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Short Communication

Haplotype diversity of 17 Y-str loci in an admixed population from the Brazilian Amazon

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Abstract

The allelic and haplotype frequencies of 17 Y-STR loci most commonly used in forensic testing were estimated in a sample of 138 unrelated healthy males from Macapá, in the northern Amazon region of Brazil. The average gene diversity was 0.6554 ± 0.3315. 134 haplotypes of the 17 loci were observed, 130 of them unique and four present in two individuals each. The haplotype diversity index was 0.9996 ± 0.0009, with the most frequent haplogroups being R1b (52.2%), E1b1b (11.6%), J2 (10.1%) and Q (7.2%). Most haplogroups of this population belonged to European male lineages (89.2%), followed by Amerindian (7.2%) and African (3.6%) lineages.

Key words: Amazon population, forensic genetics, haplogroups, Y-haplotypes, Y-STR.

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Since the beginning of the colonization of Brazil by the Portuguese, miscegenation has always been the rule, initially involving Native Americans and, later, Africans. However, the dynamics of mixing varies according to the region analyzed. Some studies have shown a higher European contribution in southern Brazil, an important African presence in northeastern Brazil and a substantial contribution from Native Americans in the northern region (Salzano, 2004; Francez *et al.*, 2011).

An important aspect of this miscegenation is that the colonization of Brazil initially involved only men; the immigration of European women during the initial centuries of colonization was insignificant. Thus, almost all of the 500,000 Portuguese that came to Brazil during the period 1500-1800 were men. Until the arrival of African slaves of both genders (about 4 million individuals, predominantly males) during the 16th to 19th centuries, the vast majority of the first Brazilians arose from matings between European males and Amerindian females (Curtin, 1969; Ribeiro, 1995).

The mixture between Europeans and Native Americans from the Amazon region started soon after the arrival of the first European colonizers. After settling in the new territory, the Europeans began using the indigenous labor force in their exploration and occupation of the Amazon region. During the 17th century, there was a reduction in indigenous slave labor and, from the mid-18th century on, Africans were introduced as slave labor, and represented the third wave of migration into the region (Cunha, 1995).

The lack of recombination between Y-chromosome-specific markers means that these markers are transmitted as haplotypes in the same way as single locus alleles. The lower effective number of Y-chromosomes in a given population also means that Y-haplotypes/haplogroups tend to show a higher proportion of variation between populations than observed for other markers located on autosomes or X chromosomes (Domingues *et al.*, 2007).

Y chromosome single tandem repeat (Y-STR) analysis can be very useful in paternity tests in which the alleged father is missing or deceased. In these cases, reference individuals from the same patrilineage can be analyzed. Y-STR analysis is also very useful in analyzing body fluid samples from criminal cases. By typing Y markers, even a minor male DNA component in a mixed male/female stain from a sexual assault can yield a male-specific profile that can be compared with the DNA of suspects (Betz *et al.*, 2001).

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The aim of this study was to type 17 Y-STR loci in order to establish a Y-STR haplotype database for the Macapá population and to use haplogroup predictor software to estimate the most common haplogroups in this population.

After obtaining signed informed consent from all study participants, peripheral blood samples were collected from 138 unrelated healthy males (mean age 39, range 19-69 years) seen for routine examination at the UNILAB Clinical Analysis Laboratory in Macapá (0°02’20” N; 51°03’59” W) in the northern Brazilian State of Amapá. This study was approved by the SEAMA College Research Ethics Committee (REC Resolution no. 023/2007).

Traditionally, Y-chromosome haplogroups have been defined based on their SNPs, but it is now possible to define them using a specific software for STR haplotypes. This approach allows comparison of the haplotype frequencies obtained using different sets of markers. In this study, with the exception of one population of 247 individuals from the State of Alagoas in northeastern Brazil for which the Y haplogroup was defined directly by SNPs (Azevedo *et al.*, 2009), the haplogroups of the other populations were estimated based on their STR haplotypes using Haplogroup Predictor software. For this estimation, we used the STR haplotypes of the Macapá population (current study) and the three main parental ethnic groups that formed the Brazilian population: Africans - 166 individuals from Angola (Melo *et al.*, 2010), Europeans - 175 individuals from Portugal (Pontes *et al.*, 2007) and Native Americans - 221 individuals from indigenous tribes in the Brazilian Amazon region (Palha *et al.*, 2010).

We also compared the Y haplogroup frequencies estimated from the STR haplotypes of 255 individuals from the State of Rio Grande do Sul in southern Brazil (Schwengber *et al.*, 2009), 200 individuals from the State of São Paulo in southeastern Brazil (Góis *et al.*, 2007), 200 individuals from the city of Belém in the State of Pará, northern Brazil (Palha *et al.*, 2007) and 48 individuals from the city of Brasília, Federal District in central-western Brazil (Grattapaglia *et al.*, 2005).

DNA was extracted from peripheral blood mononuclear cells using the phenol-chloroform procedure (Sambrook *et al.*, 1989) and was quantified spectrophotometrically (NANODROP 1000 spectrophotometer, Thermo Scientific, Wilmington, DE, USA). Polymerase chain reactions (PCR) were done with 1-2 ng of template DNA using commercial kits, according to the manufacturer’s instructions (AmpFLSTR® Y-filer PCR amplification kit, Applied Biosystems).

Electrophoresis and typing were done in an ABI 3130 Avant Automated Sequencer (Applied Biosystems, Foster City, CA, USA). Data acquisition was done with ABI PRISM 3130 - Avant Data Collection v2.0 software (Applied Biosystems) and profile analysis was done with GeneMapper ID v3.2 software (Applied Biosystems). Typing quality and allele designation were validated by simultaneous electrophoretic analysis of a control sample of known size. Allele designations were ascribed using an ABIGS LIZ-500 reference ladder (Applied Biosystems) as a molecular size marker.

Allele frequencies were calculated using the gene counting method. Gene and haplotype diversities were assessed using Arlequin Version 2.0 software. The Y haplogroups were estimated from haplotypes using Haplogroup Predictor software.

The average gene diversity at the 17 loci was 0.6554 ± 0.3315. 134 haplotypes were observed for the 17 loci, 130 of which were unique and four (h1, h8, h16 and h72) were present in two individuals each (Table 1). Haplotype diversity was 0.9996 ± 0.0009. The haplotypes were deposited in the Y-chromosome haplotype reference database (YHRD) under accession number YA003689 and the population sample was identified as “Macapá, Brazil [Admixed Brazilian]”. Table 2 shows the allelic frequency distribution for each locus.

The predominant haplogroup in the Macapá population was R1b (52.2%), followed by haplogroups E1b1b (11.6%), J2 (10.1%) and Q (7.2%). These results demonstrate the important European contribution, especially from the Iberian Peninsula, in the formation of urban populations in northern Brazil. The percentage of individuals with haplogroup Q was higher than in other Brazilian populations, indicating the important contribution of Amerindian males in the genetic makeup of this Amazonian population.

Haplogroup E1b1a, which is very prevalent in sub-Saharan African populations, was found in 3.6% of the subjects in this study; although this percentage was smaller than in other regions of Brazil, it nevertheless highlighted the contribution of individuals from this African region to the formation of admixed populations in northern Brazil. Most males in the Macapá population were primarily from European male lineage halogroups (89.2%), followed by Native American (7.2%) and African (3.6%) haplogroups (Table 3).

When the 134 haplotypes were used to search the YHRD, which includes 30,300 haplotypes (including those of 17 Y-STR) in 209 populations, we found that 18 haplotypes had matches. Eight matches were exclusively with populations from Europe (h4, h5, h16, h33, h44, h53, h88 and h91), five matches were exclusively with admixed populations from America (h36, h50, h61, h64 and h133) and one match was exclusively with African populations (h63). Two haplotypes showed simultaneous matches with European and admixed populations from America (h39, h127) and two haplotypes showed simultaneous matches with populations from Europe, Africa and America (h7 and h41). Haplotype h39 had the highest number of matches in the YHRD and was observed in seven of 81 Eurasian populations and three of 34 admixed populations from America, with most of the populations being of Basque origin. The

Table 1 - Y-chromosome haplotype distribution in a sample of 138 male from Macapá, based on the 17-STR AmpF$^{®}$STR1 Yfiler kit.

Haplotypes	N	DYS456	DYS389I	DYS390	DYS389II	DYS458	DYS19	DYS393	DYS391	DYS439	DYS635	DYS392	Y GATA H4	DYS437	DYS438	DYS448	DYS385I, II
H1	2	16	13	25	29	17	14	13	10	11	24	13	12	15	12	19	10,14
H2	1	15	13	24	29	17	14	13	11	13	23	13	12	14	12	19	12,14
H3	1	16	12	24	28	19	16	13	11	12	23	13	12	15	12	19	11,15
H4	1	16	13	24	29	18	14	13	11	12	23	13	12	15	12	19	11,13
H5	1	16	13	24	29	17	14	14	11	12	24	13	12	15	11	19	11,14
H6	1	15	14	25	30	17	12	13	10	12	22	15	11	14	11	20	15,19
H7	1	15	13	24	29	17	14	13	11	11	23	13	12	15	12	19	11,14
H8	2	16	13	24	29	18	14	13	11	12	23	13	12	15	12	19	12,14
H9	1	16	13	23	29	19	14	13	11	12	23	13	12	15	12	19	11,13
H10	1	16	14	23	30	18	13	13	9	10	21	11	12	14	10	20	13,14
H11	1	16	14	24	30	17	14	14	11	12	23	13	12	15	12	19	11,13
H12	1	15	14	23	30	15	14	12	10	11	24	14	11	16	10	20	16,17
H13	1	16	13	24	29	16	15	12	11	13	21	12	11	15	9	21	15,18
H14	1	14	13	22	29	16	15	13	10	11	21	11	11	16	10	20	13,14
H15	1	13	14	23	32	15	15	14	10	12	21	12	12	14	10	20	14,16
H16	2	16	13	24	30	16	14	13	11	12	23	13	12	15	12	19	11,14
H17	1	17	13	24	30	16	15	12	11	13	23	13	11	15	12	18	11,14
H18	1	15	13	23	29	16	14	13	11	12	23	13	11	15	12	18	11,15
H19	1	14	14	24	31	16	14	14	10	12	22	13	12	14	11	19	15,15
H20	1	15	14	24	30	18	13	13	9	10	21	11	12	15	10	18	13,14
H21	1	15	13	23	29	16	14	13	10	11	23	13	11	15	12	19	14,14
H22	1	15	13	26	29	17	14	13	11	12	23	13	11	15	12	18	11,13
H23	1	14	13	24	31	16	13	14	11	11	23	14	12	14	10	20	14,16
H24	1	16	13	24	29	18	14	13	9	10	21	11	12	14	10	19	14,14
H25	1	16	14	24	31	17	14	13	11	11	23	13	12	15	12	19	11,14
H26	1	13	12	24	28	17	15	12	10	11	21	11	11	16	9	19	14,17
H27	1	16	14	24	30	17	14	14	10	12	23	13	11	14	12	19	11,13
H28	1	17	13	23	30	18	14	13	11	12	23	13	12	15	12	19	11,14
H29	1	16	11	24	27	17	14	13	10	13	24	14	12	15	12	19	11,15
H30	1	14	12	23	29	14	13	13	10	10	21	11	11	14	10	20	17,17
H31	1	17	13	23	30	17	14	13	10	11	24	11	13	15	9	19	13,15
H32	1	16	14	24	29	16	15	13	10	11	23	13	12	15	12	17	11,14
H33	1	15	13	24	29	18	14	13	11	12	23	13	12	15	12	19	11,15
H34	1	19	13	23	29	18	14	13	11	12	23	13	11	15	12	19	11,15
H35	1	17	13	23	31	14	13	13	11	13	22	14	10	14	12	18	15,18
H36	1	17	13	23	30	15	13	13	11	11	21	11	12	14	10	20	15,18
H37	1	15	13	24	29	15	15	12	10	12	21	11	11	15	9	23	13,18
H38	1	16	13	24	29	18	13	13	9	10	21	11	12	15	10	20	13,13
H39	1	15	13	24	29	18	14	13	11	12	23	13	12	15	12	19	11,14

Table 1 (cont.)

Haplotypes	N	DYS456	DYS389I	DYS390	DYS389II	DYS458	DYS19	DYS393	DYS391	DYS439	DYS635	DYS392	Y GATA H4	DYS437	DYS438	DYS448	DYS385I, II
H40	1	15	13	24	29	17	14	12	10	13	23	13	11	15	12	20	11,14
H41	1	15	14	24	30	17	14	13	10	12	23	13	11	14	12	18	11,14
H42	1	15	13	23	32	20	14	12	10	11	20	11	12	14	10	20	13,17
H43	1	15	12	23	30	16	14	13	10	12	22	14	12	14	11	20	13,18
H44	1	14	13	23	29	19	15	13	10	13	21	11	11	14	10	18	12,15
H45	1	15	13	25	29	17	14	13	11	12	24	14	12	15	12	19	11,15
H46	1	15	12	23	29	17	15	14	10	14	20	11	12	16	10	21	14,14
H47	1	17	12	22	28	15	14	13	10	**13**	21	11	11	16	10	20	13,14
H48	1	16	14	25	30	16	14	12	11	12	23	13	12	15	12	20	11,14
H49	1	14	14	22	30	18	14	13	11	12	23	13	12	15	10	19	10,14
H50	1	16	13	24	31	18	14	13	11	12	23	13	12	15	12	19	11,15
H51	1	15	13	23	29	14	15	12	10	10	22	11	11	14	9	20	13,17
H52	1	16	13	24	29	14	15	12	9	12	22	11	12	14	9	20	14,16
H53	1	15	13	24	29	17	15	13	11	12	23	13	12	15	12	19	11,14
H54	1	14	13	23	28	16	17	13	10	11	22	11	12	15	10	21	12,13
H55	1	16	13	24	29	18	13	13	9	10	22	11	13	14	10	19	13,14
H56	1	15	12	25	30	14	14	11	9	12	19	13	10	15	12	20	11,14
H57	1	15	14	23	31	15	13	14	10	12	22	13	10	14	10	19	13,16
H58	1	17	13	24	30	15	14	13	10	12	22	11	13	14	10	20	17,17
H59	1	15	13	23	29	17	14	13	11	11	23	13	13	14	12	19	11,14
H60	1	17	13	24	30	16	13	14	10	12	22	10	12	14	10	20	16,18
H61	1	14	12	23	29	15	14	13	10	12	22	11	11	16	10	21	14,14
H62	1	15	13	24	29	18	14	13	11	12	24	12	12	15	11	19	11,14
H63	1	16	13	23	28	17	14	13	10	11	23	13	12	15	R	19	11,14
H64	1	16	13	23	30	16	13	14	10	11	20	11	11	14	10	21	16,16
H65	1	16	13	22	29	16	14	12	10	11	21	11	11	14	9	20	13,15
H66	1	14	12	23	28	19	14	8	11	12	23	13	12	15	12	20	11,14
H67	1	15	11	24	27	19	13	12	10	11	22	11	10	14	10	20	12,17
H68	1	15	14	22	31	14	13	13	10	11	23	14	11	14	11	20	15,17
H69	1	15	14	23	30	17	15	13	10	12	23	13	13	15	11	19	12,14
H70	1	17	13	24	29	17	14	13	11	12	23	13	11	15	13	19	11,13
H71	1	15	12	22	28	14	15	13	10	13	22	11	11	16	10	20	13,14
H72	2	16	12	23	29	18	14	12	10	11	22	11	9	15	9	20	13,14
H73	1	14	12	22	28	16	15	14	10	**11**	21	11	11	16	10	20	13,14
H74	1	15	13	23	30	17	14	13	11	13	24	13	12	14	13	20	12,15
H75	1	13	13	24	31	16	14	12	10	13	23	12	12	15	12	19	11,14
H76	1	15	13	24	28	17	14	13	11	11	23	13	11	14	12	18	13,14
H77	1	17	14	21	31	17	17	14	10	12	21	11	11	14	11	21	17,19
H78	1	16	14	22	30	15	14	12	10	10	21	11	11	15	9	21	13,16

Table 1 (cont.)

Haplotypes	N	DYS456	DYS389I	DYS390	DYS389II	DYS458	DYS19	DYS393	DYS391	DYS439	DYS635	DYS392	Y GATA H4	DYS437	DYS438	DYS448	DYS385I, II
H79	1	15	13	25	29	17	14	13	10	11	23	13	13	15	12	19	11,14
H80	1	16	13	25	29	16	15	12	10	11	23	13	11	15	11	20	13,14
H81	1	17	13	23	29	16	13	13	10	12	22	14	12	14	12	19	14,17
H82	1	15	13	24	29	17	14	13	11	12	24	13	12	15	12	19	12,13
H83	1	17	12	23	28	17	15	12	10	12	20	11	11	16	9	20	14,17
H84	1	15	14	25	30	17	14	14	10	12	23	13	13	15	12	19	11,14
H85	1	14	12	22	28	15	14	12	10	11	24	11	11	16	10	20	14,14
H86	1	15	13	24	29	18	14	13	10	12	24	13	12	15	12	19	11,14
H87	1	15	13	24	29	15	13	13	11	13	25	13	12	15	12	19	11,14
H88	1	16	13	25	29	16	14	13	10	12	23	13	12	15	12	19	11,14
H89	1	15	13	23	31	15	13	13	10	12	23	13	12	14	10	20	17,21
H90	1	16	13	24	29	16	15	13	12	12	23	13	12	15	11	19	11,14
H91	1	16	13	24	30	15	13	13	10	12	22	11	12	14	10	20	16,18
H92	1	16	13	24	29	17	14	13	11	11	23	10	11	15	12	19	11,14
H93	1	15	13	23	31	15	13	13	10	12	24	11	12	14	10	21	16,17
H94	1	15	13	24	29	16	14	13	10	12	22	13	12	14	12	19	11,14
H95	1	17	12	22	28	16	16	14	10	11	20	11	13	16	11	21	13,14
H96	1	14	13	24	30	16	**13**	14	10	12	22	11	12	14	10	21	13,14
H97	1	16	12	22	28	16	14	14	10	11	21	10	11	16	10	20	13,14
H98	1	16	13	24	29	18	14	13	11	12	24	13	12	15	12	19	11,12
H99	1	14	14	24	29	17	14	13	11	12	25	13	11	15	11	19	11,14
H100	1	16	13	23	30	15	17	12	10	11	23	11	13	15	9	22	13,17
H101	1	14	12	23	28	15	14	13	10	12	22	11	11	16	10	21	14,14
H102	1	15	13	22	30	16	14	12	9	11	24	11	11	15	9	21	13,17
H103	1	16	13	24	29	17	14	14	10	12	23	13	11	14	12	19	12,14
H104	1	16	13	24	29	17	14	13	11	12	24	13	12	15	11	19	11,14
H105	1	17	14	21	31	16	17	14	10	12	21	11	11	15	11	21	17,18
H106	1	15	13	24	29	16	15	13	12	12	23	13	12	15	11	19	14,14
H107	1	15	13	24	29	18	13	13	9	10	22	11	13	14	10	19	13,14
H108	1	13	13	24	29	17	14	13	11	12	24	13	12	15	12	19	11,13
H109	1	15	14	23	30	18	14	13	11	12	23	13	11	14	12	18	11,14
H110	1	15	13	23	30	**17.2**	15	12	10	13	21	11	11	14	10	21	13,15
H111	1	15	13	24	29	17	14	13	11	11	23	13	12	15	12	18	12,14
H112	1	15	14	24	29	18	14	12	11	13	24	14	13	15	12	20	12,14
H113	1	15	12	24	28	17	14	13	10	12	24	11	11	14	11	19	14,19
H114	1	15	14	24	30	18	15	13	11	12	23	13	11	15	12	19	14,14
H115	1	15	13	22	30	17	14	12	10	11	20	11	11	14	10	**20**	13,18
H116	1	16	13	24	29	16	13	13	10	13	23	13	12	15	12	19	14,14
H117	1	15	13	24	29	17	14	13	10	11	23	13	12	15	12	20	11,13

Table 1 (cont.)

Haplotypes	N	DYS456	DYS389I	DYS390	DYS389II	DYS458	DYS19	DYS393	DYS391	DYS439	DYS635	DYS392	Y GATA H4	DYS437	DYS438	DYS448	DYS385I, II
H118	1	15	13	24	29	17	15	13	10	12	23	13	12	15	12	19	11,14
H119	1	14	13	23	29	16	16	15	10	11	22	12	11	14	10	21	16,16
H120	1	15	13	22	29	17	**13**	13	10	12	22	15	10	14	11	19	14,16
H121	1	15	13	23	29	17	14	12	10	12	23	11	13	14	9	20	13,15
H122	1	16	14	24	30	18	14	13	11	12	23	12	11	15	12	19	11,14
H123	1	15	14	24	30	18	14	13	11	12	23	13	12	15	12	19	11,15
H124	1	16	13	23	29	15	13	12	10	12	22	14	12	15	12	19	14,17
H125	1	14	13	21	30	15	12	12	10	11	22	14	11	14	11	21	14,17
H126	1	15	14	22	32	16	17	13	10	13	20	11	11	17	8	19	15,18
H127	1	16	13	23	29	17	14	13	11	11	23	13	12	15	12	19	11,15
H128	1	15	12	25	27	18	15	13	11	11	22	14	11	14	9	19	13,16
H129	1	16	13	24	29	18	14	13	12	13	23	13	12	15	11	18	12,13
H130	1	15	13	24	28	16	14	13	11	12	23	13	11	15	12	19	11,14
H131	1	16	14	24	31	16	13	13	10	13	21	11	12	14	10	20	16,18
H132	1	15	13	21	31	16	15	13	11	11	21	11	13	14	11	21	17,17
H133	1	15	13	24	29	16	15	13	11	13	23	13	12	15	10	19	11,14
H134	1	15	13	22	30	16	15	13	10	12	20	11	11	17	9	19,20	15,16

Table 2 - Allele/genotype frequencies and gene diversity (GD) values of Y-STRs in a Macapá population sample (138 individuals).

Alleles	DYS456	DYS389I	DYS390	DYS389II	DYS458	DYS19	DYS393	DYS391	DYS439	DYS635	DYS392	YGATA-H4	DYS437	DYS438	DYS448	Genotypes	DYS385
8														0.0072			
9								0.0652				0.0145		0.1159		10,14	0.0226
10								0.5362	0.0652		0.0217	0.0362		0.2754		11,13	0.0602
11		0.0145					0.0072	0.3768	0.2899		0.3478	0.3623		0.1449		11,14	0.2556
12		0.1449				0.0102	0.1957	0.0217	0.5000		0.0435	0.4927		0.4348		11,15	0.0677
13	0.0290	0.6377				0.1739	0.6522		0.1377		0.4855	0.0945		0.0217		11,17	0.0075
14	0.1159	0.2029			0.0507	0.5652	0.1304		0.0072		0.0870		0.3478			12,13	0.0226
15	0.4203				0.1304	0.1884	0.0072				0.0145		0.5435			12,14	0.045
16	0.3261				0.2681	0.0217	0.0072						0.0942			12,15	0.015
17	0.1014				0.3115	0.0362							0.0145		0.0080	12,17	0.0075
18	0.0072				0.1957										0.0797	14,14	0.0526
19					0.0362					0.0072					0.4928	14,16	0.0301
20					0.0072					0.063					0.2826	14,16	0.0376
21			0.0290							0.1594					0.1232	14,16	0.0075
22			0.1160							0.1957					0.0072	13,13	0.0075
23			0.2899							0.4275					0.0072	13,14	0.1053
24			0.4782							0.1377						13,15	0.0226

Table 2 (cont.)

Alleles	DYS456	DYS389I	DYS390	DYS389II	DYS458	DYS19	DYS393	DYS391	DYS439	DYS635	DYS392	YGATA-H4	DYS437	DYS438	DYS448	Genotypes	DYS385
25			0.0797							0.0145						13,16	0.0226
26			0.0072													13,17	0.0226
27				0.0217												13,18	0.0226
28				0.1159												15,15	0.0075
29				0.4783												15,16	0.0075
30				0.2689												15,17	0.0075
31				0.1014												15,18	0.0376
32				0.0217												15,19	0.0075
																16,16	0.015
																16,17	0.015
																16,18	0.0226
																17,17	0.0226
																17,18	0.0075
																17,19	0.0075
																17,21	0.0075
GD	0.6975	0.5348	0.6714	0.6835	0.7774	0.6173	0.5230	0.5699	0.6474	0.7363	0.6378	0.6200	0.5788	0.7012	0.6604		0.88976

Table 3 - Y chromosome haplogroup distribution in parental populations, Macapá, and other Brazilian admixed populations.

Population	Systems	Y – Haplogroups (%)											n (%)
		E1b1b	E1b1a	R1b	R1a	I1	I2	G2a	J1	J2	Q	Others	
[1]Portugal	17 STRs	20 (11.4)	1 (0.6)	101 (57.7)	0	8 (4.6)	9 (5.1)	10 (5.7)	9 (5.1)	10 (5.7)	2 (1.1)	5.00 (2.9)	175 (100)
[2]Angola	12 STRs	6 (3.6)	139 (83.7)	8 (4.8)	0	0	7 (4.2)	1 (0.6)	0	1 (0.6)	1 (0.6)	3.00 (1.8)	166 (100)
[3]Amerindians	9 STRs	0	1 (0.5)	1 (0.5)	0	1 (0.5)	0	0	0	0	183 (82.8)	35.00 (15.8)	221 (100)
[4]Macapá	17 STRs	16 (11.6)	5 (3.6)	72 (52.2)	0	6 (4.3)	3 (2.2)	3 (2.2)	4 (3.0)	14 (10.1)	10 (7.2)	5 (3.6)	138 (100)
[5]Alagoas	24 SNPs	25 (10.1)	11 (4.5)	137 (55.5)	1 (0.4)	12 (4.9)	4 (1.6)	9 (3.6)	15 (6.1)	18 (7.3)	2 (0.8)		247 (100)
[6]Brasília	9 STRs	9 (18.8)	2 (4.2)	19 (39.6)	0	1 (2.1)	3 (6.3)	2 (4.2)	3 (6.3)	4 (8.3)	0	5.00 (10.4)	48 (100)
[7]São Paulo	17 STRs	20 (10.0)	22 (11)	61 (30.5)	5 (2.5)	10 (5.0)	16 (8.0)	10 (5.0)	7 (3.5)	6 (3.0)	11 (5.5)	32.00 (16.9)	200 (100)
[8]Belém	9 STRs	17 (8.5)	7 (3.5)	89 (44.5)	15 (7.5)	4 (2.0)	15 (7.5)	3 (1.5)	3 (1.5)	14 (7.0)	11 (5.5)	22.00 (11.0)	200 (100)
[9]Rio G. do Sul	17 STRs	25 (9.8)	17 (6.7)	120 (47.1)	10 (3.9)	18 (7.1)	8 (3.1)	11 (4.3)	2 (0.8)	31 (12.2)	4 (1.6)	9.00 (2.5)	255 (100)

[1]Pontes *et al.*, 2007; [2]Melo *et al.*, 2011; [3]Palha *et al.*, 2010; [4]current study; [5]Azevedo *et al.*, 2009; [6]Grattapaglia *et al.*, 2005; [7]Góis *et al*, 2007; [8]Palha *et al.*, 2007; [9]Schwengber *et al.*, 2009.

latter finding can be explained by the important contribution of Spanish immigrants in the formation of the Brazilian population. The first Spanish immigrants arrived in Brazil in 1880. Until the late 19th century, the vast majority of these were from Galicia, while in the early 20th century Andalusians predominated. Other important groups included Catalans, Basques and Valencians (Cánovas MDK, 2001, Masters dissertation, Faculdade de Filosofia, Letras e Ciências Humanas da Universidade de São Paulo, São Paulo, SP, Brazil).

The results of this study show that Europeans were the main contributors to the formation of the Macapá male genetic background. These observations agree with previous reports (Carvalho-Silva *et al.*, 2001; Silva *et al.*, 2006; Francez *et al.*, 2011).

The similar haplogroup composition between the population analyzed here and other admixed Brazilian populations (Table 3) suggested that the latter populations were probably formed by a similar process of miscegenation, with the predominant male lineages being European. This would explain the low level of Y-chromosome structuring observed in geographically and geopolitically distinct regions.

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References

Azevedo DA, Silva LAF, Gusmão L and Carvalho EF (2009) Analysis of Y-chromossome SNPs in Alagoas, Northeastern Brazil. Forensic Sci Int Genet 2:421-422.

Betz A, Babler G, Dietl G, Steil X, Weyermann G and Pflug W (2001) DYS STR analysis with epithelial cells in a rape case. Forensic Sci Int 118:126-130.

Carvalho-Silva DR, Santos FR, Rocha J and Pena SDJ (2001) The phylogeography of Brazilian Y-chromosome lineages. Am J Hum Genet 68:281-286.

Cunha MC (1995) História dos Índios no Brasil. 1st edition. Companhia das Letras, São Paulo, 611 pp.

Curtin PD (1969) The Atlantic Slave Trade: A Census. 1st edition. University of Wisconsin Press, Madison, 457 pp.

Domingues PM, Gusmão L, da Silva DA, Amorim A, Pereira WR and Carvalho RF (2007) Sub-Saharan Africa descendents in Rio de Janeiro (Brazil): Population and mutational data for 12 Y-STR loci. Int J Legal Med 121:238-241.

Francez PAC, Rodrigues EMR, Frazão GF, Borges NDR and Santos SEB (2011) Allelic frequencies and statistical data obtained from 12 CODIS STR loci in an admixed population of Brazilian Amazon. Genet Mol Biol 34:35-39.

Góis CC, Martins JA, Pereira GA, Freschi A, Paneto GG, Alvarenga VLS, Cicarelli RMB, Hirata MH and Oliveira RN (2007) Genetic population data of 12 STR loci of the PowerPlex®Y system in the state of São Paulo population (Southeast of Brazil). Forensic Sci Int 174:80-85.

Grattapaglia D, Kalupniek D, Guimarães CS, Ribeiro MA, Diener OS and Soares CN (2005) Y-chromosome STR haplotype diversity in Brazilian populations. Forensic Sci Int 149:99-107.

Melo MM, Carvalho M, Lopes V, Anjos MJ, Serra A, Vieira DN, Sequeiros J and Corte-Real F (2011) Y-STR haplotypes in three ethnic linguistic groups of Angola population. Forensic Sci Int Genet 5:83-88.

Palha TJBF, Rodrigues EMR and Santos SEB (2007) Y-chromossomal STR haplotypes in population from the Amazon region, Brazil. Forensic Sci Int 166:233-239.

Palha TJBF, Rodrigues EMR and Santos SEB (2010) Y-STR haplotypes of Native American populations from the Brazilian Amazon region. Forensic Sci Int Genet 4:121-123.

Pontes ML, Cainé L, Abrantes D, Lima G and Pinheiro MF (2007) Allele frequencies and population data for 17 Y-STR loci (AmpFSTR® Y-filer) in a Northern Portuguese population sample. Forensic Sci Int 170:62-67.

Ribeiro D (1995) O Povo Brasileiro: A Formação e o Sentido do Brasil. 1st edition. Companhia das Letras, São Paulo, 480 pp.

Salzano FM (2004) Interethnic variability and admixture in Latin America - Social implications. Rev Biol Trop 52:405-415.

Sambrook J, Fritsch EF and Maniatis T (1989) Isolation of DNA from mammalian cells. In: Ford N, Nolan C and Ferguson M (eds) Molecular Cloning - A Laboratory Manual. 2nd edition. Cold Spring Harbor Laboratory Press, New York, pp 916-919.

Schwengber SP, Kommers T, Matte CHF, Raimann PE, Carvalho BA, Leite FPN, Medeiros MA, Souza LF, Castro CS, Chassot FGC, *et al.* (2009) Population data of 17 Y-STR loci from Rio Grande do Sul state (South Brazil). Forensic Sci Int Genet 4:31-33.

Silva DA, Carvalho E, Costa G, Tavares L, Amorim A and Gusmão L (2006) Y chromosome genetic variation in Rio de Janeiro population. Am J Hum Biol 18:829-837.

Internet Resources

Arlequin - A software for population genetics data analysis ver. 2.000, http://anthro.unige.ch/software/arlequin/software/2.000/doc/buglist/buglist.html (February 10, 2011).

Haplogroup predictor software, www.hprg.com/hapest5/ (March 10, 2011).

YHRD - Y Chromosome haplotype reference database, www.yhrd.org (January 20, 2011).

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