

Migration and ethnic change in an admixed population from the Amazon region (Santarém, Pará)

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ABSTRACT

Genetic and demographic data from Santarém, PA, were analyzed. Eighty-two% of the individuals studied were born in the State of Pará and 11.7% were immigrants from Northeastern Brazil. Analysis of mean individual migration, mean marital distance, parent-offspring distance and exogamy index identified high population mobility. Characteristic alleles from three main ethnic groups, including *BCHE*A* (Whites), *ALB*Maku* (Indians) and *HBB*S* and *HBB*C* (Blacks), were identified. The proportions of Black, Indian and White ancestry were calculated as 28%, 35% and 37%, respectively. By considering the place of birth of the grandparents, a local subpopulation could be identified (natives of Santarém). The Black and Indian proportions in this subpopulation were 11% and 52%, respectively, significantly different from the estimates for the total sample. This strategy proved to be efficient for the characterization of the factors responsible for the genetic-demographic structure of this population.

INTRODUCTION

Native Amazon populations, especially indigenous ones, have been the subject of many anthropogenetic studies (for a review see Salzano and Callegari-Jacques, 1988). However, the understanding of the microevolutionary process in Amazonian groups cannot be limited to the study of such populations. For this reason, several comparative studies have been carried out among admixed urban communities, with emphasis on gene flow, which probably represents the most meaningful factor in the genetic differentiation of these populations. In the present study a strategy of

population subdivision was used for a better characterization of the process of gene flow.

MATERIAL AND METHODS

The municipality of Santarém, State of Pará, Brazil, is located at 2°17'48" latitude South and 54°42'35" longitude West. Founded in the 17th century as an extension of a village of Tapajó Indians, it is currently the second most populous municipality in the State, with a resident population of 255,000 inhabitants according to the 1991 General Census (IBGE, 1991). The study was conducted on a sample of 499 individuals from whom 10 ml of peripheral blood was obtained, as well as data about sex, age and birthplace of the individuals themselves and of their parents and grandparents. The sample, collected from army soldiers and students attending a public high school, consisted

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of 69% males, with a mean age of 28 years (15 to 69 years). The following 13 genetic systems were analyzed: albumin (ALB), transferrin (TF), haptoglobin (HP), ceruloplasmin (CP), serum cholinesterase (*BCHE* and *CHE2* loci), ABO and Rh blood groups, glyoxalase 1 (GLO), esterase D (ESD), acid phosphatase (ACP), carbonic anhydrase 2 (CA2) and hemoglobin (HBB). The methodology employed has been reported previously (Schneider *et al.*, 1987; Salzano *et al.*, 1988; Conceição *et al.*, 1987).

The demographic data and phenotype frequencies were analyzed using the SPSS software (Statistical Package for Social Sciences). Gene frequencies were estimated by the maximum likelihood method using the MAXLIK program (Reed and Schull, 1968). Racial admixture was also estimated by the gene identity and least squares method (Chakraborty, 1975).

Population dispersal was considered using the following parameters: a) mean migration distance (mean distance between the birthplace of each individual and Santarém); b) marital distance (mean distance between the birthplaces of the parents of each individual); c) parent-offspring distance (mean distance between the birthplaces of the parents and of their children) estimated for generation I (grandparents), generation II (parents) and generation III (present); d) exogamy index (proportion of marriages between individuals born in different places) estimated for generations I and II. These parameters were estimated using the DIST software developed by J.R.S. Tavares (Human Genetics Laboratory, UFPA).

The genetic data were analyzed in the total sample (497 individuals) and in a subpopulation named natives of Santarém (NS) represented by 105

individuals. The NS subpopulation is constituted of subjects whose maternal and paternal grandparents were born in Santarém, and thus this sample probably represents the population two generations ago.

RESULTS AND DISCUSSION

Demography

Table I presents information about the birthplaces of the individuals in the sample (generation III), as well as those of their parents (generation II) and grandparents (generation I). The percentage of individuals born in the municipality of Santarém increased during the three generations. Among immigrants there was a considerable contingent of individuals from other

Table I - Distribution of birthplaces of the individuals studied in Santarém and their ancestors (in %).

Birthplace	Generation III	Generation II	Generation I
	N = 497	N = 952	N = 1.576
At the locality of study	57.1	41.9	35.7
Outside the locality but in the same state	24.6	26.8	23.5
Northern region (outside the state of study)	3.2	3.7	3.7
Northeastern region	11.7	24.4	31.9
Center-west region	1.0	0.6	0.4
Southern region	1.2	0.7	0.8
Southeastern region	1.2	1.1	1.1
Outside Brazil	0.0	0.8	2.9

Table II - Individual migration, marital distance, parent-offspring distance (in km) and exogamy index observed in Amazonian populations.

Demographic parameters	Populations					
	Santarém	Castanhal ¹	Parintins ²	Oriximiná ³	Óbidos ⁴	Belém ⁵
Individual migration	379	294	116	255	80	341
Marital distance						
Generation III	366	210	174	370	165	285
Generation II	218	221	117	184	102	-
Generation I	74	79	35	49	80	-
Parent-Offspring distance						
Generation II-III	299	282	156	145	84	261
Generation I-II	159	203	88	52	138	-
Exogamy index						
Generation III	21	23	-	13	12	9
Generation II	16	23	14	12	3.4	-
Generation I	7	9	7	2	1.1	-

¹Ribeiro-dos-Santos *et al.* (1995); ²Schüler, *et al.* (1982); ³Santos *et al.* (1987); ⁴Guerreiro *et al.* (1993); ⁵Guerreiro and Chautard-Freire-Maia (1988).

towns of the State of Pará. There was a significant contribution of individuals born in the Brazilian Northeast, and they came mainly from the State of Ceará. In other Amazonian populations, the proportion of individuals from the Northeast in generation III is variable: 4% in Oriximiná (Santos *et al.*, 1987), 1% in Parintins (Schüler *et al.*, 1982), 10% in Belém (Guerreiro and Chautard-Freire-Maia, 1988), 14% in Castanhal (Ribeiro-dos-Santos *et al.*, 1995), and 20% in Manaus (Santos *et al.*, 1983). Note that in relation to these places, Santarém has one of the largest proportions of individuals born in the Northeast of Brazil.

Table II shows the mean values for individual migration, marital distance and parent-offspring distance in three generations for Santarém and for five other Amazonian populations. An increase in marital distances, parent-offspring distances and exogamy indexes in the new generations can be observed, suggesting a recent increase in population mobility. This set of demographic parameters indicates that Santarém has important population mobility and that it has received considerable migratory flow during the last generations, with a predominance of contributions from the State of Pará itself and from Northeastern Brazil.

Genetic data

Table III presents the phenotype and gene frequencies observed in Santarém and in the subpopulation NS. Except for carbonic anhydrase 2 and albumin, all other systems showed a fair degree of variation. One variant with an electrophoretic pattern similar to that of Maku, of Indian origin, and encountered in Oriximiná (Santos *et al.*, 1987; Arai *et al.*, 1989), was detected in the albumin system. Other rare alleles detected were *CP**C**, *CA2**2**, *BCHE**A**, *TF**B** and *TF**D**, the latter not characterized as *TF**D*1* vs. *TF**D*Chi*.

Racial admixture

The estimates of racial admixture for Santarém (total sample and subpopulation NS), as well as for other Amazonian populations, are presented in Table

Table III - Phenotypes and gene frequencies in Santarém and its native sub-population (NS).

Systems and phenotypes	Populations		Alleles	Populations	
	NS	Total sample		NS	Total sample
HP					
1-1	25	118	<i>HP*1</i>	0.4550	0.4781
1-2	37	205	<i>HP*2</i>	0.4980	0.4927
2-2	34	139	<i>HP*2m</i>	0.0470	0.0292
1-2m	4	13			
CP					
BB	76	325	<i>CP*A</i>	0.0246	0.0286
AB	2	16	<i>CP*B</i>	0.9630	0.9614
BC	2	7	<i>CP*C</i>	0.0124	0.0100
AA	1	2			
TF					
CC	101	487	<i>TF*B</i>	0.0096	0.0051
CD	1	4	<i>TF*C</i>	0.9856	0.9909
BC	2	5	<i>TF*D</i>	0.0048	0.0040
ALB					
A	105	497	<i>ALB*A</i>	1.0000	0.9980
A Maku	0	2	<i>ALB*AMaku</i>	0.0000	0.0020
BCHE					
UU	96	447	<i>BCHE*U</i>	0.9897	0.9900
UA	2	7	<i>BCHE*A</i>	0.0103	0.0100
AA	0	1			
CHE2					
C5+	16	81			
C5-	89	417			
ABO					
A	10	53	<i>ABO*A</i>	0.1563	0.1890
B	1	13	<i>ABO*B</i>	0.0265	0.0608
AB	1	8	<i>ABO*O</i>	0.8172	0.7502
O	26	103			
Rh					
d	1	9	<i>Rh*D</i>	0.8378	0.7745
D	37	168	<i>Rh*d</i>	0.1622	0.2255
ESD					
1-1	33	154	<i>ESD*1</i>	0.8199	0.8027
1-2	16	87	<i>ESD*2</i>	0.1801	0.1973
2-2	1	5			
CA2					
1-1	50	241	<i>CA2*1</i>	1.0000	0.9897
1-2	0	5	<i>CA2*2</i>	0.0000	0.0103
ACP					
BB	42	213	<i>ACP*A</i>	0.1544	0.1011
AB	9	36	<i>ACP*B</i>	0.8456	0.8989
AA	4	8			
GLO					
1-1	5	23	<i>GLO*1</i>	0.3203	0.3385
1-2	22	117	<i>GLO*2</i>	0.6797	0.6615
2-2	23	101			
HBB					
AA	49	232	<i>HBB*A</i>	0.9712	0.9640
AS	2	12	<i>HBB*S</i>	0.0192	0.0240
AC	1	6	<i>HBB*C</i>	0.0096	0.0120

IV, while Table V shows the parental gene frequencies used to obtain these estimates. Santarém has one of the highest black proportion admixtures observed so far in the North. In subpopulation NS, on the other hand, the proportions of Blacks and Indians were lower and higher, respectively. These latter estimates are similar to

Table IV - Estimates (in %) of racial admixture for Santarém (total sample and native of Santarém-NS-subpopulation) as well as for other populations of the Northern region of Brazil (standard errors in parentheses).

Population	Black	Indian	White
Santarém	28 (1.8)	35 (0.7)	37 (1.2)
NS	11 (0.1)	52 (0.1)	37 (0.1)
Castanhal ¹	33	25	42
Belém ²	23	30	47
Óbidos ³	10	52	38
Oriximiná ⁴	15	28	57
Parintins ⁴	13	51	36
Coari ⁴	14	43	43
Manaus ⁵	12	27	61

Systems used for the racial admixture estimates of Santarém: HP, CP, TF, ALB, BCHE, ABO, Rh, ESD, CA2, ACP, GLO, HBB. References: ¹Ribeiro-dos-Santos *et al.* (1995); ²Guerreiro and Chautard-Freire-Maia (1988); ³Guerreiro *et al.* (1993); ⁴Santos *et al.* (1987); ⁵Santos *et al.* (1983).

Table V - Gene frequencies of the parental populations used to estimate the racial admixture in Santarém.

Alleles	Frequencies in the parental populations (x 1000)		
	Indian	Black	White
HP*2	364	320	591
HP*1	636	658	409
HP*2m	0	22	0
CP*A	0	35	13
CP*C	0	05	02
CP*B	1000	960	985
TF*C	989	968	994
TF*B	0	0	06
TF*D	11	32	0
ALB*A	98	1000	1000
BCHE*U	1000	1000	980
CA2*1	1000	931	1000
Rh*d	17	224	413
ABO*O	1000	702	631
ABO*A	0	156	303
ABO*B	0	142	66
ESD*2	276	62	143
ACP*A	114	166	351
ACP*B	886	833	590
ACP*C	0	01	59
GLO*1	308	309	437
HBB*A	1000	895	1000
HBB*S	0	83	0
HBB*C	0	22	0

Source: Schneider *et al.* (1987); Santos *et al.* (1987); Bortolini *et al.* (1992).

those obtained for Parintins, an Amazonian town with low population mobility and a high Indian contribution. The comparison between Santarém's total sample and its NS subpopulation showed that they had about the same estimated White composition, but significant

differences in the Black and Indian proportions (as estimated by their respective confidence intervals).

The increase in Black and decrease in Indian contributions in Santarém in the last two generations can be explained by intensive migration. The Northeastern region is an important source of migratory gene flow to Santarém, and the estimates of racial admixture have demonstrated that this region has higher proportions of White and Black admixture (Krieger *et al.*, 1965; Franco *et al.*, 1982; Conceição *et al.*, 1987). Thus, it is reasonable to suppose that the change of ethnic structure in Santarém during the two most recent generations was due, mainly, to Northeasterner migration, as is documented in Table I.

ACKNOWLEDGMENTS

We thank Ms. Nádia Valéria B.M. Alves of the Laboratório Amazônia de Análises Clínicas, Ms. Ilma M.S. Mera and officers of the 8th BEC army division (8^o Batalhão de Engenharia e Construção) for help in sample collection, and we are grateful to Prof. Francisco Mauro Salzano for a critical reading of an earlier draft of the manuscript. This study was supported by special funds from the Universidade Federal do Pará and CNPq.

RESUMO

Dados genéticos e demográficos da população de Santarém, PA, foram analisados. Oitenta e dois por cento dos indivíduos estudados nasceram no Estado do Pará e 11.7% dos imigrantes nasceram na região Nordeste do Brasil. A análise da migração individual média, distância marital média, distância genitor-prole e índice de exogamia identificou uma elevada mobilidade populacional. Alelos característicos dos três principais grupos étnicos foram encontrados, como BCHE*A (caucasóides) ALB*Maku (indígenas) e HBB*S e HBB*C (negros). As proporções de ancestralidade negra, índia e branca foram estimadas em 28%, 35% e 37%, respectivamente. Considerando-se o local de nascimento dos avós, a presença de uma subpopulação pôde ser observada (nativos de Santarém). As proporções de ancestralidade negra e índia foram de 11% e 52% respectivamente, significativamente diferentes da amostra total. A estratégia usada, portanto, mostrou-se eficiente para a caracterização dos fatores responsáveis pela estrutura genético-demográfica desta população.

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(Received March 31, 1995)