# Genetic Demography of the Central Pano and Kanamari Indians of Brazil

By F. M. Salzano[1] and Sidia M. Callegari Jacques[2]

ABSTRACT

Four populations of Brazilian Indians were studied demographically and genetically. Overall, their estimated average ages are low, but the Kanamari are somewhat older. Intermixture with non-Indians is small, and intertribal marriages are seen mostly among the Katukina. Migration to the Central Pano (Cashinawa + Katukina) communities occurred mainly from southern places located at an average distance of 150 km. Migration to the Kanamari can be characterized as centripetal, taking place from communities situated at a mean distance of 235 km. Fertility and mortality are high. These results were integrated with genetic marker data and three indices of population variability (one based on demographic variables and the other two on genetic factors) calculated for them and four other South American tribes. These indices showed no significant relationships among themselves. It is suggested that such comparisons should be extended to populations biologically more differentiated, in attempts to unravel the intricate connections that exist between population structure and genetic variability.

The relationship between population structure and genetic variability is complex and inadequately known. The frequency of a lethal or a semilethal allele will be influenced primarily by its effects, independently of the nature of the group in which it exists. But the prevalence of alleles that have just a slight effect on fitness may be strongly affected by characteristics of the population. Studies in humans can shed much light on these questions due to the fact that we know much more about the structure of our groups than of those of animals or plants. Therefore, since the pioneering efforts of Lasker (1952, 1954) attempts have been made to relate demographic and genetic factors (recent review in Ward and Weiss, 1976).

The present report can be viewed as an additional effort in this direction. During the summer of 1976 a multidisciplinary team of research worked among several Brazilian Indians living in the Amazon region. Reports about some of these investigations have already been described

[1]Departamento de Genética, Instituto de Biociências, Universidade Federal do Rio Grande do Sul, Caixa Postal 1953, 90000 Porto Alegre, RS, Brazil.

[2]Departamento de Estatística, Instituto de Matemática, Universidade Federal do Rio Grande do Sul, 90000 Porto Alegre, RS, Brazil.

*Human Biology, December 1979, Vol. 51, No. 4, pp. 551–564.*

elsewhere (Gershowitz and Neel, 1978; Mohrenweiser et al. 1979; Lawrence et al. 1979; Salzano et al. 1979; Mestriner et al. 1979). The specific objectives of the study to be presented below were: (a) To characterize demographically four populations of three tribes: the Kanamari, Cashinawa and Katukina (the last two are often grouped with others under the general designation of Central Pano); (b) To compare the data thus obtained with those of other studies, and especially with the work of Johnston and colleagues among thè Peruvian Cashinawa (references in Johnston and Kensinger, 1971); (c) To relate the demographic with the genetic results, trying to obtain inferences about the microevolutionary processes that are acting on these groups.

## Materials and Methods

Many Indian tribes live in the western part of Brazil's large northern region, and among them we can find several that are classified as Pano. They are the descendants of populations that previously inhabited places situated in the eastern Andean slopes of what is now Ecuador. Due to many factors they had to migrate to the South, and at the end of the 17th century they could be found in a wide region delimited by the Marañon and Ucayali rivers. From there they went east, towards the upper Juruá and Purus rivers, in Brazilian territory. At that time a series of fissions occurred among these groups, giving rise to the present tribes. Two of those were studied in the present communication, the Cashinawa and Katukina.

The Cashinawa number about 2,000 persons, distributed along the high Embira river and its tributaries. Brief ethnographic information and bibliographic references about them and other Pano tribes can be found in Schultz and Chiara (1955) and Trujillo Ferrari (1960). The two populations studied, Cana Brava and Paredão, are closely interconnected, inhabitants of one having relatives in the other. They are located near a New Tribes mission, at the margins of the Embira river, eight kilometers downstream from the Brazilian town of Feijó. The other Pano community studied is called Morada Nova. Most of their inhabitants identify themselves as Katukina and their village is also situated at the margins of the Embira, two kilometers away from Feijó (Figure 1). These Indians, especially those of Morada Nova, have had a long history of contact with the outside world. Therefore, despite the fact that they have their own somewhat isolated communities, their way of living is basically similar to that of any northern rural Brazilian person. When convenient, these three

populations will be considered together under the general designation of Central Pano. This designation is often used to distinguish tribes of this general area from groups who live in the southwest and southeast.

Indians who speak the Katukina *language* (not to be confounded with the Katukina tribe just mentioned), on the other hand, occupied large portions of this general area, until they were displaced to the margins of the Juruá and Purus rivers. One tribe of this group that was studied by us is called Kanamari. They number about 800 persons, who have been in contact with non-Indians for a long time. At present, however, there is a tendency to return to their cultural origins. Our studies among them were

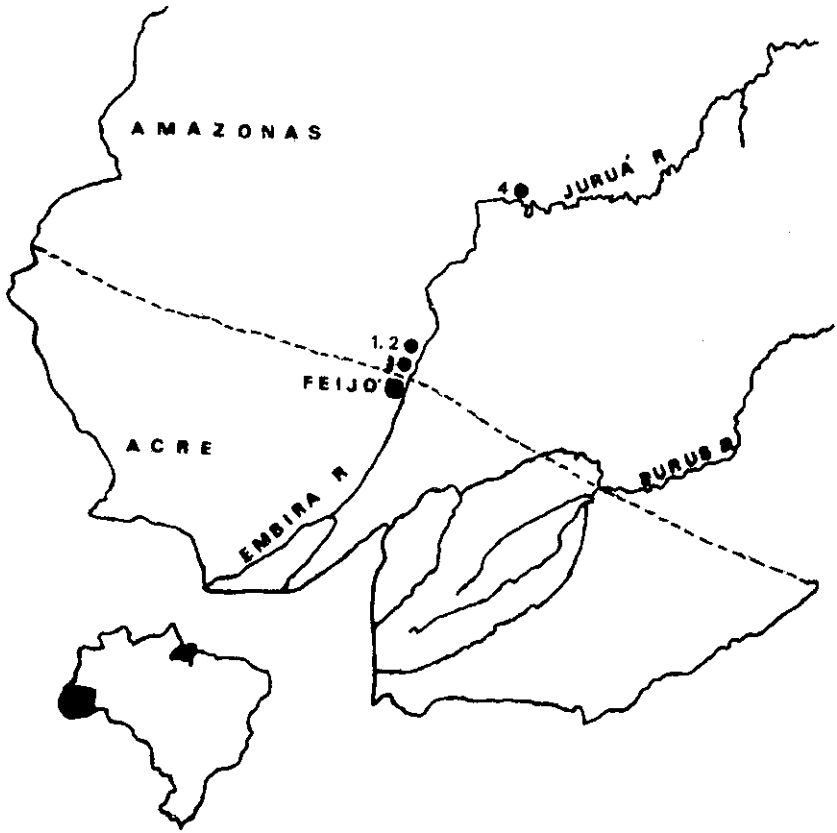


FIG. 1. Location of the populations studied. Small map of Brazil (lower left) and enlarged map of the Brazilian State of Acre, as well as part of Amazonas. The numbers indicate the sequence in which the localities are listed in Tables 1, 2, 5 and 6.

carried out at the New Tribes station of Três Unidos on the Mamoré Creek, a tributary of the Juruá (Figure 1).

The Indians were interviewed in family groups, the questions being submitted in Portuguese to one or both spouses. Most of these persons are bilingual, but we always recruited the cooperation of local chiefs to clarify any doubts. These chiefs were also responsible for assembling the Indians. Questions were asked about: (1) name, age and ethnic group of the spouses; (2) birthplace; (3) parents' names and ages; (4) names and sex of the sibs living in the community; (5) number of children alive and dead; (6) stillbirths; (7) names, sex and ages of the living children; (9) information about those who left the community; (10) other marriages of one or both spouses; (11) other persons living with the family; (12) in marriages without children, number of years of cohabitation. The ages of all subjects were estimated by visual inspection, comparisons between the figures for parents and children being also performed to arrive at the final decision. After the interviews blood samples were collected and processed as described in Mohrenweiser et al. (1979).

## Results and Discussion

Table 1 presents the results on the age and sex distributions of the four populations studied. Overall, the estimated average ages are low (around 22 years, with 47% of the persons in the 0-14 age interval). But the Kanamari are somewhat older, their mean (24 years), being significantly higher than that of the two Cashinawa communities combined (20 years; t: 1.96; p at the 5% level). The sex ratio shows large fluctuations in these four groups; when all of them are considered together the figure obtained is 111.

Despite the many years of contact with non-Indians, the number of persons of mixed or no Indian ancestry living in these communities is generally small, the exception being Morada Nova (Table 2). Moreover, the genetic data available (partially published in Gershowitz and Neel, 1978, and Mohrenweiser et al. 1979) give no indication of non-Indian markers in putative "full-blood" individuals. As for the intertribal marriages (Table 3) they do not appear in Paredão or Três Unidos and only two of them were observed in Cana Brava. But several types of intertribal hybrids occur in Morada Nova, involving the Cashinawa, Katukina and Jaminawa.

It should be emphasized that all these communities have been established recently. As a consequence, persons born there have not yet

Table 1.

*Age and Sex Distribution in Four Populations of Brazilian Indians*

| Population and Sex | Age Interval | | | | | Estimated Average Age (M ± SD) |
|---|---|---|---|---|---|---|
| | 0–14 | 15–30 | 31 and More | Unknown | Total | |
| CASHINAWA | | | | | | |
| *Cana Brava* | | | | | | |
| Males | 40 | 12 | 13 | 1 | 66 | 17.1 ± 17.9 |
| Females | 15 | 13 | 12 | 4 | 44 | 25.1 ± 19.0 |
| Total | 55 | 25 | 25 | 5 | 110 | 20.2 ± 18.7 |
| Per cent | 52 | 24 | 24 | — | — | — |
| Sex ratio | 267 | 92 | 108 | — | 150 | — |
| *Paredão* | | | | | | |
| Males | 10 | 7 | 5 | 1 | 23 | 20.9 ± 19.0 |
| Females | 19 | 8 | 6 | 0 | 33 | 18.5 ± 18.6 |
| Total | 29 | 15 | 11 | 1 | 56 | 19.4 ± 18.7 |
| Per cent | 53 | 27 | 20 | — | — | — |
| Sex ratio | 53 | 88 | 83 | — | 70 | — |
| KATUKINA | | | | | | |
| *Morada Nova* | | | | | | |
| Males | 23 | 13 | 12 | 20 | 68 | 21.0 ± 18.4 |
| Females | 17 | 14 | 11 | 13 | 55 | 20.3 ± 15.4 |
| Total | 40 | 27 | 23 | 33 | 123 | 20.7 ± 17.0 |
| Per cent | 44 | 30 | 26 | — | — | — |
| Sex ratio | 135 | 93 | 109 | 154 | 124 | — |
| KANAMARI | | | | | | |
| *Três Unidos* | | | | | | |
| Males | 26 | 20 | 20 | 2 | 68 | 24.8 ± 19.0 |
| Females | 28 | 21 | 18 | 3 | 70 | 23.7 ± 18.7 |
| Total | 54 | 41 | 38 | 5 | 138 | 24.2 ± 18.8 |
| Per cent | 41 | 31 | 28 | — | — | — |
| Sex ratio | 93 | 95 | 111 | — | 97 | — |
| *All populations* | | | | | | |
| Males | 99 | 52 | 50 | 24 | 225 | 21.0 ± 18.7 |
| Females | 79 | 56 | 47 | 20 | 202 | 22.3 ± 18.1 |
| Total | 178 | 108 | 97 | 44 | 427 | 21.6 ± 18.4 |
| Per cent | 47 | 28 | 25 | — | — | — |
| Sex ratio | 125 | 93 | 106 | 120 | 111 | — |

Table 2.

*Proportion of Non-Indian Ancestry in Four Populations of Brazilian Indians*

| Tribe and Locality | Indians | | Mixed | | No Indian Ancestry | | Total |
|---|---|---|---|---|---|---|---|
| | N | % | N | % | N | % | |
| CASHINAWA | | | | | | | |
| Cana Brava | 104 | 94 | 5 | 5 | 1 | 1 | 110 |
| Paredão | 56 | 100 | — | — | — | — | 56 |
| KATUKINA | | | | | | | |
| Morada Nova | 101 | 82 | 7 | 6 | 15 | 12 | 123 |
| KANAMARI | | | | | | | |
| Três Unidos | 135 | 98 | 3 | 2 | — | — | 138 |

reached adulthood. Table 4 furnishes information about the birthplaces of individuals with offspring living in these four villages. The main source of migrants to Cana Brava and Paredão is Porto Rubin, a locality situated some 160km from both. The most important contributors to Morada Nova are the communities of Rio Tarauacá and Rio Embira, located respectively 140 km and 90 km away. Migrants to Três Unidos are more diversified in

Table 3.

*Intra and Intertribal Marriages in Four Populations of Brazilian Indians*

| Type of Marriage | Localities | | | |
|---|---|---|---|---|
| | Cana Brava | Paredão | Morada Nova | Três Unidos |
| Cashinawa × Cashinawa | 16 | 12 | 3 | 0 |
| Cashinawa × Cash/Jaminawa | 2 | 0 | 0 | 0 |
| Cashinawa × Katukina | 0 | 0 | 1 | 0 |
| Katukina × Katukina | 0 | 0 | 6 | 0 |
| Katukina × Jaminawa | 0 | 0 | 1 | 0 |
| Katukina × Kat/Jaminawa | 0 | 0 | 1 | 0 |
| Katukina × Cash/Jaminawa | 0 | 0 | 1 | 0 |
| Jaminawa × Kat/Jaminawa | 0 | 0 | 1 | 0 |
| Kanamari × Kanamari | 0 | 0 | 0 | 28 |

Table 4.

*Back Stochastic Migration Matrix for Four Populations of Brazilian Indians*

| | Progeny living in | | | | |
|---|---|---|---|---|---|
| Parents born in | Cana Brava | Paredão | Morada Nova | Três Unidos | Total |
| Porto Rubim | 71 | 47 | 8 | 0 | 126 |
| Nova Olinda | 41 | 15 | 4 | 0 | 60 |
| Rio Tarauacá | 16 | 7 | 37 | 8 | 68 |
| Rio Murú | 11 | 0 | 11 | 0 | 22 |
| Feijó | 2 | 0 | 0 | 0 | 2 |
| Rio Embira | 0 | 7 | 39 | 0 | 46 |
| Rio Paraná | 0 | 6 | 0 | 0 | 6 |
| Rio Purús | 0 | 0 | 0 | 91 | 91 |
| Rio Juruá | 0 | 0 | 0 | 35 | 35 |
| Rio Itacuai | 0 | 0 | 0 | 13 | 13 |
| Eirunepé | 0 | 0 | 0 | 10 | 10 |
| Rio Curuçá | 0 | 0 | 0 | 2 | 2 |
| Igarapé Branco | 0 | 0 | 0 | 2 | 2 |
| Rio Jutai | 0 | 0 | 0 | 1 | 1 |
| Total | 141 | 82 | 99 | 162 | 484 |

relation to their source than those of the other populations studied (eight different places, compared with five for those mentioned previously). Rio Purús, about 300 km away, furnished the largest number.

Additional information can be gathered examining the geographical location of the places listed in Table 4. Migration to the Central Pano communities of Cana Brava, Paradão and Morada Nova occurred mostly from places situated more southerly, and the mean distance between them and the groups studied was 150 km. Migration to Três Unidos, on the other hand, can be characterized as centripetal, the contributing populations forming something like a circle around this place. They are further away, also (average distance 235 km). The Cashinawa Indians studied by Johnston et al. (1968 and later) live in villages along the Curanja river some 270 km from Cana Brava and Paredão, in Peru.

Fertility and mortality data are presented in Tables 5 and 6. Due to the small sizes of the communities studied eventual differences among localities have to be disregarded. Roughly, the mean number of liveborn offspring per couple is five if we consider all families and seven in those which presumably have completed reproduction (females with age 40 or

Table 5.

*Number of Liveborn Offspring in Four Populations of Brazilian Indians*

| Localities | All Families | | Completed Families | |
|---|---|---|---|---|
| | No. of Females | Mean no. LB ± SE | No. of Females | Mean no. LB ± SE |
| CASHINAWA | | | | |
| Cana Brava | 19 | 6.0 ± 0.9 | 8 | 6.9 ± 1.6 |
| Paredão | 12 | 5.8 ± 1.0 | 4 | 9.0 ± 1.5 |
| KATUKINA | | | | |
| Morada Nova | 16 | 4.8 ± 1.0 | 3 | 10.0 ± 1.5 |
| KANAMARI | | | | |
| Três Unidos | 30 | 3.8 ± 0.5 | 10 | 6.4 ± 0.8 |
| All villages | 77 | 4.9 ± 0.4 | 25 | 7.4 ± 0.7 |

LB = Livebirths; SE = standard error of the mean.

Table 6.

*Surviving Offspring per Female who Had at Least One Liveborn Child in Four Populations of Brazilian Indians*

| Localities | All Families | | | Completed Families | | |
|---|---|---|---|---|---|---|
| | No. of Females | Mean no. SO ± SE | Decrease as % LB | No. of Females | Mean no. SO ± SE | Decrease as % LB |
| CASHINAWA | | | | | | |
| Cana Brava | 18 | 4.1 ± 0.5 | 32 | 8 | 4.4 ± 1.1 | 36 |
| Paredão | 12 | 3.5 ± 0.6 | 40 | 4 | 5.0 ± 0.9 | 44 |
| KATUKINA | | | | | | |
| Morada Nova | 15 | 3.5 ± 0.7 | 27 | 3 | 5.7 ± 1.9 | 43 |
| KANAMARI | | | | | | |
| Três Unidos | 25 | 3.0 ± 0.3 | 21 | 10 | 3.8 ± 0.6 | 41 |
| All villages | 70 | 3.5 ± 0.3 | 29 | 25 | 4.4 ± 0.5 | 41 |

SO = Surviving offspring; SE = standard error of the mean; LB = Livebirths.

older). The respective numbers for the surviving offspring are three and four, indicating that about 40% of the children born in these communities would die before reproduction. These values are not very different from those we have been obtaining in tribes with similar sociocultural conditions (see, for instance, Salzano, 1972), but mean family sizes are higher than those observed by Johnston et al. (1969a) among the Peruvian Cashinawa. No case of sterility was observed by us.

In what way can these demographic results be related to the genetic ones? We first examined our largely unpublished information on genetic markers, comparing the Cashinawa studied by us with those tested by Johnston et al. (1968, 1969b). A total of 18 alleles related to blood group and serum protein systems could be considered (ABO: $I^0$; Kell: *k;* MNSs: $L^{MS}$, $L^{Ms}$, $L^{NS}$, $L^{Ns}$; P: $P^1$; Rh: $R^1$, $R^2$, $R^Z$, $R^0$; Duffy: $Fy^a$; Kidd: $Jk^a$; Diego: $Di^a$; Haptoglobin: $Hp^1$; Gc: $Gc^2$; Transferrin: $Tf^C$; Albumin: $Al^A$) and in only four ($L^{MS}$, $Jk^a$, $Di^a$ and $Gc^2$) were the differences higher than five per cent. The average difference in a subset of 16 gene markers known to vary among South American Indians (excluding $I^0$ and *k*) was four per cent. Dissimilarities between the Cashinawa and Katukina tested by us can be examined to place the above results in proper perspective. As was shown by Mohrenweiser et al. (1979) the Central Pano tribes are not as much differentiated linguistically as other tribes of our continent. But considering 24 alleles that are polymorphic in at least two South American Indian tribes (the 16 previously indicated plus: Lewis: *Le*; Ceruloplasmin: $Cp^B$; Gm: $Gm^{ag}$; Km: $Km^1$; Phosphoglucomutase: $PGM_1^1$; Acid phosphatase: $ACP^A$; Galactose-1-phosphate uridyltransferase: $GALT^1$; Esterase D: $ESD^1$) we found that seven of them ($L^{Ms}$, $L^{NS}$, $Jk^a$, *Le*, $Gc^2$, $Km^1$ and $ESD^1$) showed differences higher than 10% in the two tribes, the average being 8% (two times as high as the Cashinawa intratribal difference). We conclude that the Brazilian and Peruvian Cashinawa tested so far can be grouped in a common gene pool.

Further results are presented in Tables 7 and 8. Deviations from the expected proportion of heterozygotes at a given locus can be ascribed to many causes (Neel and Ward, 1972). A convenient way of quantifying these departures is Wright's (1921, 1969) fixation index. Harpending et al. (1973) noted that if a population is not highly endogamous, this estimate will be negative as a result of the effects of migration alone; this is exactly what we observed among the Kanamari and Central Pano, in good agreement with the demographic data presented above. The average F considering 11 loci is $-0.025$ for the Central Pano and $-0.015$ for the Kanamari.

In Table 8 information related to this index is compared with that of

Table 7.

*F[a] Values Derived from Heterozygote Proportions in Codominant Systems*

| Genetic Systems | Alleles | Central Pano (N = 133) F | Central Pano (N = 133) $X^2$ | Kanamari (N = 100) F | Kanamari (N = 100) $X^2$ |
|---|---|---|---|---|---|
| MNSs | $L^M$, $L^N$ | 0.024 | 0.08 | −0.095 | 0.90 |
| | $L^S$, $L^s$ | 0.117 | 1.82 | 0.111 | 1.23 |
| Rh | $C$, $c$ | −0.234 | 7.28** | −0.068 | 0.46 |
| | $E$, $e$ | −0.022 | 0.06 | 0.017 | 0.03 |
| Duffy | $Fy^a$, $Fy^b$ | −0.022 | 0.06 | 0.128 | 1.64 |
| Hp | $Hp^1$, $Hp^2$ | 0.014 | 0.02 | −0.060 | 0.36 |
| Gc | $Gc^1$, $Gc^2$ | −0.086 | 0.98 | −0.214 | 4.58* |
| Acid Phosph. | $P^A$, $P^B$ | 0.217 | 6.26* | 0.046 | 0.21 |
| $PGM_1$ | $PGM_1^1$, $PGM_1^2$ | −0.039 | 0.20 | 0.223 | 4.97* |
| EST D | $ESD^1$, $ESD^2$ | −0.097 | 1.30 | −0.148 | 1.71 |
| Km | $Km^1$, $Km^2$ | −0.147 | 2.87 | −0.104 | 1.08 |
| Average | | −0.025 | | −0.015 | |

*Sources:* Mohrenweiser et al. (1979); Mestriner et al. (1979); and unpublished data of H. Gershowitz, J. V. Neel and coworkers.

[a]F = 1-H/2pq, where H is the observed proportion of heterozygotes and p and q are the allele frequencies at that locus. This variable was called the fixation index by Wright (1921, 1969).

*$p < 0.05$; **$p < 0.01$.

two other (D—departure from the maximum degree of heterozygosity and I—index of potential selection); data from four other South American tribes besides those studied here are available for consideration. The index of potential selection usefully incorporates fertility and mortality results in a single measure. It was devised by Crow (1958) and it should be mentioned that the high value presented for the Yanomama (4.24) may be due to the fact that in this case the calculation was done by an alternative method developed by Neel and Weiss (1975). The other numbers are distributed in a relatively narrow interval between the extremes of 0.57 (found among the Wapishana) and 1.03 (observed in the Central Pano).

Table 8.

*Comparison of a Demographic Index with Two Measures of Genetic Variability*

| Tribe | Index of Potential Selection (I)[a] | Average Departure from Maximum Degree of Heterozygosity (D)[b] | Average Fixation Index (F)[c] |
|---|---|---|---|
| Central Pano | 1.03 | 0.327 | −0.025 |
| Kanamari | 1.01 | 0.341 | −0.015 |
| Wapishana | 0.57 | 0.165 | 0.025 |
| Cayapo | 0.82 | 0.132 | 0.016 |
| Krahó | 0.73 | 0.222 | 0.022 |
| Yanomama | 4.24 | 0.316 | 0.024 |

[a] $I = Im + If/ps$, where $Im = pd/ps$; pd = premature deaths and ps = proportion surviving or 1 − pd. $If = Vf/\bar{x}^2$; Vf = variance in offspring number in completed sibships; $\bar{x}$ = mean number of livebirths per woman who completed her reproduction. See Crow (1958).

[b] $D = k(\sum_i x_i^2 - 1/k)/(k-1)$, where k = number of alleles and x = frequency of each allele. See Spuhler (1963). Loci used for the calculation: MNSs, Ph, P, Duffy, Hp and Gc.

[c] The loci considered are those listed in Table 7. A list of primary publications from which data for the calculation of these values were extracted is available on request.

The latter show an index that is almost identical with that of the Kanamari (1.01) or with the one calculated by Johnston and Kensinger (1971) among the Peruvian Cashinawa (0.98).

Spuhler (1963) devised an index to measure the departure from the maximum degree of heterozygosity possible at a given locus. Averaging for the six loci indicated in Table 8 furnishes values that range from 0.132 to 0.341 in the six tribes studied. It should be emphasized that the indices calculated for the Central Pano (0.327) and Kanamari (0.341) are nearly identical. Due to the higher number of intertribal marriages observed among the first we could have expected a larger difference; but it should be remembered that the Kanamari migrants came from places located further away and were more diversified than those of the Central Pano. These two factors, therefore, may have cancelled out possible divergences. The fixation indices, on the other hand, vary from −0.025 to 0.024.

Can we find significant relationships among these three measures of population variability? To answer that, we used a test of rank correlation, that yielded non-significant results. The coefficient of concordance (Kendall, 1970) is equal to 0.25; $s = 39.5$ and $p > 0.05$. Spearman's correlation coefficients calculated for each of the three possible two-by-two comparisons also furnished non-significant numbers.

What is the meaning of these results? Theoretically D and F should have varied in the same direction. But the F values are not significantly different from zero and they provide just an indication of larger isolation for the four tribes that were compared with the Kanamari and Central Pano. The largest D average, on the other hand, is 2.6 times higher than the smallest, but no significant differences were observed in the ranks of heterozygosity considering the six loci studied in these six tribes. These largely negative findings should not discourage us in the search for the key relationships between genetic variation and population structure. New approaches with other gene markers and populations biologically more differentiated may provide better clues.

## Acknowledgements

The field work that made this work possible was conducted under the general coordination of James V. Neel. We thank him for much support and advice during all phases of the study. Thanks are also due to the other members of the expedition and to the crew of the Research Vessel Alpha Helix of the National Science Foundation. The Fundação Nacional do Indio and Instituto Nacional de Pesquisas da Amazônia provided the necessary clearances and helped in many ways. This work was supported by the Energy Research and Development Administration (now Department of Energy) and the National Science Foundation of the United States of America, as well as by the Brazilian Conselho Nacional de Desenvolvimento Científico e Tecnológico (Programa Integrado de Genética), Fundação de Amparo à Pesquisa do Estado do Rio Grande do Sul and Pró-Reitoria de Pesquisa e Pós-graduação da Universidade Federal do Rio Grande do Sul.

## Literature Cited

Crow, J. F. 1958 Some possibilities for measuring selection intensities in man. Human Biol. 30: 1-13.

Gershowitz, H. and J. V. Neel 1978 The immunoglobulin allotypes (Gm and Km) of

twelve Indian tribes of Central and South America. Amer. J. Phys. Anthrop. 49: 289-301.

HARPENDING, H., P. WORKMAN AND J. GROVE 1973 Local genotypic disequilibrium in a generalized island model. Human Biol. 45: 359-362.

JOHNSTON, F. E., B. S. BLUMBERG, K. M. KENSINGER, R. L. JANTZ AND G. F. WALKER 1969b Serum protein polymorphisms among the Peruvian Cashinahua. Amer. J. Human Genet. 21: 376-383.

JOHNSTON, F. E., R. L. JANTZ, K. M. KENSINGER, G. F. WALKER, F. H. ALLEN, JR., AND M. E. WALKER 1968 Red cell blood groups of the Peruvian Cashinahua. Human Biol. 40: 508-516.

JOHNSTON, F. E. AND K. M. KENSINGER 1971 Fertility and mortality differentials and their implications for microevolutionary change among the Cashinahua. Human Biol. 43: 356-364.

JOHNSTON, F. E., K. M. KENSINGER, R. L. JANTZ AND G. F. WALKER 1969a The population structure of the Peruvian Cashinahua: demographic, genetic, and cultural interrelationships. Human Biol. 41: 29-41.

KENDALL, M. G. 1970 Rank correlation methods. Griffin, London.

LASKER, G. W. 1952 Mixture and genetic drift in ongoing human evolution. Amer. Anthrop. 54: 433-436.

——— 1954 Human evolution in contemporary communities. Southw. J. Anthrop. 10: 353-365.

LAWRENCE, D. N., R. R. FACKLAM, F. O. SOTTNEK, G. A. HANCOCK, J. V. NEEL AND F. M. SALZANO 1979 Epidemiologic studies among Amerindian populations of Amazônia. I. Pyoderma: prevalence and associated pathogens. Amer. J. Trop. Med. Hyg. 28: 548-558.

MESTRINER, M. A., A. L. SIMÕES AND F. M. SALZANO 1979 New studies on the esterase D polymorphism in South American Indians. Amer. J. Phys. Anthrop. (in press).

MOHRENWEISER, H., J. V. NEEL, M. A. MESTRINER, F. M. SALZANO, E. MIGLIAZZA, A. L. SIMÕES AND C. M. YOSHIHARA 1979 Electrophoretic variants in three Amerindian tribes: the Baniwa, Kanamari, and Central Pano of western Brazil. Amer. J. Phys. Anthrop. 50: 237-246.

NEEL, J. V. AND R. H. WARD 1972 The genetic structure of a tribal population, the Yanomama Indians. VI. Analysis by F-statistics (including a comparison with the Makiritare and Xavante). Genetics, 72: 639-666.

NEEL, J. V. AND K. M. WEISS 1975 The genetic structure of a tribal population, the Yanomama Indians. XII. Biodemographic studies. Amer. J. Phys. Anthrop. 42: 25-51.

SALZANO, F. M. 1972 Genetic aspects of the demography of American Indians and Eskimos. *In*: The structure of human populations, G. A. Harrison and A. J. Boyce (eds.), Clarendon Press, Oxford, pp. 234-251.

SALZANO, F. M., S. M. CALLEGARI JACQUES AND J. V. NEEL 1979 Genetic demography of the Amazonian Ticuna Indians. (Submitted for publication).

SCHULTZ, H. AND V. CHIARA 1955 Informações sobre os índios do alto rio Purus. Rev. Museu Paulista, 9: 181-201.

SPUHLER, J. N. 1963 The scope for natural selection in man. *In*: Genetic selection in man, W. J. Schull (ed.), University of Michigan Press, Ann Arbor, pp. 1-111.

TRUJILLO FERRARI, A. 1960 Análisis del comportamiento económico de los Kashibo frente a los efectos aculturativos. Rev. Museu Paulista, 12: 199-309.

WARD, R. H. AND K. M. WEISS (eds.) 1976 Demographic aspects of the biology of human populations. J. Hum. Evol. 5: 1-154.

WRIGHT, S. 1921 Systems of mating. Genetics, 6: 111-178.

——— 1969 The theory of gene frequencies, vol. 2, Evolution and the genetics of populations. University of Chicago Press, Chicago.