



(Foto: TV Brasil. Reprodução)

As consequências do contato para os indígenas são múltiplas, envolvendo desde a estrutura populacional até novos agentes infecciosos.

## Brazilian Indians/ non-Indians interactions and their effects

\* Sidia M. Callegari-Jaques

\*\* Francisco Mauro Salzano

### Abstract

A short review was made of the history of the Brazilian population starting with the Asians who colonize the region 30,000-40,000 years ago and continuing with evaluations of the European, African, and Neo-Asiatic immigration. Social aspects of the contact situation between Brazilian Indians and the surrounding society were briefly considered, as well as quantitative estimates of the amount of Amerindian genes present in neo Brazilians. Special emphasis however was placed in the inverse gene flow (neo Brazilian genes into Amerindians). In this case, two methods, which quantify the degree of such admixture were employed, and the one considered to give better estimates was chosen. Although the correlation obtained between these admixture values and the number of years of more permanent contact with non Indians yielded a low number (perhaps due to the deficiencies in obtaining precise figures concerning years of contact) a clear correlation was found between the admixture estimates obtained in certain nine Brazilian Indian tribes or populations and their location in degrees of longitude West. This is probably a reflection of the general neo Brazilian East-West colonization movement. At present, it is difficult to ascertain the degree of biological and cultural homogeneity that will be reached by Brazilian populations in the future. It is hoped, however, that a certain amount of diversity will be maintained in a climate of mutual respect.

**Keywords:** Brazil; Native populations; Indigenous people; Interactions.

## Resumo

Foi feita uma breve revisão sobre a história da população brasileira, iniciando com os asiáticos, que colonizaram a região a 30.000-40.000 anos, e continuando com avaliações das imigrações europeia, africana e neoasiática. Consideraram-se brevemente aspectos sociais da situação de contato entre indígenas brasileiros e a comunidade envolvente, bem como estimativas quantitativas da fração de genes ameríndios presentes e neobrasileiros. Foi dada ênfase especial, no entanto, quanto ao fluxo gênico inverso (genes neobrasileiros em ameríndios). Neste caso, foram empregados dois métodos que quantificam o grau de tal mistura, sendo escolhido aquele considerado como fornecendo as melhores estimativas. Apesar de que a correlação obtida entre esses valores de mistura e o número de anos de contato mais permanente em não indígenas forneceu um número baixo (talvez devido a deficiências na obtenção de valores precisos referentes a anos de contato), foi encontrada uma correlação clara entre as estimativas de mistura obtidas em 39 tribos ou populações indígenas brasileiras e sua localização em graus de longitude oeste. Isto é, provavelmente, um reflexo do movimento geral da colonização leste oeste dos neobrasileiros. Atualmente, é difícil avaliar o grau de homogeneidade biológica e cultural que será alcançado pelas populações brasileiras no futuro. Espera-se, entretanto, que seja mantido um certo nível de diversidade em clima de respeito mútuo.

**Palavras-chave:** Brasil; Populações originárias; Indígenas; Interações.

## Introduction

Preparations are being made for commemoration in the year 2000 of five years of Pedro Álvares de Cabral arrival at the Brazilian coast near Porto Seguro. As an example of the exaggeration that surrounds this event Capistrano de Abreu the well known Brazilian historian who lived between 1853 and 1927 referred to the letter of Pero Vaz de Caminha who arrived here with Cabral and sent the news to Portugal's king Manuel I as Brazil's birth certificate [1].

Although this could be news for Europe, what is now known as Brazil had been colorized thousands of years before 1500 by persons who Christopher Columbus named Indians because he was sure he was arriving in India, not in a continent unknown to his European contemporaries. This colonization was made by

people of Asiatic origin who enter the continent through the Bering Strait about 30,000-40,000 years ago [2, 3].

The estimates about the number of persons who were here in 1500, however, vary a great deal. Carneiro da Cunha [4] listed estimates that ranged from 1 to 8.5 million. Bethell [5] discussed these values and favored a number of 2.4 million. This seems to be at present the most reasonable estimate emphasizing the fact that the region had already a considerable number of inhabitants before the "discovery".

### The European African and Neo-Asiatic "invasions"

Population changes started to occur with varying degrees of speed in the following centuries. While the Indians experimented a

process of marked demographic decline due to conflicts with non-Indians and diseases to which they were not adapted, this was compensated by a steady flow of persons from other ethnic groups. Table 1 lists the statistics obtained mostly from the migration division of the Labor Ministry for the European and recent Asiatic immigrations in front of disembarkation documents and other sources for the African influx.

Trends in time are clearly visualized in Table 1. Thus, the peak of the African immigration took place before 1820 while the bulk of the European arrival occurred during the 1877-1930. Important Japanese and Chinese introductions happened in recent times (peak for the Japanese in 1931-1963, for the Chinese in 1964-1972). The relative contributions of all these groups up to 1972 were of 58% for Europeans, 40% for Africans, and 2% for Neo-Asiatics.

The question of which naturally arises is how much these people have contributed to the gene pool of present Brazilians. This problem has been considered by several scholars, and a recent analysis [6] indicated that the migrant contribution (as opposed to vegetative growth) to the formation of the present Brazilian population could be estimated as being 18%. That indicates that differential fertility and mortality is the key variable for the representativeness of national and ethnic groups to present their Brazilians. Inter mixtures is also of course important. The country's 1996 population (157 million) was estimated as being composed of 55.2% European derived, 6.0% predominantly African derived, 38.2% admixed, 0.4% Neo-Asiatic, and 0.2% Indian individuals [7]. The contrast between the 280,000 Brazilians Indians leaving now [8] and the pre Colombian estimate of 2.4 million is striking. In principle, this would correspond to just 10% survival. But the actual situation is more complex, since a large proportion of the alleles present in the admixed persons (especially in the north and center West) are of Amerindian origin.

## Contact and consequences

What happens when Indians and non-Indians establish contact? The situation can be analyzed through the concept of interethnic friction, developed by Cardoso de Oliveira some time ago [9, 10, 11, 12]. He argued that tribal societies maintained with the surrounding society (national or colonial) relationships of opposition which are easily demonstrable since the existence of one tends to deny the existence of the other. This creates a dialectical relationship, since the two groups have interdependent but diametrically opposed interests.

The outcome differs, however, to the painting on the side of the contact. Cardoso de Oliveira and Castro Faria [10] created a classification based on polar categories distinguished by population density and rate of economic development. The critical regions and those with low densities and high rate of economic development since it is there where more relatively non-contacted group exists and the clash with an aggressive expansion front are generally inevitable.

**“The surrounding non-Indian dominant society is not immune to Indian influences which may be reflected in the acquisition of new customs words food and genes.”**

Other important factor are those related to the integration potential [11]. Here Cardoso de Oliveira identified three levels, economic, social and political. In the first, the important factor is the degree of dependence/independence of the two groups in terms of resources for subsistence. At the social level, the question is whether engines and non-engines are capable of mobilizing their respective components and to the Orient them towards their respective ends. Finally, at the political level, the point to be considered is the means chosen by the group to attain its objectives. In this case, following Max Weber, he distinguished power (the probability of imposing his/her own will inside a given social relationship) and authority (the probability of finding obedience).

The consequences of the contact for Indians are manifold involving their population

Periods	Europeans			Neo-Asiatics		Africans
	Portuguese	Italians	Others	Japanese	Chinese	
Before 1820	465,000	-	-	-	-	2,859,200
1820-1876	160,119	16,562	173,436	-	-	1,150,200
1877-1903	389,580	1,127,773	410,553	-	86	-
1904-1930	792,227	346,029	903,339	100,653	533	-
1931-1963	425,408	134,358	400,866	141,518	4,254	-
1964-1972	22,980	4,527	35,087	5,836	5,652	-
Total	2,255,314	1,629,249	1,923,281	248,007	10,525	4,009,400
%	22.38	16.17	19.09	2.46	0.11	39.79

Fonte: [26-29].

Table 1. Main immigration to Brazil during different periods of time [26-29].

structure (with changes in mortality fertility and mobility patterns); nutrition (frequently with substitution of a varied for a somewhat restricted diet based on one or a few staple foods); new infectious agents; variation in their hygienic conditions due to increased sedentary habits; cultural changes (sometimes involving negative self images); and interethnic marriages [13].

On the other side the surrounding non-Indian dominant society is not immune to Indian influences, which may be reflected in the acquisition of new customs, words, food, and genes. A factor that sometimes serves to increase the amount of gene flow is that since the Indians generally live in reservations, they have free access to land for cultivation. Neo-Brazilians without lands therefore many times marry Indian women and establish themselves in these reservations, in some cases even claiming a certain degree of Indian ancestry to guarantee land rights.

## Quantitative estimates of interethnic admixture

In terms of biological or social history, sometimes it is important to establish the amount of interbreeding that occurred between two ethnic groups. The methods available to quantify eventual estimates have been aptly reviewed by Chakraborty [14]. They can be broadly classified into two categories: those based on a) gene frequencies, and b) phenotype prevalence. They

then can be separated according to the statistics used estimation procedure or number of parental strains considered.

Independently of the method used, however, two assumptions are made that are not always met but the available data: a) that the information about ancestral populations is reliable; b) and that no systematic factors beside gene flow are acting on the systems considered.

It is not our objective to reviewing the tale all the methods presently available since this was done by other authors [14, 15] Instead, we are going to concentrate in two of them that were employed by us to evaluate the amount of non-Indian inheritance present among a series of Brazilian Indian groups. The basic principles behind the two methods are different so that we should clearly indicate them at the beginning.

Szathmary and Reed's [16] Procedure relies on rare alleles that can be assumed to be ethnic specific. Since they are rare, their distribution can be assumed to follow a Poisson distribution. The number of "foreign" markers is counted ( $x$ ) and divided by the total number of genes examined ( $N$ ) considered all loci that have such distinctive alleles. The frequency of the markers in the parental population is, taking into account by dividing the preliminary amount of admixture obtained by the mean parental gene frequency.

Chakraborty's method [17] uses the gene identity coefficient [18] to approach the problem. This coefficient estimates the probability that two genes chosen at random (from one or more populations) are identical in nature. Assuming that a

**"Whenever two humans populations meet they inevitably exchange cultural values and genes."**

hybrid population ( $h$ ) received  $m_1$  fraction of its genes from population 1 and  $(1-m_1)$  fraction from population 2, the gene identity between population 1 and  $h$ ,  $J_{1h}$ , is composed of two parts: 1) when did gene in the hybrid population is from population 1 (that has probability  $m_1$ ), gene's identity is  $J_{11}$ ; and 2) when it originates from population 2 (event that occurs with probability  $1-m_1$ ) gene identity is  $J_{12}$ . Therefore,

$$J_{1h} = m_1 J_{11} + (1-m_1) J_{12}$$

This can be generalized to include several alleles, loci and populations [19]. The next step [17] was to extend the gene identity method by applying a least square solution to all possible relationships derived independently by equations of the form given above. Chakraborty [14] argues that the  $J_{11}$  statistics are more stable than individual allele frequencies for sampling fluctuations and are therefore less likely to be affected by rare alleles (which have higher coefficients of variation).

## Amerindian genes in neo-Brazilians

A relatively large number of studies have been performed in predominantly European or African derived Brazilian populations [20, 21] The amount of Amerindian ancestry in these groups varies widely, showing also distinct patterns in the different

main regions of the country. The main influence occurs in the northern region. Santos and Guerreiro [20] considered 11 populations of the area, only formally using for the admixture estimates the maximum likelihood method of Krieger *et al.* [22]. The average obtained for the region as a whole was 41% Indian, 12% African, and 47% European ancestries. Considering that the population of Amazonia consists of about 10 million persons they concluded that if all Indian genes were concentrated in unmixed individuals the Amerindian population of the region would be composed of 4 million persons about two times more than the pre Colombian estimate for the whole country! One of us [21] arrived at somewhat different figures due to the inclusion of four predominantly African derived and won predominantly Amerindian derived populations but the fundamental contribution of Brazilian Indians to the gene pool of our northern population is also clearly demonstrated in this other data set.

The picture changes when we move to the Northeast. The data available for this region are less numerous, but the six studies listed [21] point to a smaller Amerindian influence (average of certain percent 36% African, and 51% European ancestries).

Previous studies reviewed in had not even considered the possible American influence in southeastern and southern populations. Recent results, however, indicate that this attitude may be wrong. Dornelles *et al.* [23] taking into account a considerable amount of information (2,706 European derived individuals from several regions of Brazil's

southernmost state Rio Grande do Sul) obtained an average of 11% Indian, 7% African, and 82% European ancestry for the state as a whole. The figures for Santa Catarina ( $n=226$ ) are different (5% Indian, 5% African, 90% European) but also indicated a certain Amerindian influence. These estimates were obtained using Chakraborty's method [17]; in the comparison of the figures of attained by this method and that proposed in [16] among the Indians (below) we always observed higher estimates of admixture with the former. Therefore, these results in southern populations should be confirmed using ethnic specific markers.

As far as African derived populations are concerned Bortolini *et al.* [24] found that in Porto Alegre and Ribeirão Preto situated respectively in Brazil's South and Southeast while the DNA autosomal hyper variable and protein loci did not detect any Amerindian influence in Porto Alegre and the former only 5% Amerindian ancestry in Ribeirão Preto, the picture changed when uniparental genetic markers were considered. In Porto Alegre while an estimate of the possible paternal contribution also did not indicate any Amerindian parentage, that maternally inherited mitochondrial DNA suggested 7% to 14% of Indian genes. For Ribeirão Preto, the Amerindian contribution was found to be low (4%) are absent using the Y-chromosome locus, DYS19, but this contribution increased to 10% when the mtDNA results were considered. It is clear therefore that the history of admixture uncovered may be different when matrilineal or patrilineal lineages are involved.

“Biological and cultural differences are important aspects of our life since the dawn of humanity and they should be preserved in a climate of mutual respect.”

## Neo-Brazilian genes in Brazilian Indians

One of us (FMS) has been interested in the patterns of genetic distribution among Amerindians for more than four decades now. About 16 years ago, we decided to join efforts in the analysis of the data that were increasingly accumulating due to the studies of our group and those of others. In 1988, we published a global analysis based essentially on protein markers [13], since DNA population studies were only starting to be performed at the time. Since then considerable new information was obtained regarding South American Indians in general, and Brazilian Indians in particular, which was duly recorded in our databank.

For some genetic evolutionary analysis, it is sometimes important to consider that as free of the influence of recent interethnic admixture as possible. Therefore, in the above-mentioned 1988 study [13] we estimated at mixture levels (using Szathmary and Reed's [16] method) for 58 South American (17 Brazilian) Indian groups. The number of systems available at the time however was smaller (at the most 12) than those that we have at our disposal now; and despite the fact that in individual papers such levels had been estimated

for some tribes, no recent global evaluation of Brazilian Indians in general existed. This prompted the present review.

Assert in our databank indicated the possibility of analysis in 39 Brazilian Indian populations or tribes. A list of them is given in Table 2. Based on a variable number of genetic systems (full list giving in Table 3) it was possible to calculate

for all of them degrees of interesting admixture based on Chakraborty's [17] and Szathmary and Reed's [16] Methods. The 90 primary articles from which the genetic marker frequencies were obtained are listed in the appendix. In addition, based on the general information available to us, we tried to estimate the number of years of more

intensive contact these groups had with non-Indians.

The results of this effort are presented in Table 2. The first point to be emphasized is that while in somewhat more than 1/3 (36%) of the estimates the differences obtained with the two methods are less than 5% in almost half of them (44%) these differences are higher than 10%. Moreover, a) in the vast majority of the cases (34/39; 87%) the value of the admixture is higher when Chakraborty's method is employed; and b) Spearman's rank correlation coefficient [25] yields a value of 0.21 only between the two methods. We tried to verify if these discrepancies were due to unusual values observed in certain genetic systems but could find no clear pattern, the differences not being due to any of them specifically. Moreover, many of the estimates obtained with Chakraborty's method are clearly discrepant in relation to our fieldwork experience (for instance as much as 32.9% and 22.9% of non-Indian admixture among the Cayapo and Xavante, respectively). Also, while Spearman's correlation coefficient between the estimates of years of contact and admixture obtain with Szathmary and Reed's method yielded allows 0.06 value (Figure 1) this coefficient is negative (-0.25) using Chakraborty's method estimates.

We therefore decided to adopt Szathmary and Reed's method figures for further analysis. They were then plotted on Brazil's map to evaluate eventual geographic patterns (Figure 2) and one was indeed discerned. As can be observed, higher admixture estimates

Tribe or population	No. of years of more intensive contact	Percentage of non-Indian admixture			
		Method 1		Method 2	
		Estimate	No. systems	Estimate	No. systems
Apalai-Wayana	50	6.6	22	6.4	14
Arara	10	20.6	22	0.0	14
Araweté	21	2.9	22	0.3	14
Asurini Koatinemo	16	28.8	23	0.0	14
Asurini Trocará	34	14.2	24	1.1	14
Baniwa	130	7.3	24	0.0	12
Cayapo	57	32.9	23	3.0	13
Central Pano	330	2.4	24	0.4	12
Cinta Larga	33	17.3	23	2.6	14
Emerillon	80	3.9	20	1.2	11
Galibi	68	15.9	17	13.6	9
Gavião	58	21.2	19	0.9	10
Guarani	196	19.2	9	3.0	7
Içana Indians	130	8.6	23	0.0	12
Jamamadi	190	4.8	22	0.0	14
Kaingang	180	5.5	19	6.6	11
Kanamari	39	7.4	16	0.0	10
Karitiana	93	10.2	22	0.2	14
Kraho	176	9.7	21	1.2	11
Macushi	200	2.3	23	0.6	13
Makiritare	65	8.9	24	0.4	13
Mundurucu	200	13.9	17	0.3	11
Mura	240	8.4	24	0.8	12
Pacaás Novos	24	0.1	22	0.6	12
Palikour	80	18.1	17	10.4	9
Parakanã	16	7.2	24	6.4	14
Sateré-Mawé	350	1.7	23	1.8	13
Surui	25	15.3	23	0.6	12
Tenharim	27	43.7	20	2.4	11
Ticuna	230	2.5	24	1.3	15
Tiriyó	15	4.1	17	7.2	12
Urubu-Kaapor	60	15.5	24	4.2	14
Wai Wai	150	32.8	22	4.1	10
Waiãpi	80	0.0	24	0.2	12
Wapishana	200	12.1	24	1.9	11
Xavante	30	22.9	22	2.0	12
Xokleng	50	13.9	9	2.3	6
Yanomama	20	0.0	24	0.0	15
Zoró	21	25.8	18	0.0	10

\* Method 1: Gene identity, Chakraborty (17); Method 2: Szathmary and Reed (16). The primary articles from which the genetic marker frequencies were obtained are presented in the Appendix.

(Fonte: Elaboração dos autores)

Table 2. Estimates of non-Indian admixture obtained by two different methods in 39 Brazilian Indian populations or tribes.

occur at West. Spearman's correlation coefficient controlling for latitude effects yielded it a highly significant ( $p = 0.000$ ) value (-0.54) relating admixture with longitude West (Figure 3).

It is clear therefore that the estimates will be detained for years of contact do not really represent the state of non-Indian influence that the populations and tribes considered are experiencing. But the West E trend found is indicative of the general Neo-Brazilian colonization movement that is therefore nicely identified.

## Uniformity or pluralism?

Whenever two humans populations meet, they inevitably exchange cultural values and genes. The question that should be answered in terms of the future is what would be ideal for the Brazilian population as a whole: high uniformity or heterogeneity? Due to the peculiarities of our genetic material and the sexual reproduction process, it is highly unlikely that a pronounced degree of biological uniformity could be achieved in a country of continental size as Brazil. Moreover, it is not clear whether the present pattern of Indian reservations (which conditions are relative isolation of the Indians in relation to outsiders) will be maintained indefinitely. In the long run, the Indian communities themselves are those that should decide the degree of merging with the surrounding society that would be appropriate for them.

### 1. Chakraborty's method (21)

- 1.1. Blood groups: ABO, Diego, Duffy, Kell, MNSs, P, Rhesus (Rh)
- 1.2. Serum proteins: Ceruloplasmin, Gc, Gamma-globulins (Gm), Haptoglobin, Transferrin
- 1.3. Nonenzymatic erythrocyte protein: Hemoglobin
- 1.4. Enzymatic erythrocyte enzymes: Acid phosphatase, Adenylate kinase, Carbonic anhydrase 2, Esterase D, Glucose-6-phosphate dehydrogenase, Glutamate pyruvate transaminase, Glyoxalase I, Peptidase A, Phosphoglucomutase 1, Phosphoglucomutase 2, Phosphogluconate dehydrogenase

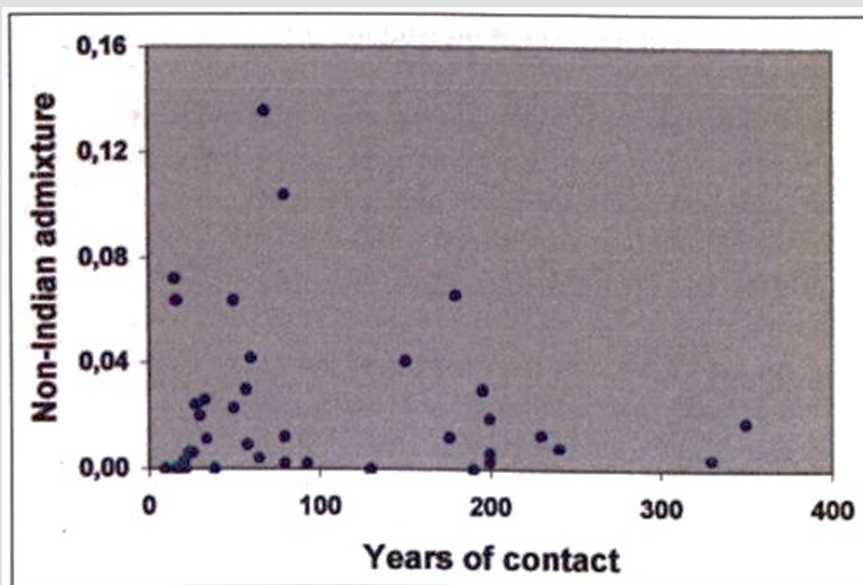
### 2. Szathmary and Reed's method (20)

- 2.1. Blood groups: ABO, Kell, Lutheran, Rh
- 2.2. Serum proteins: Gm, Haptoglobin, Transferrin
- 2.3. Nonenzymatic erythrocyte protein: Hemoglobin
- 2.4. Enzymatic erythrocyte proteins: Acid phosphatase, Adenylate kinase, Carbonic anhydrase 2, Glucose-6-phosphate dehydrogenase, Peptidase A, Phosphoglucomutase 2, Phosphogluconate dehydrogenase

<sup>a</sup> Variable combinations of these markers were available for the estimates of non-Indian admixture given in Table 2. It is impossible, here, to give details about all these genetic systems. A general source of information is (30).

(Fonte: Fonte [30])

Table 3. List of the systems used to evaluate the amount of non-Indian ancestry present in 39 Brazilian Indian populations or tribes.



(Foto: Fonte [16])

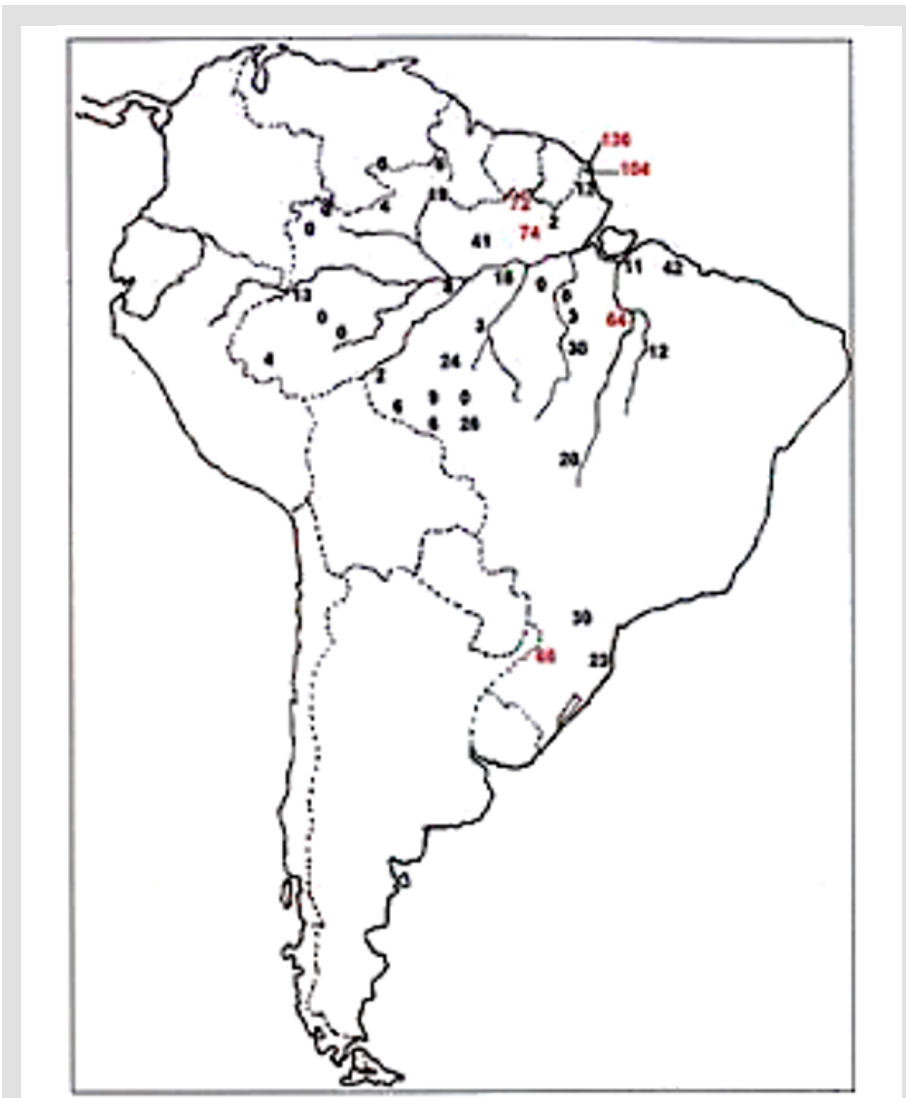
Figure 1. Relationship between the degree of non-Indian admixture estimated by Szathmary and Reed's method [16] and the estimated number of years of contact in 39 Brazilian Indian populations.

We live in a world in which now, provided the technical means are available, communication is instantaneous between any two points. The key expression here however is technical availability; power and wealth differences between individuals and nations are the true barriers to an effective one-world community. Let us hope that more social justice will decrease or eliminate these obstacles. This however does not mean that a dull repetition of some pattern should be sought. Biological and cultural differences are important aspects of our life since the dawn of humanity, and they should be preserved in a climate of mutual respect.

**Texto publicado originalmente em:**

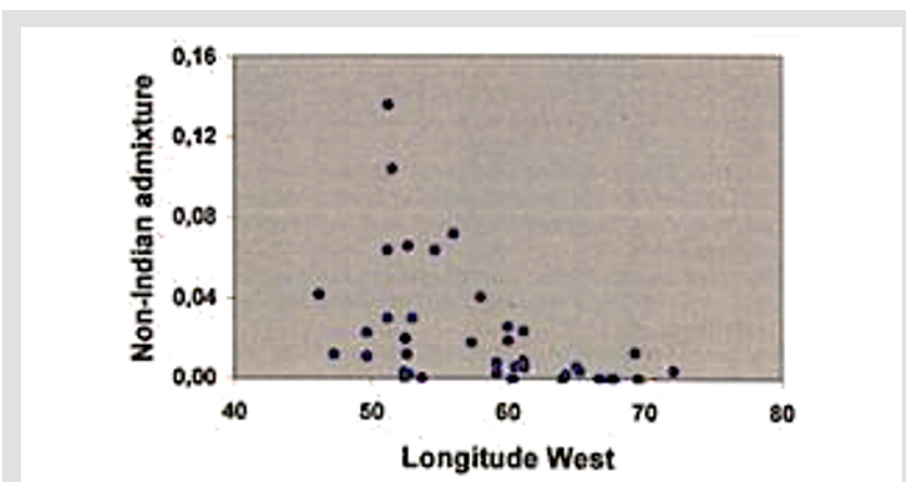
CALLEGARI-JACQUES, S. M.; SALZANO, F. M. Brazilian Indians/Non-indians interactions and their effects. *Ciência & Cultura*, São Paulo, v. 51, n. 3/4, 1999.

*Acknowledgements:*  
We are grateful to Sabrina P Salamoni and Nara FM Laner for help in the calculation of the Amerindian admixture estimates. Financial help was provided by Programa de Apoio a Núcleos de Excelência (PRONEX), Financiadora de Estudos e Projetos (FINEP), Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq), Fundação de Amparo à Pesquisa do Estado do Rio Grande do Sul (FAPERGS), and Pró-Reitoria de Pesquisa da Universidade Federal do Rio Grande do Sul (PROPESQ-UFRGS).



(Foto: Fonte [16])

Figure 2. Degree of non-Indian admixture (x1000) estimated by Szathmary and Reed's method [16] in 39 Brazilian Indian populations. Numbers in red indicate estimates above 5%.



(Foto: Fonte [16])

Figure 3. Relationship between the degree of non-Indian admixture estimated by Szathmary and Red's [16] method and the geographical location (longitude) of 39 Brazilian Indian populations.



\* **Sidia M. Callegari-Jaques** é professora convidada pelo Departamento de Estatística da Universidade Federal do Rio Grande do Sul (UFRGS), com experiência em análise de dados, em especial na área de Genética Humana. Atua como professora colaboradora nos programas de pós-graduação PPG em Medicina - Ciências Médicas (desde 1986) e PPG em Genética e Biologia Molecular (desde 1990), na UFRGS.

\*\* **Francisco Mauro Salzano** foi um geneticista, pesquisador e professor universitário brasileiro. Membro da Academia Brasileira de Ciências (ABC), foi precursor e pioneiro na pesquisa genética no Brasil e professor emérito da UFRGS.

## References

- JOHNSON, H. B. A colonização portuguesa do Brasil, 1500-1580. In: BETHELL, L. *História da América Latina: América Latina Colonial*. São Paulo: Edusp, 1997. p. 241-281.
- BONATTO, S. L.; SALZANO, F. M. A single and early migration for the peopling of the Americas supported by mitochondrial DNA sequence data. *Proceedings of the National Academy of Sciences of the United States of America*, Washington, v. 94, p. 1866-1871, 1997.
- BONATTO, S. L.; SALZANO, F. M. Diversity and age of the four major mtDNA haplogroups, and their implications for the peopling of the New World. *American journal of human genetics*, Baltimore, v. 61, p. 1413-1423, 1997.
- CUNHA, C. M. Introdução a uma história indígena. In: CUNHA, C. M. *História dos índios no Brasil*. São Paulo: Companhia das Letras, 1992. p. 9-24.
- BETHELL, L. Nota sobre as populações americanas às vésperas das invasões europeias. In: BETHELL, L. *História da América Latina: América Latina Colonial*. São Paulo: Edusp, 1997. p. 129-131.
- CLEVELARIO JUNIOR, J. A participação da imigração na formação da população brasileira. *Revista Brasileira de Estudos de População*, Rio de Janeiro, v. 14, p. 51-71, 1997.
- CAMARGO, L. *Almanaque Abril 98*. São Paulo: Editora Abril, 1998.
- RICARDO, C. A. *Povos indígenas no Brasil*, 1991/1995. São Paulo: Instituto Socioambiental, 1996.
- OLIVEIRA, C. R. *O índio e o mundo dos brancos: a situação dos Tukúna do Alto Solimões*. São Paulo: Difusão Europeia do Livro, 1964.
- OLIVEIRA, C. R.; FARIA, C. L. Interethnic contact and the study of populations. In: SALZANO, F. M. *The ongoing evolution of Latin American populations*. Springfield: Charles C. Thomas, 1971. p. 41-59.
- OLIVEIRA, C. R. *A sociologia do Brasil indígena*. Rio de Janeiro: Tempo Brasileiro, 1978.
- OLIVEIRA, C. R. *A crise do indigenismo*. Campinas: Editora da Unicamp, 1988.
- SALZANO, F. M.; CALLEGARI-JACQUES, S. M. *South American Indians: a case study in evolution*. Oxford: Clarendon Press, 1988.
- CHAKRABORTY, R. Gene admixture in human populations: models and predictions. *Yearbook of physical anthropology*, New York, v. 29, p. 1-43, 1986.
- BERTORELLE, G.; EXCOFFIER, L. Inferring admixture proportions from molecular data. *Molecular biology and evolution*, Chicago, v. 15, p. 1298-1311, 1998.
- SZATHMARY, E. J. E.; REED, T. E. Calculation of the maximum amount of gene admixture in a hybrid population. *American journal of physical anthropology*, Hoboken, v. 48, p. 29-34, 1978.
- CHAKRABORTY, R. Gene identity in racial hybrids and estimation of admixture rates. In: AHUJA, Y. R.; NEEL, J. V. *Genetic microdifferentiation in human and other animal populations*. Delhi: Indian Anthropological Association, 1985. p. 171-180.
- NEI, M. Genetic distance between populations. *The American naturalist*, Chicago, v. 106, p. 283-292, 1972.
- CHAKRABORTY, R. Estimation of race admixture a new method. *American journal of physical anthropology*, Hoboken, v. 42, p. 507-511, 1975.
- SANTOS, S. E. B.; GUERREIRO, J. F. The indigenous contribution to the formation of the population of the Brazilian Amazon region. *Revista Brasileira de Genética*, Ribeirão Preto, v. 18, p. 311-315, 1995.
- SALZANO, F. M. Human races: myth, invention, or reality? *Interciencia*, Caracas, v. 22, p. 221-227, 1997.
- KRIEGER, H.; MORTON, N. E.; MI, M. P.; AZEVEDO, E.; FREIRE-MAIA, A.; YASUDA, N. Racial admixture in north-eastern Brazil. *Annals of human genetics*, Oxford, v. 29, p. 113-125, 1965.
- DORNELLES, C. L.; CALLEGARI-JACQUES, S. M.; ROBINSON, W. M.; WEIMER, T. A.; FRANCO, M. H. L. P.; HICKMANN, A. C.; GEIGER, C. J.; SALZANO, F. M. Genetics, surnames, grandparents' nationalities, and ethnic admixture in southern Brazil: do the patterns of variation coincide? *Genetics and molecular biology*, Ribeirão Preto, v. 22, n. 2, 1999.
- BORTOLINI, M. C.; DA SILVA JUNIOR, W. A.; GUERRA, D. C.; REMONATTO, G.; MIRANDOLA, R.; HUTZ, M. H.;

- WEIMER, T. A. *et al.* African-derived South American populations: A history of symmetrical and asymmetrical matings according to sex revealed by bi- and uni-parental genetic markers. *American journal of human biology: the official journal of the Human Biology Council*, New York, v. 11, n. 4, p. 551-563, 1999.
25. ZAR, J. H. *Biostatistical analysis*. 3rd ed. Upper Saddle River: Prentice-Hall, 1996.
26. LEVY, M. S. F. O papel da migração internacional na evolução da população brasileira (1872 a 1972). *Revista de Saúde Pública*, São Paulo, v. 8, p. 49-90, 1974.
27. BERGMANN, M. *Nasce um povo*. Petrópolis: Editora Vozes, 1977.
28. NADALIN, S. O. Imigração alemã no Brasil: dois problemas. In: KOCH, W. *III Colóquio de Estudos Teuto-Brasileiros*. Porto Alegre: Editora da Universidade Federal do Rio Grande do Sul, 1980. p. 297-303.
29. KLEIN, H. Tráfico de escravos. In: COSTA, I. N.; LIMA, L. J. *Estatísticas históricas do Brasil: séries econômicas, demográficas e sociais de 1550 a 1985*. Rio de Janeiro: Fundação IBGE, 1987. p. 51-59.
30. VOGEL, F.; MOTULSKY, A. G. *Human genetics: problems and approaches*. Berlin: Springer-Verlag, 1996.