

Demographic and genetic structure of the population of Castanhal, in the Amazon Region of Brazil

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ABSTRACT

Five-hundred individuals were investigated for five demographic parameters and 13 genetic markers in the trihybrid population of Castanhal, State of Pará, Brazil. The rate of immigration (20.4%) was one of the highest in the region. In general, the genetic polymorphisms did not present significant differences within the region. Rare alleles such as *HP*2M*, and *CP*A* and *CP*C* were observed, as well as two albumin variants. Mean heterozygosity, mean number of alleles per locus, and percent of polymorphic loci were similar to those observed in nine other Amazonian communities. The relative contribution of the main ethnic groups was estimated to be 42% White, 25% Indian and 33% Black, in Castanhal, the percentage of African ancestry being the largest observed among the admixed populations of the Amazon Region.

INTRODUCTION

During Brasil's first 50 years as a colony, the Portuguese paid little attention to it. Later, with the threat of invasion of our territory by other European nations, they made attempts to secure ownership of the land by intensifying the settling of the land by colonizers. This process started in the Amazon Region, in the 17th century, Belém being founded in January, 1616. Upon their arrival, the colonizers encountered a native population which was mainly represented by the Tupinambá Indians, distributed throughout the Northern region. Africans were introduced in large numbers after 1755 by the "Companhia Comercial e Geral do Grão Pará e Maranhão" (General Commerce Company of Great Pará and Maranhão). A total of 50,910

individuals from that continent were brought to Brazil from 1755 to 1815 (Salles, 1971).

In 1870, major changes occurred in Brazil, such as the shift of political and economic control from the Northeast to the Southeast, as well as a shortage of manpower due to the liberation of slaves. This led the elite of the South and Southeast to favor a policy of encouragement of European immigration, with strong restrictions against the entry of African and Asiatic ethnic groups (Schwarcz, 1993). In the North, far from the political and economic control of the republic, the immigration process was made more difficult.

After the European immigrants first entered the country, a process of significant regional differentiation began. Due to the intense flow of immigrants, Whites predominated in the South and Southeast, with little influence from other ethnic groups. In the Northern Region it is possible to clearly observe the influence of the three ethnic groups through a unique and singular

process of miscegenation, with a consequent prevalence of the model existing in Colonial and Imperial Brazil. This process was more marked between Whites and Indians than between Whites and Blacks. Another important factor contributing to the present genetic constitution of the Amazonian population was internal migration, especially from the Northeast. Approximately 300,000 individuals, most of them from the State of Ceará, migrated to the region due to the great droughts that devastated their homeland (Carneiro, 1980).

MATERIAL AND METHODS

Castanhal is located along the Belém-Brasília highway (BR 316), at approximately 1°17'48''S, 47°55'20''W, northern Pará state. Castanhal was founded by two Italian family groups (Anita Garibaldi and Ianetama) who arrived there in 1885. In 1889, three other Spanish, Cuban and North American family groups also settled in the region; and starting in 1891, migrants from the Northeast arrived there. After the effective creation of the municipality in 1932, two events marked the beginning of intensive growth and of a new immigration wave, i.e., the end of the Belém-Bragança railroad and the construction of the Belém-Brasília highway.

The sample consisted of 500 individuals. Information about name, age, sex, color, number of living children, number of dead children, and birthplace of the individual, of the spouse, parents, and maternal and paternal grandparents were obtained. Ages ranged from 18 to 62 years, and external appearance indicated 14% Whites and 86% mixed race.

Venous blood (10 ml) was collected from each individual using EDTA as the anticoagulant. The serum fraction was separated from the red blood cell fraction and frozen until the time of analysis.

The following genetic systems were analyzed: ABO and RH blood groups, ceruloplasmin, haptoglobin, transferrin, albumin, serum cholinesterase (CHE1 and CHE2), carbonic anhydrase 2, acid phosphatase 1, glyoxalase 1, esterase D, and hemoglobin. The assays used have been described by Santos *et al.* (1987) and Guerreiro *et al.* (1993).

Gene frequency analyses were performed using the MAXLIK software (Maximum Likelihood, Reed, 1968) and racial admixture was estimated using the MISTURA 3 program (Krieger *et al.*, 1965). The level of population dispersal was evaluated using the following parameters: a) mean individual migration (average

migration distance between birthplace and place of present residence); b) marital distance (average distance between the spouses' birthplaces); c) parent-offspring distance (average of the father-child and mother-child birthplace distances); d) exogamy coefficient (percent of marriages between people born in different localities). All of these parameters were analyzed using the DIST computer program developed by J.R.S. Tavares (Human Genetics Laboratory, Federal University of Pará).

RESULTS AND DISCUSSION

Migratory parameters

Information about the birthplace of the individuals studied in Castanhal as well as in seven other Amazonian populations is presented in Table I (Schüler *et al.*, 1982; Santos *et al.*, 1983, 1987; Guerreiro and Chautard-Freire-Maia, 1988; Guerreiro *et al.*, 1993 and Santos *et al.*, 1991). Most of the populations presented a larger proportion of immigrants from the state where they were located. However, the municipality of Castanhal showed a high percentage of immigrants from other regions of Brazil (20.4%), mainly from the Northeast (13.7%). In general, the individuals studied in Castanhal presented high values for the migration parameters when compared to those of other populations in the Amazon Region such as Óbidos, Oriximiná, Belém and Parintins (Table II) (Guerreiro *et al.*, 1993).

Polymorphisms

Phenotypic frequencies, gene frequencies and heterozygosity at 12 of the 13 loci investigated in the Castanhal population are presented in Table III. No significant differences in phenotype distribution were observed when comparing this to other Amazonian populations (Schüler *et al.*, 1982; Santos *et al.*, 1983, 1987; Guerreiro and Chautard Freire-Maia, 1988; Guerreiro *et al.*, 1993 and Santos *et al.*, 1991). Among the enzyme systems investigated, ESD ($\chi^2 = 8.6$; 1 D.F.; $P < 0.01$) and ACP ($\chi^2 = 14.5$; 1 D.F.; $P < 0.001$) were found to be in Hardy-Weinberg disequilibrium. Both systems exhibit a clear reduction in the number of heterozygotes and an increase of the homozygotes of the less common allele (ESD*2 and ACP*A, respectively). Simões (1980) found an absence of equilibrium in ESD phenotypes among Indian, Black

Table I - Birthplaces of individuals of eight populations of the Amazon Region.

Origin	CST	BEL	SNT	ORX	OBD	MAN	PRT	ALQ
At the site	24.5	-	57.1	75.7	80.1	19.4	71.8	82.2
Other regions of the State	54.7	84.1	24.7	16.5	17.5	34.3	11.5	11.6
Other Regions of Brazil:								
North	1.2	2.0	3.2	0.5	0.8	15.6	15.7	1.3
Northeast	13.7	9.6	11.6	4.4	1.2	20.2	0.8	4.1
Center-West	1.4	0.8	1.0	0.5	-	2.0	-	0.4
Southeast	3.3	2.5	1.2	2.4	-	2.7	0.2	-
South	0.8	0.1	1.2	-	-	4.5	-	0.4
Foreigners	0.4	0.9	-	-	0.4	1.3	-	-

CST-Castanhal, BEL-Belém, SNT-Santarém, ORX-Oriximiná, OBD-Óbidos, MAN-Manaus, PRT-Parintins, ALQ-Alenquer.

Table II - Demographic data from the Castanhal population.

Generation	Individual migration (km)	Marital distance (km)	Parent-offspring distance (km)	Exogamy index
Present generation	293.88	210.51	281.70 (II-III)	22.64
Parent's generation	-	221.08	203.40 (I-II)	22.59
Grand parent's generation	-	79.20	-	9.05

and Northeastern populations of Brazil. The *HP*2M* allele presented a frequency of 0.01, the same as detected in Belém (Ayes *et al.*, 1976), Manaus (Santos *et al.*, 1983), Coari (Rosa *et al.*, 1984) and Oriximiná (Santos *et al.*, 1987). The *CP*B* allele presented the lowest frequency (0.94) observed thus far in the Amazon Region, and *CP*C* had a prevalence of 0.02, the same as that observed in Óbidos (Guerreiro *et al.*, 1993). Two rare variants of albumin were observed. Their electrophoretic mobility was compared to other variant forms detected in our laboratory in buffer TEB from pH 6.1 and pH 6.9 and pH 6.0 acetate/EDTA buffer. The first, had a electrophoretic migration faster than that usually observed. It's pattern was similar to Maku albumin, a form detected in the Oriximiná population and identified by Arai *et al.* (1989). The second presented a slower electrophoretic migration and could not be compared to any other variant form. The frequency of the *CA2*2* allele (0.03), characteristic of Black populations, was the highest found among all Amazonian populations studied.

In the 13 systems investigated in Castanhal, heterozygosity was high (about 50%) for the haptoglobulin and glyoxalase loci, and low (less than 5%) for the hemoglobin, serum cholinesterase 1, and for albumin loci.

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Table IV presents the estimates of mean heterozygosity (H), mean number of alleles per locus (N) and percent polymorphic loci (P) in Castanhal and in seven other trihybrid populations of the Amazon Region. For comparison, we also present the values observed in two rural, semi-isolated Black populations of the region. The table presents two groups of estimates: one involving the 12 systems investigated (ABO, RH, HP, CP, TF, ALB, CHE1, HBB, ESD, CA2, ACP, and GLO), the other with only 10 systems (all except CP and CHE1). In general, the populations investigated were found to be homogeneous for these parameters. They had approximately 20% mean heterozygosity, around two alleles per locus, and about 80% polymorphic loci. The table also presents the values observed in two semi-isolated Black communities of the Amazon Region, Cameté and Trombetas. Our expectation was that genetic drift and/or founder effects, almost always invoked to explain phenomena in isolated populations, would lead

Table III - Phenotypes, gene frequencies and heterozygosity per locus (h) in Castanhal.

System and phenotypes		Number	Alleles	Frequency per locus	Heterozygosity
HP	1-1	110	<i>HP*1</i>	0.4802	0.511
	2-1	217	<i>HP*2</i>	0.5088	
	2-2	118	<i>HP*2M</i>	0.0110	
	2-1M	10			
CP	B	391	<i>CP*B</i>	0.9453	0.105
	AB	33	<i>CP*A</i>	0.0376	
	BC	15	<i>CP*C</i>	0.0171	
TF	C	429	<i>TF*C</i>	0.9725	0.054
	CD	23	<i>TF*D</i>	0.0253	
	BC	2	<i>TF*B</i>	0.0022	
ALB	A	464	<i>ALB*A</i>	0.9968	0.006
	A/MAKU	2	<i>ALB*MAKU</i>	0.0021	
	A/SLOW	1	<i>ALB*SLOW</i>	0.0011	
CHE1	U	425	<i>CHE1*U</i>	0.9829	0.034
	UA	15	<i>CHE1*A</i>	0.0171	
CHE2	C5+	63			
	C5-	411			
ABO	O	248	<i>ABO*O</i>	0.7650	0.379
	A	133	<i>ABO*A</i>	0.1830	
	B	35	<i>ABO*B</i>	0.0520	
	AB	08			
RH	D-	24	<i>RH*D-</i>	0.2379	0.363
	D+	400	<i>RH*D</i>	0.7621	
ESD	1-1	151	<i>ESD*1</i>	0.8027	0.317
	2-1	56	<i>ESD*2</i>	0.1973	
	2-2	16			
CA2	1-1	211	<i>CA2*1</i>	0.9731	0.052
	2-1	12	<i>CA2*2</i>	0.0269	
ACP	B	175	<i>ACP*B</i>	0.8165	0.300
	AB	55	<i>ACP*A</i>	0.1835	
	A	18			
GLO	1-1	30	<i>GLO*1</i>	0.3670	0.466
	2-1	100	<i>GLO*2</i>	0.6330	
	2-2	88			
HBB	A	241	<i>HBB*A</i>	0.9839	0.032
	AS	8	<i>HBB*S</i>	0.0161	

Mean heterozygosity (H) = 0.218 (SEM 0.054).

Mean number of alleles per locus (N) = 2.42 (SEM 0.15).

Percent polymorphic loci (P) = 92%.

Table IV - Some genetic parameters obtained for eight populations and two Black rural communities of the Amazon Region.

Population	With 13 loci			With 10 loci			Reference
	H	N	P (%)	H	N	P (%)	
Castanhal	0.218	2.42	92	0.248	2.40	90	1
Belém	0.206	2.42	75	0.244	2.50	90	*
Oriximiná	0.213	2.42	92	0.248	2.50	90	2
Óbidos	0.206	2.00	84	0.242	1.90	80	3
M. Alegre	0.191	2.17	75	0.225	2.10	80	*
Bragança	0.192	2.33	75	0.222	2.40	70	*
Santarém	0.200	2.42	75	0.231	2.40	80	4
Alenquer	0.199	2.17	75	0.231	2.20	70	*
Cametá	-	-	-	0.225	2.10	80	5
Trombetas	-	-	-	0.265	2.20	90	6

H: Mean heterozygosity; N: Mean number of alleles per locus; P: Percent of polymorphic loci.

(1) Present study; (2) Santos *et al.* (1987); (3) Guerreiro *et al.* (1993); (4) Santos *et al.* (1991); (5) Bortolini *et al.* (1992); (6) Schneider *et al.* (1987); (*) Unpublished data.

to a reduction of mean heterozygosity. The data show that this was not the case, the values observed being similar to those of the other hybrid populations.

Racial admixture

Racial admixture was calculated on the basis of the gene frequency of 12 loci (HP, CP, TF, ALB, CHE1, ESD, CA2, ACP, GLO, ABO, RH, and HBB). The values obtained were 42% Caucasian, 25% Indian, and 33% African ancestry, the highest percentage of Black contribution observed thus far among trihybrid populations of the Amazon Region.

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RESUMO

Foram investigados seis parâmetros demográficos e 13 sistemas genéticos na população trihíbrida de Castanhal, Estado do Pará, Brasil. A taxa de imigração foi alta (20,4%), uma das maiores da região. Em geral os polimorfismos genéticos não apresentaram diferenças significativas dentro da região. Alelos raros como *HP*2M*, *CP*A* e *CP*C* foram observados, assim como duas variantes

de albumina. A heterozigidade média, o número médio de alelos por loco e a percentagem de locos polimórficos, foi similar à observada em outras comunidades amazônicas. A contribuição relativa dos grupos étnicos principais foi estimada em 42% para Brancos, 25% para Índios e 33% para Negros, sendo a contribuição africana a maior observada entre as populações miscigenadas da região amazônica.

REFERENCES

Arai, K., Huss, K., Madsion, J., Putnam, F.W., Salzano, F.M., Franco, M.H.P., Santos, S.E.B. and Freitas, M.J.M. (1989). Amino acid substitutions in albumin variants found in Brazil. *Proc. Natl. Acad. Sci. USA* 86: 1821-1825.

Ayres, M., Salzano, F.M., Franco, M.H.L.P. and Barros, R.M.S. (1976). The association of blood groups, ABH secretion, haptoglobins and hemoglobins with filariasis. *Hum. Hered.* 26: 105-109.

Bortolini, M.C., Weimer, T.A., Franco, M.H.L.P., Salzano, F.M., Layrisse, Z., Schneider, H., Schneider, M.P.C. and Harada, M.L. (1992). Genetic studies in three South American black populations. *Gene Geography* 6: 1-16.

Carneiro, E. (1980). *A Conquista da Amazônia*. Civilização Brasileira, Rio de Janeiro, 168 pp.

Guerreiro, J.F. and Chautard-Freire-Maia, E.A. (1988). ABO and Rh blood groups, migration and estimates of racial admixture for the population of Belém, State of Pará, Brazil. *Rev. Brasil. Genet.* 11: 171-186.

Guerreiro, J.F., Ribeiro-dos-Santos, Â.K.C., Santos, E.J.M., Cayres, I.M.V. and Santos, S.E.B. (1993). Genetic structure and demography of the human population of Óbidos, in the Brazilian Amazon. *Rev. Brasil. Genet.* 16: 1075-1084.

Krieger, H., Morton, N.E., Azevedo, E., Freire-Maia, N. and Yasuda, N. (1965). Racial admixture in the Northeastern Brazil. *Ann. Hum. Genet.* 29: 113-125.

- Reed, T.E. and Schull, W.J.** (1968). A general maximum likelihood estimation program. *Am. J. Hum. Genet.* 20: 579-580.
- Rosa, V.L., Salzano, F.M., Franco, M.H. and Melo e Freitas, M.J.** (1984). Blood genetic studies in five Amazon populations. *Rev. Brasil. Genet.* 7: 569-582.
- Salles, V.** (1971). *O Negro no Pará. Sob o regime da escravidão.* Coleção Amazônica, Rio de Janeiro, pp. 336.
- Santos, E.J.M., Ribeiro-dos-Santos, Â.K.C., Tavares, J.R.S. and Santos, S.E.B.** (1991). Variabilidade genética em populações humanas da Amazônia. Santarém. In: *37th Annual Meeting of the Brazilian Genetics Society (SBG)*, September 4 to 7, Caxambu, MG, Brasil, pp. 141.
- Santos, S.E.B., Salzano, F.M., Franco, F.H.L.P. and Melo e Freitas, M.J.** (1983). Mobility, genetic markers, susceptibility to malaria and race mixture in Manaus, Brazil. *H. Hum. Evol.* 12: 373-381.
- Santos, S.E.B., Guerreiro, J.F., Salzano, F.M., Weimer, T.A., Hutz, M.H. and Franco, M.H.L.P.** (1987). Mobility, blood genetic traits and race mixture in the Amazon population of Oriximiná. *Rev. Brasil. Genet.* 10: 745-759.
- Schneider, H., Guerreiro, J.F., Santos, S.E.B., Weimer, T.A., Schneider, M.P.C. and Salzano, F.M.** (1987). Isolate breakdown in Amazonia - The blacks of the Trombetas river. *Rev. Brasil. Genet.* 10: 565-574.
- Schüler, L., Salzano, F.M., Franco, M.H.L.P., Melo e Freitas, M.J., Mestriner, M.A. and Simões, A.L.** (1982). Demographic and blood characteristics in an Amazonia population. *J. Hum. Evol.* 11: 549-558.
- Schwarcz, L.M.** (1993). *O Espetáculo das Raças. Cientistas, Instituições e Questão Racial no Brasil 1870-1930.* Companhia das Letras, São Paulo, pp. 287.
- Simões, A.L.** (1980). *O Polimorfismo da Esterase D em Indígenas Sulamericanos.* Doctoral Thesis, Faculdade de Medicina de Ribeirão Preto, Universidade de São Paulo, Ribeirão Preto, SP.

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