Inbreeding in Brazil*

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INTRODUCTION

ALTHOUGH the genetic implications of consanguineous matings in human populations were recognized in the first years of Mendelism through the pioneering work of Garrod, it is only recently that enough data have been collected for an evaluation of the intensity of inbreeding in specific human populations. It is the purpose of the present paper to record data for a population concerning which there has previously been relatively little information.

METHOD

The method here used has been described previously (Freire-Maia, 1952). In this section, we will discuss only its validity and the magnitude of the errors involved.

Only data on Catholic marriages were used. This raises, of course, the question whether the findings can be safely extended to the whole population. The frequency of Roman Catholics in Brazil is about 93 per cent, with the lowest frequencies in the southernmost State, Rio Grande do Sul (84%), and the highest in the northern Piaui (99%). (All the census information reported in this paper has been obtained in 1950 unless otherwise specified.) Assuming random mating, we would have about 0.5 per cent of marriages between non-Catholic people, 13 per cent mixed marriages, and 86.5 per cent between Catholics. Certainly the figures vary enormously according to the relative size of the non-Catholic group in each community as well as to the degree of social pressure against mixed marriages. These tend to occur at lower rates than those prevailing in a panmictic society. It is known that the great majority of marriages between Catholics and non-Catholics are consecrated by the Roman Catholic Church due to familial and social pressures, and this is also true for marriages between non-sectarian people. For this reason, it seems reasonable to assume that non-Catholic marriages would represent probably less than 5 per cent of all Brazilian religious marriages, and that figures based only on marriages involving Catholics may with a small error be taken as representative of Brazil as a whole.

The incidence of unions not consecrated by any religious denomination varies greatly from region to region, it being a commonplace to say that it is generally higher in urban than in rural communities. The frequency of marriage records with brides

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and/or grooms incapable of declaring their father's or mother's name (sometimes even both) has been shown to be much lower now than about one hundred years ago in the Archdiocese of São Paulo (Freire-Maia, 1952). Some regions in the North present a very high frequency of unmarried mothers. For instance, in the State of Maranhão, it is estimated that about 50 per cent of the unions do not have religious records. Data from the 1940 census for the same State show that about 50 per cent of the unmarried women have had living children. The frequency of unmarried mothers more than 12 years old was higher than 30 per cent in Maranhão and Pará. If, in these populations, the unmarried fraction shows frequencies of consanguineous unions very different from those found in the Catholic married fraction, a significant difference would result. Only a direct survey of the situation, with the inclusion of all couples, married and unmarried, would clarify the problem. However, we think that no great deviation is to be found between these two population fractions because it is quite common for unmarried couples to have their union consecrated by the Church after a period of common-law marriage. It is estimated that in some regions this kind of marriage may attain frequencies as high as 50 per cent.

Our data refer to urban and rural populations taken together. The proportions of each within each locality varies enormously, from almost 100 per cent urban in big cities (e.g., 95% in the City of São Paulo) to almost 100 per cent rural as in some small villages of the hinterland. There is a tendency for the predominantly rural communities to present the highest inbreeding rates, but our data unfortunately do not permit differentiating between rural and urban populations within each parish.

It ought to be mentioned also that the present data are not strictly comparable to those collected through the use of procedures, employed by a series of investigators, involving samples of all marriages in a population regardless of when they occurred. In the present method, inbreeding levels have been estimated from samples of marriages contracted in a given period. For this reason almost all the populations studied would be expected to be characterized, at the time of their analysis, by frequencies of consanguineous marriages somewhat higher than would be suggested by the estimate based on current marriages. On the basis of the data at our disposal, the majority of contemporary populations would present rates about 20 per cent higher than those detected by the method here employed.

All the frequencies will be presented as percentages. The following abbreviations and terms (some of them taken from Spuhler and Kluckhohn, 1953, and Schull, 1953) will be used in the tables with data on inbreeding.

N—Total number of marriages contracted in the given period.

UNi + ANe—Marriages between uncles and nieces plus marriages between aunts and nephews.

1C—Marriages between first cousins.

1½C—Marriages between first cousins once removed.

2C—Marriages between second Cousins.

(In our previous papers (1952, 1954), in which the Brazilian nomenclature was translated literally into English, the first cousins once removed and the second cousins were called respectively second cousins and third cousins.)

T—Total frequency of consanguineous marriages up to and including second cousins. (In the text, the expressions "total frequency of consanguineous marriages" or "total frequency" will always have the same meaning.)

Sub-Total—Total not including the state capital (indicated by ✱).

α—Mean coefficient of inbreeding of the population for autosomal genes, calculated according to Haldane and Moshinsky (1939). Identical to Wright's F-coefficient (Wright, 1922, 1951).

Multiple consanguinity, relatively common in some localities, has been disregarded in the frequency data, with each marriage entered only once and marriages involving multiple degrees of consanguinity entered in the column belonging to the closest degree involved if the degrees are different. All the degrees of multiple consanguinity, however, were used for the α calculation. So, sometimes α has a value higher than would be inferred from the tabular data, and thus expresses the breeding structure of the population more accurately. Naturally, all values of α to be presented are somewhat smaller than the true ones as they do not include data on the frequencies of consanguineous marriages with degrees lower than second cousins. The difference, at least regarding second cousins once removed and third cousins, has been proved to be very small in some Brazilian populations (Freire-Maia, 1953, and unpublished data).

The values of α are generally a little lower (about 20%) than one-tenth of the frequencies of first cousin marriages. This fact provides an easy and rapid way of obtaining an approximate idea of the values of α.

Our tables will not present all the data we have collected regarding localities, but only those thought to be representative of two of the five Brazilian regions. The others, together with information on the inbreeding levels in other Latin American countries (Argentina, Puerto Rico, and Uruguay), have been presented elsewhere (Freire-Maia, 1957a).

THE DATA

Geographic distribution

National level. The distribution of the inbreeding rates in Brazil is highly heterogeneous (*cf.* table 1 and Fig. 1). The South is characterized by relatively low frequencies of consanguineous marriages, the central part of the Northeastern region presents the highest coefficients of inbreeding in the whole country, and with only a few exceptions, the other regions show intermediate situations. There is, however, a remarkable homogeneity within each socioeconomic zone (table 1, Fig. 1).

In some regions, very clear inbreeding gradients could be found. For instance, in the Northeast the intensity of the inbreeding increases from the coast to the interior (Fig. 1). One of these gradients is formed by the following inbreeding coefficients, 0.00121, 0.00176, 0.00565, 0.00830, 0.00967, involving three States, from the northern region of Alagoas to the interior of the State of Piaui. Another gradient, from the northern Bahia coast (East region) to the coast of Ceará (in the Northeast)

TABLE 1.—FREQUENCIES OF CONSANGUINEOUS MARRIAGES IN SOME BRAZILIAN DIOCESES

States and Dioceses	Period	N	UNi+ ANe	1C	1½C	2C	T	α
Rio Grande do Sul								
Porto Alegre	1946–51	4032	0.05	1.17	0.30	0.27	1.79	0.00097
Passo Fundo	1954	2404	0	0.83	0.17	0.37	1.37	0.00063
Vacaria	1954	1163	0	2.58	0.26	1.03	3.87	0.00185
Caxias do Sul	1954	2104	0	0.76	0.48	1.71	2.95	0.00091
Santa Catarina								
Florianópolis	1948–51	4361	0.02	1.17	0.53	1.83	3.55	0.00121
Lages	1954	3968	0.02	1.06	0.35	0.28	1.71	0.00089
Paraná								
Curitiba	1945–51	23615	0.02	1.23	0.55	0.99	2.79	0.00112
Palmas*	1954	2181	0.05	0.32	0.14	0.27	0.78	0.00034
Foz de Iguaçú	1954–55	4172	0	0.46	0.16	0.41	1.03	0.00044
Ponta Grossa	1951–53	7757	0.06	1.11	0.48	0.72	2.37	0.00106
Jacarèzinho	1947–49	14019	0	1.28	0.29	0.43	2.00	0.00098
São Paulo								
Santos	1944	1700†	0	0.94	0.12	0.12	1.18	0.00064
São Carlos	1954	3819	0	0.29	0.02	0.34	0.65	0.00024
São Paulo	1939–50	46465	0.01	0.78	0.19	0.23	1.21	0.00059
Botucatú	1954	3368	0	0.80	0.27	0.27	1.34	0.00066
Assis	1952–53	6918	0.03	1.68	0.49	0.42	2.62	0.00133
Bragança Paulista	1954	1415	0.57	0.71	0.21	0.21	1.70	0.00148
Jaboticabal	1954	1574	0	1.65	0.32	0.38	2.35	0.00119
Rio Preto	1954	4182	0	1.00	0.17	0.24	1.41	0.00073
Piracicaba	1954	1148	0.09	0.43	0.17	0.70	1.39	0.00064
Campinas	1951	4821	0	0.60	0.04	0.33	0.97	0.00044
Lins	1955	4334	0	0.88	0.14	0.16	1.18	0.00062
Minas Gerais								
Belo Horizonte	1951	3651	0	3.40	1.72	1.78	6.90	0.00294
Pouso Alegre	1954	3895	0.08	2.95	1.31	2.28	6.62	0.00275
Guaxupé	1953	3089	0.03	2.82	1.39	1.68	5.92	0.00250
Campanha	1951–52	7251	0.07	5.16	2.00	2.32	9.55	0.00450
Leopoldina	1954	3252	0	2.06	0.55	1.02	3.63	0.00170
Aterrado	1954–55	2483	0	6.32	1.97	3.83	12.12	0.00537
Uberaba(1)	1948–49	5646	—	3.29	1.51	—	—	0.00284‡
Arassuaí	1954	7091	0	2.88	1.03	1.20	5.11	0.00242
Rio de Janeiro (State)								
Niteroi	1954	1698	0	1.18	0.41	0.53	2.12	0.00103
Barra do Piraí	1954	1460	0.07	1.30	0.48	0.20	2.05	0.00108
Valença	1954	1272	0	1.18	0.23	0.16	1.57	0.00085
Distrito Federal								
Rio de Janeiro City								
Estácio de Sá (parish)	1946–56	1172	0.09	0.42	0.17	0.09	0.77	0.00044
Mato Grosso								
Cuiabá	1934–52	1875	0.05	2.24	0.38	0.64	3.31	0.00168
Cáceres	1953	376	0	2.66	0.27	0.79	3.72	0.00204
Ch. dos Guimarães	1952	120	0	4.17	2.50	0.83	7.50	0.00378
Corumbá	1953	2137	0.05	0.70	0.19	0.09	1.03	0.00057
Goiás								
Goiás	1937–53	3026	0	2.58	0.56	0.76	3.90	0.00191

TABLE 1.—*Concluded*

States and Dioceses	Period	N	UNi+ ANe	1C	1½C	2C	T	α
Bahia								
Salvador	1932–52	4689	0.02	2.96	0.83	0.92	4.73	0.00228
Ilhéus	1945–49	2245	0.04	2.18	0.67	1.34	4.23	0.00184
Caeteté	1954	1923	0	9.10	3.90	8.84	21.84	0.00829
Bomfim	Recent	4095	0.02	4.67	1.39	1.81	7.89	0.00400
Sergipe								
Aracajú	1954	3815	0.10	4.04	0.63	1.65	6.42	0.00315
Pernambuco								
Pesqueira	1954	3846	0.03	6.71	2.05	3.90	12.69	0.00565
Nazaré	1954	3399	0.21	1.97	1.44	2.03	5.65	0.00236
Garanhuns	1954	5103	0	2.21	0.53	1.02	3.76	0.00176
Petrolina	1950	3063	0.26	9.50	2.74	5.00	17.53	0.00830
Paraiba								
João Pessôa	1954	5537	0.09	3.79	0.41	1.81	6.10	0.00301
Rio Grande do Norte								
Caicó	1954	936	0.11	5.88	1.28	3.84	11.11	0.00499
Ceará								
Fortaleza	1953–54	14615	0.27	4.82	1.40	2.50	8.99	0.00433
Crato	1953	4217	0.40	8.42	2.80	3.91	15.53	0.00736
Piaui								
Oeiras	1954	1931	0.57	10.67	3.73	6.00	20.97	0.00967
Alagoas								
Penedo	1954	3566	0.19	6.23	1.99	3.28	11.69	0.00579
Maceió	1952	4394	0.05	1.52	0.20	0.55	2.32	0.00121
Pará								
Santarem	Recent	1318	0.91	0.30	0.61	0	1.82	0.00156
Xingú	1951–55	578	0.17	1.04	0.52	1.38	3.11	0.00124
Amazonas and Guaporé								
Porto Velho	1955	365	0.27	2.74	0	0.55	3.56	0.00214
Maranhão								
Pinheiro	1954	1423	0	0.70	0.28	1.13	2.11	0.00098

* Includes a part of the State of Santa Catarina.
† Estimate based on data of neighboring years.
‡ Assuming 2% of second cousin marriages.
(1) Previously reported in Freire-Maia (1952).

is formed by the following coefficients: 0.00228, 0.00400, 0.00830, 0.00736 and 0.00436. This gradient has its ends at zones with relatively low inbreeding rates, and so the increase is centripetal from both of them towards the diocese of Petrolina (State of Pernambuco).

Diocese level. The distribution of the inbreeding rates is somewhat heterogeneous within each diocese (tables 2 and 3). Each diocese can be defined by its mean total frequency of consanguineous marriages, or better, by its mean coefficient of inbreeding, but the values for its parishes generally fluctuate widely around the mean for the diocese.

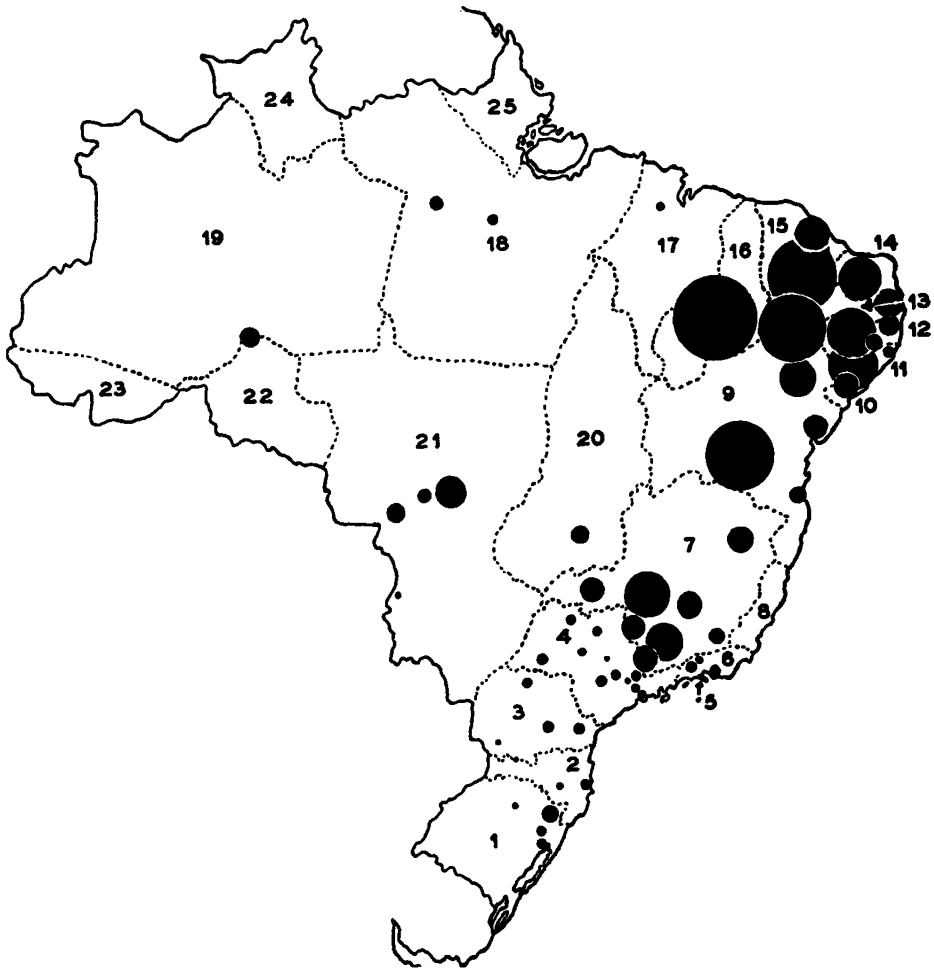

FIG. 1. INBREEDING LEVELS IN THE BRAZILIAN TERRITORY. THE DIAMETERS OF CIRCLES ARE PROPORTIONAL TO THE VALUES OF THE INBREEDING COEFFICIENTS OF TABLE 1.

States: 1—Rio Grande do Sul; 2—Santa Catarina; 3—Paraná; 4—São Paulo; 6—Rio de Janeiro; 7—Minas Gerais; 8—Espírito Santo; 9—Bahia; 10—Sergipe; 11—Alagoas; 12—Pernambuco; 13—Paraiba; 14—Rio Grande do Norte; 15—Ceará; 16—Piaui; 17—Maranhão; 18—Pará; 19—Amazonas; 20—Goiás; 21—Mato Grosso; *Federal District:* 5—Rio de Janeiro city. *Territories:* 22—Guaporé; 23—Acre; 24—Rio Branco; 25—Amapá.

Trends in time

There is generally a tendency for decreasing inbreeding rates with time. Some examples have already been given in our paper of 1952, and others may be seen in tables 3 and 4. Sometimes the decrease is so rapid that the time gradient may be discovered in very short periods.

Sometimes no clear change is present, but only chance fluctuations leading even to small increases of the inbreeding rates. However, real "reversed" trends with

TABLE 2. FREQUENCIES OF CONSANGUINEOUS MARRIAGES IN THE STATE OF MINAS GERAIS (ARCHDIOCESE OF BELO HORIZONTE, 1951)

Localities	N	UNi + ANe	1C	1½C	2C	T	α
S. Sebastião do Curral	57	0	17.54	3.51	10.53	31.58	0.01371
Indaiá	69	0	14.49	2.90	5.80	23.19	0.01178
Camacho	56	0	8.93	14.29	3.57	26.79	0.01060
Rio do Peixe	55	0	12.73	1.82	7.27	21.82	0.00994
Pompéu	83	0	12.05	2.41	1.20	15.66	0.00847
Itaguara	45	0	6.67	6.67	13.33	26.67	0.00833
Papagaio	67	0	8.96	1.49	4.48	14.93	0.00676
Martinho Campos	111	0	6.31	5.41	4.50	16.22	0.00676
Pitangui	89	0	7.87	1.12	2.25	11.24	0.00597
Sabará	72	0	6.94	2.78	0	9.72	0.00521
Mateus Leme	94	0	3.19	4.26	6.38	13.83	0.00482
Itapecerica	105	0	3.81	2.85	2.86	9.52	0.00461
Caeté	33	0	6.06	0	0	6.06	0.00379
Sete Lagoas	180	0	5.00	1.11	1.11	7.22	0.00373
Lagoa Santa	83	0	2.41	3.62	3.61	9.64	0.00320
Pedro Leopoldo	65	0	3.08	1.54	4.61	9.23	0.00313
Baldim	104	0	3.85	0	0.96	4.81	0.00255
Santa Luzia	78	0	3.85	0	0	3.85	0.00240
Itauna	132	0	1.52	2.27	0.76	5.30	0.00225
Carmo do Cajurú	71	0	0	2.82	7.04	9.86	0.00198
Divinópolis	216	0	1.85	2.32	0	4.17	0.00195
Pará de Minas	110	0	1.82	0.91	2.73	5.46	0.00185
Betim	76	0	1.32	2.63	0	3.95	0.00164
Rio Acima	43	0	2.33	0	0	2.33	0.00145
Cruzilândia	46	0	0	4.35	0	4.35	0.00136
Belo Horizonte *	1469	0	1.02	0.48	0.27	1.77	0.00083
União de Caeté	42	0	0	0	2.38	2.38	0.00037
Sub-total	2182	0	5.00	2.57	2.80	10.36	0.00436
Total	3651	0	3.40	1.72	1.78	6.90	0.00294

rapid changes have been observed (table 4) in some parishes, sometimes over long periods of time. This indicates that the trend is not due to accidents of sampling.

ESTIMATES OF INBREEDING RATES FOR THE DIFFERENT STATES, REGIONS AND BRAZIL AS A WHOLE

With the data of table 1 supplemented by the information not presented here (Freire-Maia, 1957a, b), we have calculated the mean coefficient of inbreeding for the dioceses in each State, and for the States. In some cases the coefficient is an estimate because a guess based on the probable rates of the zones with unknown degrees of inbreeding was introduced. For instance, the total rates shown for Goiás, Bahia and Maranhão are somewhat and differentially higher than those calculated from the available data, because the zones lacking information in our tables have been assumed to have more consanguineous marriages than the dioceses here reported (for Goiás, see Frota-Pessoa and Filgueiras, 1957). The Pernambuco estimate, however, is a little lower than the mean computed from the available data. The most probable rates for each of the five Brazilian regions were calculated from

the State means and, on the basis of regions, a general estimate has been obtained for the whole country. Table 5 summarizes the results with remarks on the probable degree of accuracy of each estimate given in footnotes.

All the estimates have been made on the basis of weighted means, using as weights, for the dioceses, the total number of marriages contracted per year in each one, and for the States and the regions, the appropriate 1950 populations. Since the regions with poorer information (North and West-central) have joint populations representing less than 7 per cent of the total Brazilian population, we are confident that our estimate for the whole country will not deviate very much from the true value.

The fact that the mean coefficient of inbreeding for contemporary Brazilian population is just a little higher than 0.002 may be very misleading if the great heterogeneity in the rate of inbreeding in the different zones (some of them presenting coefficients more than 10 times that of others) is not taken in account. About 40 per cent of the Brazilian population (South and part of the East) has an "European" inbreeding level. This explains why the Brazilian mean is relatively low, in spite of the fact that some regions are highly inbred from the modern point of view.

TABLE 3. FREQUENCIES OF CONSANGUINEOUS MARRIAGES IN THE STATE OF PERNAMBUCO (DIOCESE OF PETROLINA)

Localities	N	UNi + ANe	1C	1½-C	2C	T	α
Parnamirim, 1	155	0	13.55	2.58	11.61	27.74	0.01200
3	179	0	19.55	2.23	8.94	30.72	0.01563
Manacá, 1	196	0	9.69	4.08	5.10	18.88	0.00861
3	206	0.49	15.53	1.94	7.77	25.73	0.01388
Salgueiro, 1	209	0.96	13.40	4.31	9.09	27.76	0.01391
3	278	0.36	15.11	3.24	5.76	24.47	0.01265
Cruz de Malta, 2	55	0	10.91	1.82	3.64	16.36	0.00795
3	55	0	14.55	5.45	7.27	27.27	0.01222
Serrita, 1	102	0	20.59	2.94	3.92	27.45	0.01547
3	177	0	11.30	3.95	5.65	20.90	0.00945
Coripós, 1925	127	0	14.96	5.51	5.51	25.98	0.01255
3	133	0	11.28	3.76	4.51	19.55	0.00940
Petrolina, 1	351	0	9.97	1.99	3.13	15.10	0.00761
3	431	0	7.89	4.41	9.05	21.35	0.00866
Bodocó, 3	313	0.96	7.67	0.96	3.83	13.42	0.00699
Araripina, 1	311	0	10.61	2.57	5.14	18.33	0.00940
3	529	0.38	6.05	2.27	3.40	12.29*	0.00641
Cabrobó, 1	162	1.85	12.96	2.47	6.17	23.45	0.01379
3	178	0	7.30	3.37	3.37	14.04	0.00623
Ouricuri, 1	52	0	23.08	7.69	13.46	44.23	0.01983
3	179	0	6.15	1.68	3.35	11.17	0.00550
Exú, 3	322	0	6.83	2.18	1.24	10.25	0.00529
Granito, 1950	83	1.20	3.61	2.41	0	7.23	0.00452
Total (1)	1720	0.29	12.85	3.84	8.89	25.87	0.01098
Total (3)	3063	0.26	9.50	2.74	5.00	17.53†	0.00859

1—1925–1927; 2—1926–1927; 3—1950–1951.

* Including one marriage between niece and great uncle (0.19).

† Idem (0.03).

TABLE 4. FREQUENCIES OF CONSANGUINEOUS MARRIAGES IN SOME DIOCESES AND LOCALITIES

Dioceses (d) and localities (l)	Period	N	UNi + ANe	1C	1½C	2C	T	α
Florianópolis, SC (l)	1927–1931	568	0	0.88	0.18	0.18	1.24	0.00063
	1933–1941	599	0	0.83	0.33	0.50	1.66	0.00070
	1948–1951	1,135	0	0.09	0.09	0.17	0.35	0.00011
Goiás, Go (l)	1917–1937	600	0	3.17	0.33	1.67	5.17	0.00247
	1937–1945	342	0	2.34	0	1.46	3.80	0.00169
	1945–1950	348	0	0.86	0.57	2.30	3.73	0.00108
Belo Horizonte, MG (l)	1924–1930	570	0	1.93	0	1.05	2.98	0.00137
	1950–1952	790	0	0.38	0	0	0.38	0.00023
Coqueiral, MG (l)	1924–1929	161	0	6.83	1.86	4.97	13.66	0.00563
	1944–1947	268	0	6.72	5.22	2.61	14.55	0.00624
	1949–1951	219	0	4.57	4.57	4.57	13.70	0.00499
São Sebastião, SP (l)	1917–1921	69	0	1.45	0	1.45	2.90	0.00113
	1928–1936	300	0	3.00	0	0.33	3.33	0.00193
	1938–1942	159	0	3.77	0	2.52	6.29	0.00295
	1945–1952	250	0.40	2.00	0	1.60	4.00	0.00238
Ponta Grossa, Pr (d)	1933–1935	5,352	0.11	1.81	0.77	0.65	3.34	0.00167
	1936–1938	6,676	0.05	1.63	0.50	0.70	2.88	0.00135
	1939–1941	4,900	0.02	1.96	0.63	0.92	3.53	0.00162
	1942–1944	6,914	0.04	1.95	0.54	0.80	3.33	0.00163
	1945–1947	7,590	0	1.80	0.70	0.78	3.28	0.00149
	1948–1950	8,242	0.01	1.25	0.66	0.76	2.68	0.00118
	1951–1953	7,757	0.06	1.11	0.48	0.72	2.37	0.00106
Curitiba, Pr (l)	1850–1851	120	0	2.50	3.33	0	5.83	0.00260
	1865–1866	137	0	1.46	2.92	0.73	5.11	0.00194
	1870–1872	291	0.69	4.47	4.47	2.06	11.68	0.00537
	1873–1874	149	0.67	2.01	2.01	0.67	5.37	0.00283
	1890–1891	386	0.26	1.29	0.52	0.52	2.59	0.00138
	1908–1909	252	0	0.79	0	0.79	1.58	0.00062
	1910–1911	318	0	0.63	0	0.63	1.26	0.00049
	1931–1932	580	0	1.03	0	0.35	1.38	0.00070
	1945–1951	7,298	0	0.49	0.22	0.21	0.92	0.00041
Itajaí, SC (l)	1897–1899	192	0	2.60	0	0.52	3.13	0.00171
	1914–1916	237	0	4.21	1.27	1.69	7.17	0.00330
	1941–1942	444	0	0.68	0	0.45	1.13	0.00049
	1950–1951	589	0.17	0.68	0.51	1.36	2.72	0.00101
Mogi das Cruzes, SP (l)	1788–1800	444	0	0.45	0.45	0	0.90	0.00042
	1802–1809	333	0	0.60	0.90	1.20	2.70	0.00084
	1812–1821	394	0.25	0.76	1.27	0.76	3.05	0.00131
	1821–1829	301	0	2.33	1.00	2.99	6.31	0.00223
	1829–1835	272	0.73	4.78	1.47	5.15	12.13	0.00517
	1838–1845	285	1.05	6.67	2.11	3.51	13.33	0.00669
	1845–1850*	200	1.50	7.00	5.00	4.50	18.00	0.00852
São Paulo city (parish of Sta. Efigênia)	1809–1826	220	0.45	2.73	0.91	1.82	5.91	0.00284
	1836–1855*	238	5.46	5.04	1.68	3.36	15.55	0.01103
São Paulo (the whole city)	1826–1859	1,053	3.04	6.93	1.62	4.84	16.43	0.00939
	1939–1950	37,447	0.01	0.66	0.12	0.16	0.95	0.00049
Vacaria, RGS (prelacy)	1939	754	0	1.46	0	0.93	2.39	0.00106
	1951	1,026	0	1.37	0.29	0.78	2.44	0.00107
	1952	930	0	1.40	0.65	1.18	3.23	0.00128
	1953	997	0	2.51	0.50	1.00	4.01	0.00190
	1954	1,163	0	2.58	0.26	1.03	3.87	0.00185
Regente Feijó, SP (l)	1931–1936	590	0	0.51	0	0.17	0.68	0.00034
	1955	170	0	0.59	0	0	0.59	0.00037
Presidente Prudente, SP (l)	1925–1929	597	0	0.67	0.17	0.33	1.17	0.00058
	1952-1956	973	0	0.82	0.10	0	0.92	0.00061

* From this time up to the present, a decrease of the inbreeding rates has been observed (cf. Freire-Maia, 1952).

TABLE 5. ESTIMATES OF INBREEDING RATES FOR THE BRAZILIAN STATES AND REGIONS AND FOR THE WHOLE BRAZILIAN POPULATION IN RECENT YEARS

State and region	$\frac{UNi}{ANe}+$	1C	1½C	2C	T	α
Rio Grande do Sul (2)*	0.02	1.25	0.35	0.80	2.42	0.00104
Santa Catarina (1)	0.02	1.10	0.40	1.00	2.52	0.00099
Paraná (1)	0.02	1.00	0.30	0.60	1.92	0.00084
São Paulo (1)	0.02	0.85	0.20	0.30	1.37	0.00067
Minas Gerais (2)	0.03	3.60	1.45	2.00	7.08	0.00305
Rio de Janeiro (2)	0.02	1.25	0.40	0.35	2.02	0.00099
Distrito Federal (2)	0.01	0.50	0.15	0.20	0.86	0.00040
Espírito Santo (4)	0.03	2.00	0.60	1.00	3.63	0.00163
Bahia (2)	0.02	4.80	1.65	2.85	9.32	0.00399
Sergipe (1)	0.10	4.00	0.60	1.70	6.40	0.00308
Alagoas (1)	0.10	3.50	0.90	1.80	6.30	0.00288
Pernambuco (1)	0.06	4.00	1.30	2.30	7.66	0.00334
Paraiba (3)	0.08	4.50	1.50	2.50	8.58	0.00377
Rio Grande do Norte (3)	0.06	3.50	1.10	2.00	6.66	0.00292
Ceará (2)	0.10	5.00	1.50	2.50	9.10	0.00411
Piaui (3)	0.10	5.00	2.00	3.50	10.60	0.00442
Maranhão (4)	0.08	4.50	1.50	3.00	9.08	0.00385
Pará (4)	0.04	2.00	0.80	1.20	4.04	0.00174
Amazonas (4)	0.05	2.50	1.00	1.50	5.05	0.00217
Goiás (4)	0.03	2.50	1.00	1.50	5.03	0.00215
Mato Grosso (3)	0.04	3.00	1.20	1.80	6.04	0.00258
South (1)	0.02	1.00	0.26	0.52	1.80	0.00081
East (2)	0.02	2.30	0.80	1.28	4.40	0.00191
North-East (2)	0.08	4.35	1.42	2.50	8.35	0.00365
North (4)	0.04	2.20	0.86	1.30	4.40	0.00190
Center-West (3)	0.03	2.65	1.07	1.60	5.35	0.00228
Brazil (2)	0.04	2.40	0.77	1.35	4.56	0.00200

* Approximate degrees of accuracy: (1) high, (2) fair, (3) low, and (4) poor.

No calculation is presented for the territories, whose populations represent, in all, less than 0.04% of the total Brazilian population.

The estimates for the State of Espirito Santo has been made on the basis of the data for the neighbor zones belonging to the other states.

The estimates for the Distrito Federal, that includes the city of Rio de Janeiro (to be not confused with the State of the same name), have been made not only on the basis of the data at our disposal and referring to one of its parishes, but also taking into consideration the values obtained for the city of São Paulo, approximately of the same population size.

These estimates do *not* refer to contemporary populations, but only to marriages contracted in recent times.

DISCUSSION

Factors of the geographic distribution

It is difficult to evaluate the specific factors which account for the differences in inbreeding rates in various parts of Brazil. The socioeconomic features of the South (sometimes referred to by sociologists as the "new Brazil") are, however, quite different from those characterizing the other four physiographic regions taken together (called "old Brazil", Fig. 1). From an analysis of the problem (a full account of which will be published elsewhere), it is concluded that cultural pattern, economic level, migration, population density, and degree of ruralization are the most effective factors acting on inbreeding levels in Brazil. While it is not possible to isolate any one of these factors completely, some notion of their individual contributions can be obtained. Figures 2 and 3 present two examples where this is possible. It is seen, for instance, that socio-economically different populations may show large differences in inbreeding rates even when they have the same demographic density (Fig. 2) or the same ruralization index (Fig. 3).

The trends in time

The "normal" secular trends, found in so many populations, reflect the growth of isolate size in two different ways, namely, the expansion of previous boundaries, and the break-up of these same boundaries through migration (Dahlberg, 1938). As both of these phenomena present increasing rates and wider and wider geographic distribution in the modern world, inbreeding rates would be expected to show the de-

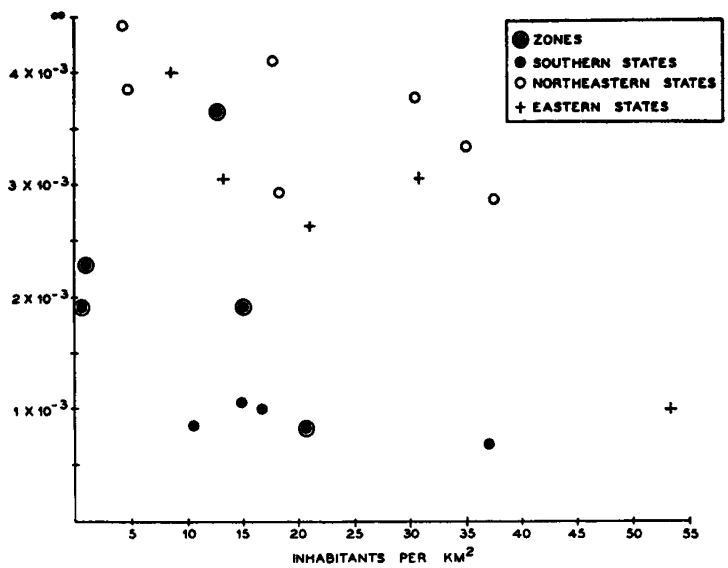

FIG. 2. NEGATIVE ASSOCIATION BETWEEN COEFFICIENT OF INBREEDING AND POPULATION DENSITY. DATA ARE GIVEN FOR THE FIVE BRAZILIAN ZONES AND FOR EACH ONE OF THE STATES IN THE THREE ZONES WITH MORE ACCURATE ESTIMATES OF INBREEDING COEFFICIENTS.

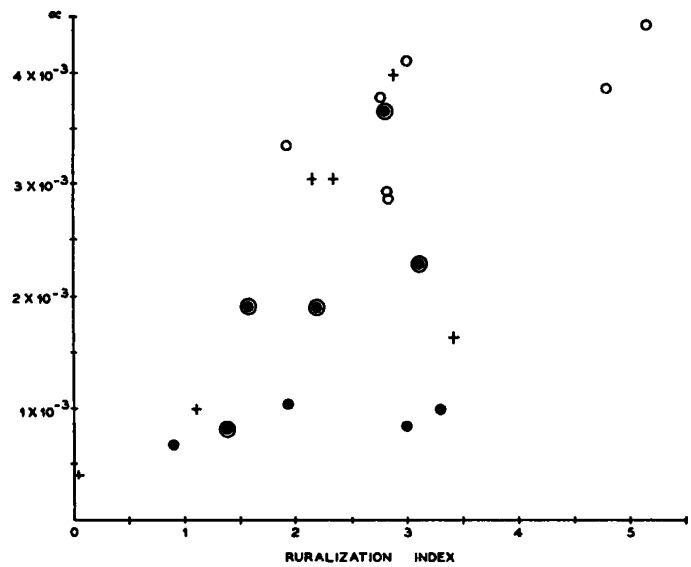

FIG. 3. POSITIVE ASSOCIATION BETWEEN COEFFICIENT OF INBREEDING AND "RURALIZATION INDEX" (SYMBOLS IDENTICAL TO THOSE OF FIG. 2). "RURALIZATION INDEX" IS THE RATIO OF THE RURAL PART OF THE POPULATION TO THE URBAN ONE. RURAL IS HERE DEFINED ON THE DOMICILAR AND NOT OCCUPATIONAL POINT OF VIEW.

creasing feature commonly seen. Unusual reversed trends found in a few localities and regions in the last as well as in the present century (table 4) probably reflect the reversed action of socio-economic factors previously analysed. Only historic research could throw light on this problem. It is interesting to point out that Ellis (1936), in his studies based on genealogical data gathered by Silva Leme, also detected increasing inbreeding among the upper class in São Paulo during the last century and that, in France, one department also showed a similar "reversed" trend during about 30 years in the first half of the 19th century (Sutter and Tabah, 1955).

Isolate sizes

Although the first attempt to estimate isolate sizes was made in the year of the "rediscovery" of the Mendelian laws (Raseri, 1900), the genetic implications of the concept were not fully realized until some decades later.

Several attempts have been made in the last years to obtain a quantitative evaluation of the problem using direct or semi-direct methods generally in religious or ethnic isolated communities (Birdsell, 1950, 1953; Glass *et al.*, 1952; Lasker, 1952, 1954; Malaurie, Tabah, and Sutter, 1952; Spuhler and Kluckhohn, 1953; Schull, 1953; and Kraus and White, 1956) as well as indirect methods in general populations (Dunn, 1947; Sutter and Tabah, 1951; Freire-Maia, 1951, 1952; Böök and Mawe, 1955; Böök, 1956; Frota-Pessoa, 1957; Cavalli-Sforza, 1957; and Fraccaro, 1957). This second approach, developed by Dahlberg (1938), is based on the assumption

that consanguineous marriages occur at random, which is known not to be true and thus involves an error whose magnitude is difficult to evaluate correctly (*cf.* discussion of the problem in Morton, 1955).

Frota-Pessoa (1957) showed that the use of the value b (i.e., the average number of children who become adult and marry per marriage) introduces a certain degree of inaccuracy in the Dahlberg formula and leads to an appreciable lowering of the results. The corrected formula, developed by Frota-Pessoa, has been applied by him to the situation in three Brazilian states, namely, Pernambuco, Alagoas and Paraná. The frequencies of first cousin marriages used are those presented here. (The fact that the frequencies of first cousin marriages are more influenced by population size than by migration (the reverse situation being true for second cousin marriages), according to recent research by Cavalli-Sforza (1957), brought new support to the idea that estimates of isolate sizes based on the first parameter will probably give more reliable values than those obtained through the incidence of second cousin matings.) Isolate sizes of 900, 980 and 3,752 have been obtained. These values are about 50 per cent higher than those calculated using Dahlberg's formula. Assuming that the same approximate relation prevails for all Brazilian populations, then the mean isolate size in Brazil would be about 1,500, with the lowest values in some zones of the Eastern and Northeastern regions (about 390) and the highest value in the Southern states (about 4,000). The previous estimate of the mean isolate size in Brazilian populations as 500 or less (Freire-Maia, 1951, 1952) is certainly too low not only because it was obtained through the use of Dahlberg's formula but also because it was based on too high an estimate of first cousin marriage.

The present values, naturally, are not to be compared to those calculated through the classical Dahlberg formula which uses the frequency of first cousin marriage, or that employed by Sutter and Tabah (1951) which is based on the incidence of marriage between second cousins.

Ludwig and Schelling (1948) devised a formula to estimate the coefficient of inbreeding from the number of sexually mature couples (N) in the population, and the degree of stability of these couples (g), where g may vary from 0, when the couples separate after the conception of a child, to 1, when each individual has a single monogamous marriage. Assuming that the above mentioned isolate sizes represent 2N individuals, the resulting estimates (for g = 0.8–1.0) are about one-third of those calculated on the basis of consanguineous marriages (table 6). Due to the errors involved in the estimates of the parameters, it is our opinion that the agreement is good between the two sets of estimates.

Different approaches to the concept of isolate size have been presented by other authors. The upper limit of the number of mates available for a reproductive in-

TABLE 6—ESTIMATES OF COEFFICIENTS OF INBREEDING BASED ON ISOLATE SIZES

Population	Isolate sizes	Calc. based on cons. marriages (A)	Calc. based on isolate sizes (B)		A/B	
			g = 1.0	g = 0.8	g = 1.0	g = 0.8
Pernambuco	900	0.00334	0.00111	0.00100	3.0	3.3
Alagoas	980	0.00288	0.00102	0.00092	2.8	3.1
Paraná	3,752	0.00084	0.00027	0.00024	3.1	3.5
South	4,000	0.00081	0.00025	0.00023	3.2	3.5
Northeast (central)	390	0.00794	0.00257	0.00231	3.1	3.4

dividual selected at random in a medium-sized American city, through consideration of only isolation by distance (so neglecting all the other factors) has been, for instance, calculated by Spuhler and Clark (1956). This approach was inspired by the concepts developed for animals and plants by Sewall Wright (1943, 1946). Some idea of the relative isolate sizes of different communities can also be obtained through the calculation of the "mean matrimonial radius" (*cf.*, for instance, Schwidetzky, 1955). This simpler approach is subject to a greater number of limitations than the previous one, because no consideration is given to population density. Another estimate, also subject to several limitations, may be obtained through the use of the exogamy index (Freire-Maia, 1951, 1952). With the collaboration of A. Freire-Maia, these methods have been applied to a number of Brazilian populations, from small villages to large cities, and from rapidly developing rural zones with their new and fast growing communities to old regions and their socio-economically stagnated towns. The results, not yet complete, will be published elsewhere.

SUMMARY

An analysis is made of the incidence of consanguineous marriages in about 60 dioceses distributed among almost all the Brazilian States. Some of the inbreeding levels found are the highest known up to the present time. However, the Southern States present relatively low coefficients of inbreeding. Several examples of geographic gradients and trends in time are presented. Estimates of mean incidence of consanguineous marriages are calculated for each Brazilian State and for the whole country. The problem of isolate size is briefly discussed.

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