	-0.9751	-0.5693	0.3361	0.3099
MORIORI	-0.8395	-0.3597	0.9811	0.2075	0.7839	0.9285	0.7207	-0.4064	-0.0332	-0.6943	0.0920	-0.4158	0.1836
SANTA CR	0.2837	-0.4349	1.1446	0.9687	0.6356	-0.0181	-0.1461	0.6677	0.2591	-0.0789	-0.1378	0.3284	-0.5881

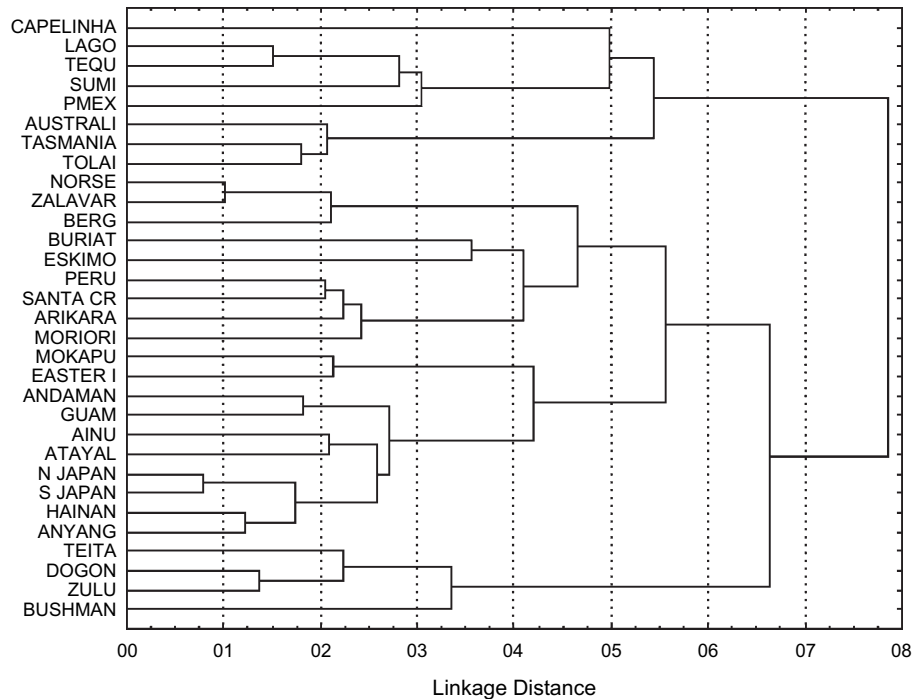


Fig. 3. Dendrogram (Ward's method) of the morphological relationship between the Capelinha individual and the other samples. The linkage distance is based on the first 13 factors of the PCA.

dispersion of the Paleoindians, while most of the other modern samples do not.

Discussion and conclusion

Our results support a Paleoamerican affiliation for the early Holocene individual from Capelinha, as is the case with all early human skeletal remains derived from Lagoa Santa, 700 km to the north (Neves and Pucciarelli, 1989, 1990, 1991; Munford et al., 1995; Neves et al., 1998, 1999b, 2003; Powell and Neves, 1999), and other localities in South and Central America (Neves et al., 1999b; González-José et al., 2001; Neves et al., 2003; Hubbe et al., in press).

As wisely remarked by Van Vark et al. (2003), comparative morphological analyses based on single skulls can be very misleading when dealing with long intervals of time and large differences in skeletal robusticity. This is not the case with the Capelinha Burial II because, as with most South

American Paleoindians, this male specimen is very gracile, as can be seen in Fig. 2. Due to the high degree of within-population morphological variation in humans (Relethford, 1994), it is also likely that isolated skulls do not represent the central tendency of the population from which they come. A legitimate strategy to overcome this drawback is to compare several isolated individuals from different geographic places. The more convergent the results obtained, the lower the probability these results are meaningless. In the specific case of South America, this strategy has been carried out by us and complemented by results generated on the basis of samples composed of several individuals from a few sites (Neves and Pucciarelli, 1989, 1990, 1991; Munford et al., 1995; González-José et al., 2001, 2002; Neves et al., 2003, 2004).

The increasing evidence that all late Pleistocene/early Holocene human groups from South America are characteristically non-Mongoloid has major implications for the colonization of the Americas, as argued by one of us (WAN) since the end of

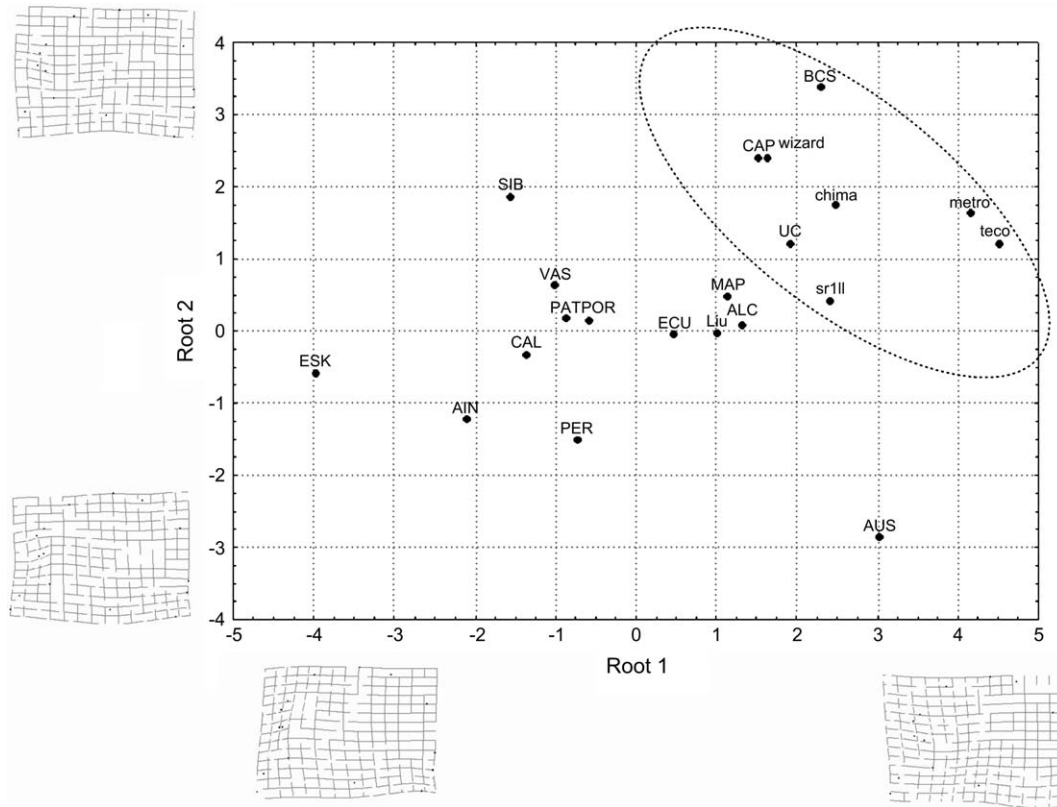


Fig. 4. Canonical analysis based on weight matrix, first and second roots. The TPS illustrations accompanying each axis show the skull shape deformation along each root.

the 1980s. Even if few studies with large samples from single sites have been carried out so far with Paleoindians (see Neves et al., 2003, 2004, as examples of these studies), it is evident by now that South America, Central America, and possibly North America were populated by human groups with a more generalized cranial morphology before the arrival of the Mongoloids. Since this more generalized morphology (“Australo-Melanesian-like”) was also present in East Asia at the end of the Pleistocene, transoceanic migrations are not necessary to explain our findings.

As presented in detail elsewhere (Neves et al., 2003) the arrival of an “Australo-Melanesian-like” population in the Americas is easily accommodated under what is presently known about the place of origin and the routes taken by modern humans in their first long-distance dispersions (Lahr and

Foley, 1998). Accordingly, a population that began to expand from Africa around 70 ka reached southeast Asia by the middle of the late Pleistocene, carrying with it a cranial morphology characterized by long, narrow neurocrania and narrow, projecting faces. We postulate that after reaching southeast Asia, this stem population gave rise to at least two different dispersions. One took a southward direction and arrived at Australia around 50 ka. Sometime between 50 and 20 ka a second branch dispersed towards the north, and arrived in the Americas by the end of the Pleistocene, bringing with it the same cranial morphology that characterized the first modern humans. When the classical Mongoloid cranial morphology appeared in northeastern Asia, either as a local response to extreme environmental conditions, or as the product of a migration from

Table 5
Values for each sample of the two canonical roots used in morphometric geometric analyses

Group	Root 1	Root 2
LIU	1.01782	-0.02719
SR111	2.40510	0.40873
UC	1.91997	1.21162
CHIMA	2.47375	1.74463
WIZARD	1.64427	2.40274
METRO	4.16402	1.63746
TECO	4.51829	1.20223
LUZIO	1.52398	2.39216
AIN*	-2.10412	-1.22013
ALC*	1.33055	0.07309
AUS*	3.01709	-2.86219
BCS*	2.28851	3.37575
CAL*	-1.36666	-0.33133
ECU*	0.47574	-0.04870
ESK*	-3.96819	-0.59204
MAP*	1.13562	0.47087
PAT*	-0.87335	0.16873
PER*	-0.72744	-1.51221
POR*	-0.58812	0.14455
SIB*	-1.56672	1.85194
VAS*	-1.00844	0.62931

* Scores averaged over all individuals' scores of the sample.

northern Europe, a new expansion of northern Asians reached the New World, bringing with it a cranial morphology characterized by short, wide neurocrania and broad, retracted faces.

Although local microevolutionary processes in the Americas can not be precluded to explain the transition from a generalized to a very specialized cranial morphology (Powell and Neves, 1999), a model based on the entrance of two different morphological patterns from the Old World is much more parsimonious. As recently demonstrated by Roseman (2004), significant changes in cranial morphology are much less frequent than previously expected. As such, cranial morphology has much to say about human evolutionary history.

Acknowledgments

This research was financially supported by FAPESP (Grants 99/00670-7, 99/12684-2, 98/14254-2, 02/13441-0, and 01/11420-3) and CNPq (Grant 305918/85-0). This paper is dedicated to Guy C. Collet, *in memoriam*, the first investigator

to reveal an early Holocene occupation in the valley of Ribeira de Iguape River.

References

- Barreto, C.N.G.B., 1988. A ocupação pré-colonial do vale do Ribeira de Iguape, SP: os sítios concheiros do médio curso. Master Thesis, University of São Paulo, São Paulo.
- Barreto, C.N.G.B., De Blasis, P., Dias Neto, C.M., Karmann, I., Lino, C.F., Robrahn, E.M., 1982. Abismo Ponta de Flecha: um projeto arqueológico, paleontológico e geológico no médio vale do rio Ribeira de Iguape, São Paulo. *Revista de Pré-História* 3, 195–215.
- Bass, W.M., 1987. *Human Osteology: A Laboratory and Field Manual*. Missouri Archaeological Society, Columbia.
- Bookstein, F.L., 1989. Principal warps, thin-plate splines and the decomposition of deformations. *IEEE. Trans. Pat. Anal. Mac. Intel.* 11, 567–585.
- Buikstra, J.E., Ubelaker, D.H., 1994. Standards for Data Collection from Human Skeletal Remains. *Arkansas Archaeological Survey Research Series* no. 44.
- Collet, G.C., 1985. Novas informações sobre os sambaquis fluviais do Estado de São Paulo. *Arquivos do Museu de História Natural da UFMG* 10, 311–324.
- Collet, G.C., Loebl, E., 1988. Informações sobre os sambaquis fluviais do Estado de São Paulo. *Anuário Staden (Estudos Brasileiros)*, 36. Fundação Martius (Inst. Hans Staden), São Paulo.
- Cunningham, D., Jantz, R.L., 2003. The morphometric relationship of Upper Cave 101 and 103 to modern *Homo sapiens*. *J. Hum. Evol.* 45, 1–18.
- Darroch, J.N., Mosimann, J.E., 1985. Canonical and principal components of shape. *Biometrika* 72, 241–252.
- De Blasis, P.A., 1988. A ocupação pré-colonial do vale do Ribeira de Iguape, SP: os sítios líticos do médio curso. Master Thesis, University of São Paulo, São Paulo.
- Dillehay, T.D., 1989. Monte Verde: A Late Pleistocene Settlement in Chile, volume 1: Palaeoenvironment and Site Context. Smithsonian Institution Press, Washington, DC.
- Dillehay, T.D., 1997. Monte Verde: A Late Pleistocene Settlement in Chile, volume 2: The Archaeological Context. Smithsonian Institution Press, Washington, DC.
- Goodall, C.R., 1991. Procrustes methods in the statistical analysis of shape. *J. R. Stat. Soc. B* 53, 285–339.
- González-José, R., Dahinten, S.L., Luis, M.A., Hernández, M., Pucciarelli, H.M., 2001. Craniometric variation and the settlement of Americas: testing hypothesis by means of R-matrix and matrix correlation analyses. *Am. J. Phys. Anthropol.* 116, 154–165.
- González-José, R., Hernández, M., Neves, W.A., Pucciarelli, H.M., Correal, G., 2002. Cráneos del Pleistoceno tardio-Holoceno temprano de México en relación al patrón morfológico paleoamericano. Paper presented at the 7th Congress of the Latin American Association of Biological Anthropology, Mexico City.

- González-José, R., González-Martín, A., Hernández, M., Pucciarelli, H.M., Sardi, M., Rosales, A., Van der Molen, S., 2003. Craniometric evidence for Paleoamerican survival in Baja California. *Nature* 425, 62–65.
- Howells, W.W., 1973. Cranial Variation in Man: A Study by Multivariate Analysis of Patterns of Difference among Recent Human Populations. Papers of the Peabody Museum of Archaeology and Ethnology, 67 Harvard University, Cambridge.
- Howells, W.W., 1989. Skull Shapes and the Map. Papers of the Peabody Museum of Archaeology and Ethnology, 79. Harvard University, Cambridge.
- Howells, W.W., 1995. Who's Who in Skulls. Ethnic Identification of Crania from Measurements. Papers of the Peabody Museum of Archaeology and Ethnology, 82. Harvard University, Cambridge.
- Howells, W.W., 1996. Howells' craniometric data on the internet. *Am. J. Phys. Anthropol.* 101, 441–442.
- Hubbe, M., Neves, W.A., Atui, J.P.V., Cartelle, C., Silva, M.P. A new early human skeleton from Brazil: further support to the "two main biological components model" for the settlement of the Americas. *Current Research in the Pleistocene*, in press.
- Jantz, R.L., Owsley, D.W., 2001. Variation among early North America crania. *Am. J. Phys. Anthropol.* 114, 146–155.
- Jantz, R.L., Owsley, D.W., 2003. Reply to Van Vark et al.: is European Upper Paleolithic cranial morphology a useful analogy for early Americans? *Am. J. Phys. Anthropol.* 121, 185–188.
- Kammaing, J., Wright, R.S.V., 1988. The upper cave at Zhoukoudian and the origins of the Mongoloids. *J. Hum. Evol.* 17, 739–767.
- Krone, R., 1914. Informações etnográficas do vale do Ribeira de Iguape. Exploração do rio Ribeira de Iguape, Comissão Geográfica e Geológica do Estado de São Paulo, 2. Edição Typ. Brazil de Rothschild & Co, São Paulo.
- Lahr, M.M., Foley, R., 1998. Towards a theory of modern human origins: geography, demography, and diversity of recent human evolution. *Yearb. Phys. Anthropol.* 41, 137–176.
- Lovejoy, C.O., Meindl, R.S., Pryzbeck, T.R., Mensforth, R.P., 1985. Chronological metamorphosis of the auricular surface of the ilium: a new method for the determination of age at death. *Am. J. Phys. Anthropol.* 68, 15–28.
- Manly, B.F.J., 1994. *Multivariate Statistical Methods: A Primer*. Chapman and Hall, London.
- Munford, D., Zanini, M.C., Neves, W.A., 1995. Human cranial variation in South America: implications for the settlement of the New World. *Braz. J. Genet.* 18, 673–688.
- Neves, W.A., Pucciarelli, H.M., 1989. Extra continental biological relationships of early South American human remains: a multivariate analysis. *Ciência e Cultura* 41, 566–575.
- Neves, W.A., Pucciarelli, H.M., 1990. The origins of the first Americans: an analysis based on early South American human remains. *Am. J. Phys. Anthropol.* 81, 247.
- Neves, W.A., Pucciarelli, H.M., 1991. The origin of the first Americans: an analysis based on the cranial morphology of early South American human remains. *J. Hum. Evol.* 21, 261–273.
- Neves, W.A., Pucciarelli, H.M., 1998. The Zhoukoudian upper cave skull 101 as seen from the Americas. *J. Hum. Evol.* 34, 219–222.
- Neves, W.A., Powell, J.F., Prous, A., Ozolins, E.G., 1998. Lapa Vermelha IV Hominid 1: morphological affinities of the earliest known American. *Am. J. Phys. Anthropol.* 26, 169.
- Neves, W.A., Powell, J.F., Ozolins, E.G., 1999a. Extra-continental morphological affinities of Lapa Vermelha IV, Hominid I: a multivariate analysis with progressive number of variables. *Homo* 50, 263–282.
- Neves, W.A., Powell, J.F., Ozolins, E.G., 1999b. Extra-continental morphological affinities of Palli Aike, southern Chile. *Interciência (Venezuela)* 24, 258–263.
- Neves, W.A., Prous, A., González-José, R., Kipnis, R., Powell, J., 2003. Human skeletal remains from Santana do Riacho I, Brazil: archeological background, chronological context and comparative cranial morphology. *J. Hum. Evol.* 45, 759–782.
- Neves, W.A., González-José, R., Hubbe, M., Kipnis, R., Araujo, A.G.M., Blasi, O., 2004. Early Holocene Human Skeletal Remains from Cerca Grande, Lagoa Santa, Central Brazil, and the origins of the first Americans. *World Archaeology* 36, 479–501.
- Powell, J.F., Neves, W.A., 1998. Dental diversity of early New World population: taking bite out of the tripartite model. *Am. J. Phys. Anthropol.* 26 (Suppl.), 179–180.
- Powell, J.F., Neves, W.A., 1999. Craniofacial morphology of the first Americans: pattern and process in the peopling of the New World. *Yearb. Phys. Anthropol.* 42, 153–188.
- Relethford, J.M., 1994. Craniometric variation among modern human populations. *Am. J. Phys. Anthropol.* 95, 53–62.
- Robrahn, E.M., 1988. A ocupação pré-colonial do vale do Ribeira de Iguape, SP: os grupos ceramistas do médio curso. Master Thesis, University of São Paulo, São Paulo.
- Robrahn-González, E.M., 1999. Diversidade cultural entre os povos ceramistas do sul-sudeste brasileiro: o caso do Vale do Ribeira do Iguape. In: Tenório, M.C. (Ed.), *Pré-História da Terra Brasilis*. Editora UFRJ, Rio de Janeiro, pp. 293–306.
- Robrahn-González, E.M., De Blasis, P.A., 1998. Investigações arqueológicas no médio/baixo vale do Ribeira de Iguape, São Paulo. *Revista do Museu de Arqueologia e Etnologia* 8, 57–69.
- Rohlf, F.J., 1993. Relative warp analysis and an example of its application to mosquito wings. In: Marcus, L.F., Bello, E., García-Valdecasa, A. (Eds.), *Contributions to Morphometrics*. Monografías del Museo Nacional de Ciencias Naturales, Madrid, pp. 131–190.
- Rohlf, F.J., 1999. Shape statistics: procrustes superimpositions and tangent spaces. *J. Classif.* 16, 197–223.
- Roosevelt, A.C., Lima da Costa, M., Lopes Machado, C., Michab, M., Mercier, N., Valladas, H., Feathers, J., Barnett, W., Imazio da Silveira, M., Henderson, A., Silva, J., Chernoff, B., Reese, D.S., Holman, J.A., Toth, N., Schick, K., 1996. Paleindian cave dwellers in the Amazon: the peopling of Americas. *Science* 272, 373–384.
- Roseman, C.C., 2004. Detecting interregionally diversifying natural selection on modern human cranial form by using

- matched molecular and morphometric data. *Proc. Natl. Acad. Sci.* 101, 12824–12829.
- Roseman, C.C., Weaver, T.D., 2004. Multivariate apportionment of global human craniometric diversity. *Am. J. Phys. Anthropol.* 125, 257–263.
- Sakai, K., 1981. *Notas arqueológicas do Estado de São Paulo, Brasil*. Instituto Paulista de Arqueologia, São Paulo.
- Steele, D.G., Powell, J.F., 1992. The peopling of the Americas: the paleobiological evidence. *Hum. Biol.* 63, 301–336.
- Steele, D.G., Powell, J.F., 1993. Paleobiology of the first Americans. *Evol. Anthropol.* 2, 138–146.
- Steele, D.G., Powell, J.F., 2002. Facing the past: a view of the North American human fossil record. In: Jablonski, N.G. (Ed.), *The First Americans: The Pleistocene Colonization of the New World*. *Wattis Symposium Series in Anthropology, Memoirs of the California Academy of Sciences*, 27.
- Van Vark, G.N., Kuizenga, D., L'Engle Williams, F., 2003. Kennewick and Luzia: lessons from the European Upper Paleolithic. *Am. J. Phys. Anthropol.* 121, 181–184.
- Wright, R.V.S., 1995. The Zhoukoudian Upper Cave skull 101 and multiregionalism. *J. Hum. Evol.* 29, 181–183.