

NEW DATA ON THE VISION OF SOUTH AMERICAN INDIANS¹

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Data are presented on the frequency of color blindness in the Krahó, Cayapo, Caingang, and Yanomama Amerindians, and on visual acuity and ophthalmological findings in the Yanomama. The latter studies were conducted in some of the same Yanomama villages in which, five years later, apparently endemic onchocerciasis was encountered by Moraes and colleagues (2). Analysis of these earlier data raises the probability that the disease has been recently acquired or has manifested itself quite atypically in this Amerindian group.

Introduction

Good vision can be presumed to have played an essential role in survival during the early days of human evolution. But with the advent of agriculture and medical measures for correcting visual defects, selection against persons with poor vision presumably was greatly relaxed. (See Post (1) for review of this subject and further references.)

In order to obtain quantitative information about the results of this process, it is necessary that a large number of populations living at different socioeconomic levels be examined. The present article provides new data about the prevalence of color blindness among four Brazilian Indian tribes in different stages of acculturation, as well as information about the visual acuity of a sample of Yanomama Indians. The latter results are of special interest because Moraes and co-workers (2-4)

have recently reported the occurrence among these Indians of onchocerciasis, a disease widespread in parts of Africa but thus far of very limited occurrence in the Americas. Since onchocerciasis can lead to visual impairment and blindness, studies of visual acuity can provide indirect information about the size of this endemic area and the severity of the symptoms experienced by affected individuals.

Materials and Methods

The Indian tribes studied were as follows:

1) *The Yanomama*: They speak an independent language. Individuals from nine villages, four in Venezuela and five in Brazil, received an ophthalmological examination and were tested for color blindness and visual acuity (in 1966 and 1967). The designations given to the villages are listed in Table 1, and their exact locations are given in Ward (5). Ophthalmological examinations without visual acuity tests were carried out in the Venezuelan villages 08E and F (see 5).

2) *The Krahó*: This is a Ge-speaking group. Persons living in two communities some 60 km apart were examined in 1974.

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TABLE 1—Prevalence of color blindness in Yanomama, Kraho, Cayapo, and Caingang Indian Tribes, compared with data obtained from similar studies of these and other South American Indian populations

Tribe and locality	Number studied	Males			Females	
		Number with the indicated type of color blindness			Number studied	Number defective
		Deutero-defective	Proto-defective	Type not diagnosed		
Yanomama						
Village 03A	24	0	0	0	24	0
" 03B	7	0	0	0	11	0
" 03C	21	0	0	0	15	0
" 03D	23	1	0	0	10	0
" 03K	36	6	1	2	29	0
" 03MN	23	2	0	0	20	0
" 03R	10	0	0	0	17	0
" 03S	11	0	0	0	11	0
" 03T	18	0	0	0	21	0
Krahó						
Pedra Branca	69	1	0	0	72	0
Cachoeira	36	1	0	0	34	0
Cayapo						
Gorotire	137	0	0	0	115	0
Other (12)	120	1	0	0	149	0
Caingang						
Guarita	31	0	0	0	37	0
Nonoai	20	0	0	2	21	0
Other (13-16)	301	0	5	2	224	0
Xavante (17, 18)	172	0	0	0	186	0
Several tribes (14)	205	0	0	0	95	0
Carajá (19)	35	2	0	0	0	0
Jivaro (20)	183	0	0	13	144	0

Both communities are located in the Indian reservation of Kraolandia in northern Goiás, near the small neo-Brazilian town of Itacajá (lat. 8°10'S, long. 47°50'W).

3) *The Cayapo*: This is also a Ge-speaking group. The subjects were from a village called Gorotire, which is located at 7°44'S, 51°10'W in southern Pará State. Again, the examinations were performed in 1974.

4) *The Caingang*: Some scholars classify their language as Ge, but others consider it an independent linguistic stock. The subjects tested were living at Guarita (27°30'S; 53°50'W) and Nonoai (27°40'S; 52°40'W), both of which are in the State of Rio Grande do Sul. These examinations were performed in 1975.

The degree of acculturation of these Indians varies markedly. The least accul-

tured are the Yanomama, who are still relatively isolated and have quite an independent life (6). The Cayapo villagers of Gorotire first established peaceful contacts with neo-Brazilians in 1937 and have had intermittent contacts with non-Indians since then. But because their village is situated in a hard-to-reach area they still maintain much of their traditional way of life (7).

The history of the Krahó is quite different. Their peaceful contacts date from 1809, at which time they were living in the south of the State of Maranhão. Afterwards they moved to the vicinity of the present neo-Brazilian towns of Carolina and Pedro Afonso, before settling in their current location in northern Goiás. Their contacts with non-Indians were previously more intense, the reduction being due to creation of a special reservation for them



A young Yanomama male, his head adorned with buzzard down, photographed near the Toototobi Mission.

in 1944. Today, despite some 150 years of interethnic contact, they still keep many of their traditions (8) and show little evidence of admixture with non-Indians (9).

The first contacts of the Caingang with pioneers advancing into the interior of Brazil also date back to the beginning of the 19th century. However, since they were located in areas subjected to more rapid economic development, they experienced rather rapid acculturation and at present can be considered as integrated into the neo-Brazilian rural way of life (10). As a result, intermixture with Caucasians and Negroes has occurred. For purposes of the present analysis, however, individuals suspected of having a partially non-Indian ancestry were not considered.

The color vision tests were performed with pages 26-38 of Ishihara's charts (11), as described in (12). Visual acuity was determined with a Snellen Illiterate E Chart at 20 feet, *both eyes being tested simultaneously*. Most of the persons studied were also subjected to a detailed physical examination.

Results

The data concerning color blindness are presented in Table 1, where they are

compared with results obtained previously. To our surprise, we observed nine individuals with defective color vision among the 36 males tested in Yanomama village 03K. Two of the nine bore no apparent blood relationship to the other affected subjects. But five others (three brothers, their father, and a paternal uncle) were closely related to each other, and the two remaining color-blind subjects were also related as brothers. Due to the difficulty of obtaining reliable information about dead ancestors, and also to other taboos existing in this tribe, it was not possible to ascertain if all these cases had a common origin. Three other Yanomamas, from villages 03D and 03MN, were also found to be color-blind.

There were two deuterodefectives among 105 Krahó males, and two color-blind Indians whose defect could not be diagnosed among 51 Caingang males, but none among 137 Cayapo (Gorotire) males. The new data obtained from the limited number of Caingang males examined confirm previous data (15) indicating the absence of this condition in Guarita and its presence in Nonoai. (Detailed inquiries were made to ensure that we were not simply retesting individuals studied in the first round of field work.)

The results of the visual acuity studies, which were limited to the Yanomamas, are shown in Table 2. As noted in our previous studies (12,17,18), males performed better than females. The better ratings encountered among individuals of ages 15-30 (as compared to younger subjects) could simply reflect possible inhibition experienced by some of the latter under test conditions. The average visual acuity found in the Yanomama subjects was inferior to the average found among the Cayapo and the Xavante; in these latter two tribes, 56 and 68 per cent of the persons tested showed an acuity better than 20/20, but the corresponding proportion among the Yanomamas was only 32 per cent. However, it is our impression that the Yanomamas taking the test did not cooperate to the same extent as the members of the other tribes.

TABLE 2—Visual acuity data obtained from the Yanomama Indians, compared with similar data from two other Brazilian Indian tribes.

Tribes and Yanomama age-groups tested	Sex	No. tested	Visual acuity					
			20/70	20/50	20/30	20/20	20/15	20/10
<u>Yanomama</u>								
0-14 years	M	44	0	0	16	13	13	2
	F	28	0	3	13	10	2	0
15-30	M	76	0	0	11	18	39	8
	F	80	0	0	22	38	18	2
31 or over	M	41	0	0	18	14	8	1
	F	27	0	0	15	9	1	2
Total	M+F	296	0	3	95	102	81	15
%			-	1	32	35	27	5
<u>Cayapo (12)</u>								
Total	M+F	194	1	0	20	64	85	24
%			1	-	10	33	44	12
<u>Xavante (17, 18)</u>								
Total	M+F	301	1	3	28	65	131	73
%			-	1	9	22	44	24

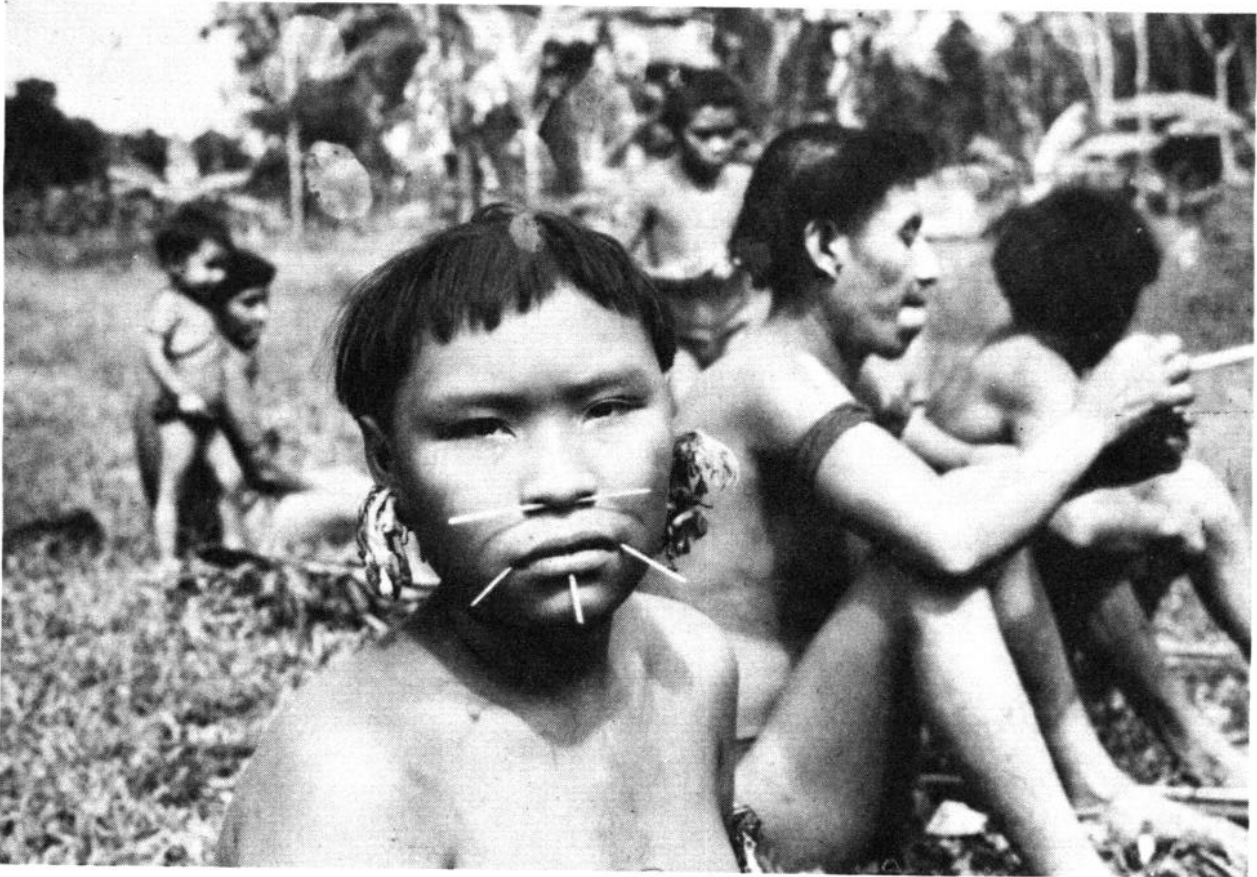
Ophthalmological examinations were carried out on all 296 Yanomamas from whom visual acuity data were obtained, as one aspect of a complete physical examination (exclusive of the genitals). An additional 315 ophthalmological examinations were carried out on persons not tested for visual acuity. Reasons for not testing the latter 315 were extreme youth, apparent lack of comprehension or motivation in the test situation, lack of time for the examination (in which case entire villages were omitted), or severe disease rendering such tests impossible.

A mild degree of diffuse conjunctivitis was common, which we attributed to the subjects' close and prolonged exposure to camp fires. Because of extreme miosis (and our reluctance to use mydriatics under jungle conditions), the retina was not always visualized satisfactorily. Bilateral cataracts, none sufficiently severe to cause blindness, were encountered in eight older persons. But two persons exhibited advanced unilateral cataracts, with amaurosis (blindness) in the affected eye; one of these cases was definitely attributed to trauma. Six persons had significant unilateral corneal scarring, and in three cases this resulted in amaurosis.

The left fundus of one male estimated to be about 20 years old exhibited a disc-sized area of retinal scarring and pigmentation just inferior to the optic disc. There was also one case of unexplained blindness in a male, estimated to be about age 40, who lived in village 03R (near Toototobi). This older man, who had experienced poor vision for many years, lost his sight completely about two years before our examination. Fundi could not be visualized. Finally, a girl of seven was found in this same village whose vision was limited to finger-counting. She exhibited extensive bilateral retinitis pigmentosa, with peripheral vision only.

Accurate and extensive pedigree data are always difficult to obtain from the Yanomama (individuals will not talk about deceased relatives), but the pedigree relationships between this girl and the older male we have just described appear to be as shown in Figure 1. We interpret the loss of vision in these two persons as being due to genetic factors rather than to acquired disease. No other significant retinal disease was recognized.

Six different physicians participated in the physical examinations. Although their exami-

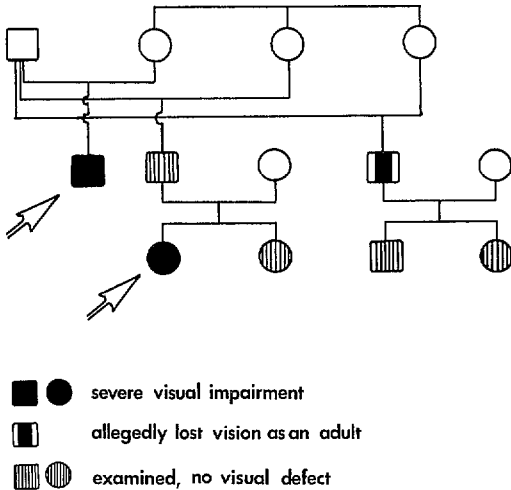


Above: *A young Yanomama woman with traditional adornments in her pierced ears, nose, and lower lip.*

Below: *The New Tribes Mission at Toototobi, seen from the air. The large circular building is a typical Yanomama communal dwelling.*



FIGURE 1 — The apparent genetic relationships of three Yanomamas with severely defective vision; squares represent males, circles represent females, arrows indicate the two subjects whose cases are discussed. The possibility of additional links in these relationships should not be ruled out (see text).



nation forms comment on abrasions, a variety of dermatitides, and evidence of exposure to insects, none reported noteworthy subcutaneous nodules. Moraes, Fraiha, and Chaves (2) and Moraes and Chaves (4) have indicated that even when a *directed* search is undertaken the subcutaneous nodules of onchocerciasis are difficult to detect in this group, the scalp nodule characteristically associated with the disease being rare. Our experience, antedating their examinations by some five or six years, certainly confirms their impression and underlines the possibility that the appearance of the disease in the endemic proportions reported is a rather recent development.

Discussion

It has been asked if the Indians of South America possessed genes for color blindness before their contact with Europeans (12). The number of instances in which it is difficult to attribute the presence of the defect to admixture is increasing, and we now consider its presence to be characteristic of native Indians. Nevertheless, available data on 1,492 males and 1,235 females clearly indicate the

frequency of this trait to be lower than the frequency observed in Caucasian populations. The present results also confirm earlier findings indicating that the visual acuity of unacculturated Amerindians is generally excellent (12, 17, 18).

Discussing their recent findings of onchocerciasis among the Yanomama, Moraes and Chaves (4) suggest that this disease is endemic in the Brazilian region from which some of our samples were obtained (villages 03K, 03MN, and 03R are located near the Surucucu Mission, 03S and 03T near the Toototobi Mission), that the entire Yanomama group is involved, and that the disease probably came into this area from Venezuela. Extensive epidemiologic investigations in both Brazil and Venezuela are needed to prove or disprove their hypothesis. Our relatively limited data have the usual unsatisfactory aspects of negative information, but do underline one unusual aspect of the situation already evident from the reports of the Brazilian investigators—namely, the relative paucity of physical findings in the Indians tested, despite the fact that almost 100 per cent of those estimated to be over age 30 were later found to be infected. We are forced to conclude that the focus discovered by Moraes, *et al.*, may well be of recent origin, or else that for reasons unknown the manifestations of the disease in the Amerindians depart significantly from the “classical” picture. Given the extremely limited contacts of the Yanomama with possible non-Indian carriers, the source of the disease remains a mystery.

Recently, Beaver, *et al.* (21) reported a chance finding of *Mansonella ozzardi* microfilariae in 17 of 159 short-term leucocyte cultures of blood specimens from Venezuelan Yanomamas living to the west of the onchocerciasis focus just described. In that same study, eight of 28 Piaroa Indians living west of the Yanomamas were found to be infested with *Mansonella ozzardi* and/or *Dipetalonema perstans*. The specimens in question were obtained in 1969, 1970, and 1971. Since the chance observation of microfilariae in karyotyping preparations such as

these is scarcely an effective diagnostic procedure, we assume the true frequency of infection to have been substantially higher.

It thus seems clear that infection with a variety of filariae is relatively common among the Amerindians of this region.

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SUMMARY

A total of 466 males and 437 females from four Brazilian Indian tribes were tested for color blindness with Ishihara's plates. Defective persons were found in three of the four tribes, but when these and other groups are considered the evidence suggests that the frequency of this trait is lower among Amerindians than among Caucasian populations.

Visual acuity tests were performed on 296 Yanomama Indians. Their visual acuity was apparently not as sharp as that of the Cayapo or Xavante. But the scarcity among the Yanomama of persons with serious visual impairment of subcutaneous nodules suggests that the focus of onchocerciasis discovered among them is of recent origin.

REFERENCES

- (1) Post, R. H. Possible cases of relaxed selection in civilized populations. *Humangenetik* 13:253-284, 1971.
- (2) Moraes, M.A.P., H. Fraiha, and G. M. Chaves. Onchocerciasis in Brazil. *Bull Pan Am Health Organ* 7:50-56, 1973.
- (3) Moraes, M.A.P. "Onchocerciasis in Brazil." PAHO Conference on Research and Control of Onchocerciasis in the Western Hemisphere, Washington, D.C., 18-21 November 1974 (PAHO document RD 49/9-2).
- (4) Moraes, M.A.P., and G. M. Chaves. Onchocerciasis in Brazil: New findings among the Yanomama Indians. *Bull Pan Am Health Organ* 8:95-99, 1974.
- (5) Ward, R. H. The genetic structure of a tribal population, the Yanomama Indians: V. Comparison of a series of genetic networks. *Ann Hum Genet* 36:21-43, 1972.
- (6) Neel, J. V., T. Arends, C. Brewer, N. Chagnon, H. Gershowitz, M. Layrisse, Z. Layrisse, J. MacCluer, E. Migliazza, W. Oliver, F. Salzano, R. Spielman, R. Ward, and L. Weitkamp. Studies on the Yanomama Indians. *Proc 4th Intern Congr Hum Genet. Excerpta Medica*, Amsterdam, 1972, pp. 96-111.
- (7) Salzano, F. M. Demographic and genetic interrelationships among the Cayapo Indians of Brazil. *Soc Biol* 18:148-157, 1971.
- (8) Melatti, J.C. Kraho: balanço de 150 anos de contato interétnico. *Inf FUNAI* (Brasilia) 11/12: 89-131, 1974.
- (9) Salzano, F. M., J. V. Neel, H. Gershowitz, and E. C. Migliazza. Intra and intertribal genetic variation within a linguistic group: The Ge-speaking Indians of Brazil. (In manuscript.)
- (10) Salzano, F. M. Estudos genéticos e demográficos entre os índios do Rio Grande do Sul. *Bol Inst Cienc Nat* (Porto Alegre) 9:1-161, 1961.
- (11) Ishihara, S. *Tests for Colour-Blindness*. Kanehara Shuppan, Tokyo, 1957.
- (12) Salzano, F. M. Visual acuity and color blindness among Brazilian Cayapo Indians. *Human Hered* 22: 72-79, 1972.
- (13) Fernandes, J. L., P. C. Junqueira, H. Kalmus, F. Ottensooser, R. Pasqualin, and P. Wishart. P.T.C. thresholds, colour vision and

blood factors of Brazilian Indians: I. Kaingangs. *Ann Hum Genet* 22:16-21, 1957.

(14) Mattos, R. B. *Acuidade Visual para Longe e Frequência de Discromatopsia em Índios Brasileiros* (M.D. Thesis). Escola Paulista de Medicina, São Paulo, 1958.

(15) Salzano, F. M. Rare genetic conditions among the Caingang Indians. *Ann Hum Genet* 25:123-130, 1961.

(16) Salzano, F. M. Color blindness among Indians from Santa Catarina, Brazil. *Acta Genet (Basel)* 14:212-219, 1964.

(17) Neel, J. V., F. M. Salzano, P. C. Junqueira, F. Keiter, and D. Maybury-Lewis. Studies on the Xavante Indians of the Brazilian Mato Grosso. *Am J Hum Genet* 16:52-140, 1964.

(18) Weinstein, E. D., J. V. Neel, and F. M. Salzano. Further studies on the Xavante Indians: VI. The physical status of the Xavantes of Simões Lopes. *Am J Hum Genet* 19: 532-542, 1967.

(19) Junqueira, P. C., H. Kalmus, and P. Wishart. P.T.C. thresholds, colour vision, and blood factors of Brazilian Indians: II. Carajas. *Ann Hum Genet* 22:22-25, 1957.

(20) Sunderland, E., and R. Ryman. P.T.C. thresholds, blood factors, colour vision, and fingerprints of Jivaro Indians in Eastern Ecuador. *Am J Phys Anthropol* 28:339-344, 1968.

(21) Beaver, P. C., J. V. Neel, and T.C. Orihel. *Dipetalonema perstans* and *Mansonella ozzardi* in Indians of Southern Venezuela. *Am J Trop Med Hyg.* (In press.)