

DISTRIBUTION OF BLOOD ANTIGENS AMONG GUATEMALAN INDIANS ¹

BY C. TEJADA, MARGARITA SANCHEZ, M. A. GUZMAN,
E. BREGNI ² AND N. S. SCRIMSHAW

Institute of Nutrition of Central America and Panama (INCAP), Guatemala, C. A.

ONE of the objectives in physical anthropology is to classify human beings into various groups according to their physical characteristics. As genetic traits have been identified, it has been increasingly possible to define a number of specific characteristics which vary with different populations. The serological blood groups are among the most useful for such definition, and numerous surveys have been made regarding their geographic distribution.

Thorough studies of the American Indians have been made and blood groups among Indian populations in South America have recently been reviewed by Salzano (1957) and Mourant (1954). Cabrera (1950) studied the Mayan Indians in Guatemala using the ABO system, and Aguirre, Tandon and Scrimshaw (1953) investigated the ABO, Rh and MN blood groups. A recent report by Matson and Swanson (1959) studied the distribution of blood groups from selected populations in Mexico, and the Mam and Quiché Indians in Guatemala, using the ABO, Rh, MNSs, P, Kell, Lewis, Duffy, Kidd and Diego systems.

The present paper summarizes the findings of a blood group survey started in 1958 which includes all the principal linguistic groups identified in Guatemala. It also presents some previously unpublished data collected and summarized by Aguirre, Tandon and Scrimshaw (1953).

MATERIALS AND METHODS

With the cooperation and technical advice of the Instituto Indigenista de Guatemala, a total of 260 individuals in 29 Indian communities, including the main linguistic groups, were surveyed. The map in figure 1, compiled by Goubaud Carrera (1946), identifies the geographic dis-

¹ INCAP publication I-211. This investigation was supported by grants H-2653 from the National Institutes of Health and 266 from the Nutrition Foundation.

² Clinical Laboratory, Hospital Roosevelt, Guatemala, C. A.

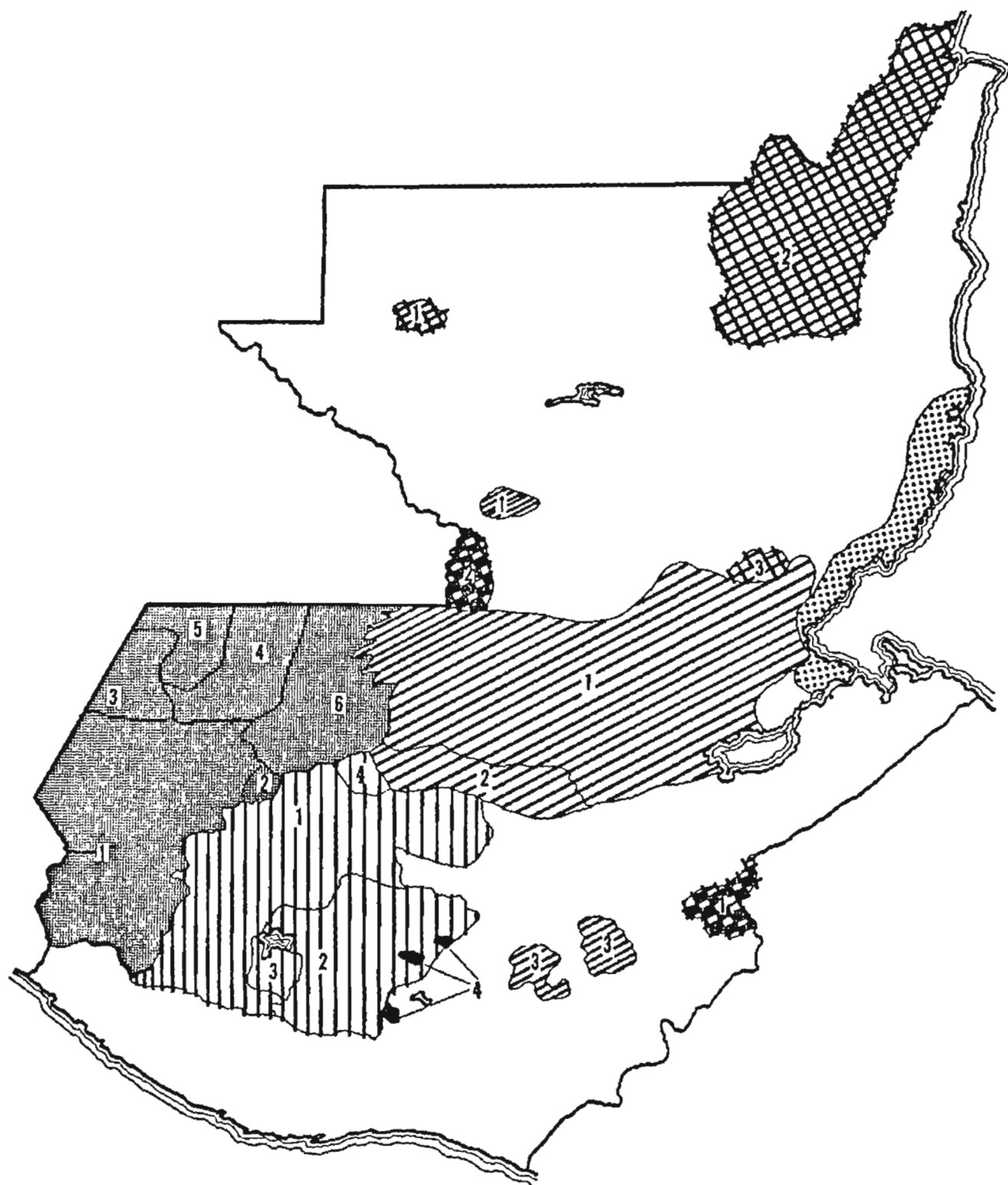









FIG. 1. MAP OF PRESENT INDIAN LINGUISTIC GROUPS OF GUATEMALA.

Compiled by: Lic. A. Goubaud Carrera and Prof. A. Arriaga (Goubaud Carrera, (1946).

	<u>QUICHE GROUP</u>
	1. QUICHE 2. CAKCHIQUEL 3. TZUTUJIL 4. USPANTECA
	<u>MAM GROUP</u>
	1. MAM 2. AGUACATECA 3. JACALTECA 4. KANJOBAL 5. CHUJ 6. IXIL
	<u>POCOMAM GROUP</u>
	1. KEKCHI 2. POCOMCHI 3. EASTERN POCOMAM 4. CENTRAL POCOMAM
	
	<u>CHOL GROUP</u>
	1. CHORTI 2. LACANDON CHOL
	<u>MAYAN GROUP</u>
	1. NORTHERN LACANDON 2. YUCATECO 3. MOPAN
	<u>CARIBBEAN GROUP</u>
	1. CARIBE ARAGUACO

tribution of the various linguistic groups, Quiché, Mam, Pocomam, Maya and Chol.

According to population, the main groups are the Quiché, Mam and Pocomam; the Chol and the Maya are now limited to a few localities. As shown in table 1, each of the main linguistic groups is divided into different subgroups. The Indian villages surveyed are presented in the same table, according to the linguistic groups and subgroups to which they belong. Most of the villages in this survey were studied previously by Aguirre, Tandon and Scrimshaw (1953) for the ABO, Rh and MN systems. The dotted area locates the Carib group which consists mainly of Negroes and mixtures of white with Negro (mulatto) or Indian with Negro (Red Carib). In the remaining white area there is no predominating linguistic group and the majority of people speak Spanish.

In each Indian community an effort was made to obtain ten blood samples from selected, non-related Indians. The field workers of the Instituto Indigenista were well acquainted with the communities, spoke the local dialects and selected the candidates on the following basis: a) acceptance of status as an Indian, b) wearing of their typical native costumes, c) speaking Indian dialect, and d) in some communities, possessing an Indian last name. This last criterion was not always possible to follow since several Indian communities have already translated the old Indian names into Spanish or changed the last name to one of Spanish origin.

The blood group systems studied were: ABO (119 cases), Rh (40), MNSs (260), P (260), Kell (260), Duffy (260), Diego (260), Kidd (220). The typing sera were obtained from different commercial firms and the techniques employed were those recommended by them.³ The anti Di^a serum was kindly provided by Dr. Miguel Layrisse of Venezuela, and the technique recommended by him (personal communication) was used.

RESULTS AND DISCUSSION

Rh Blood Group: Tables 2 and 3, which include previously unpublished data of work by Aguirre, Tandon and Scrimshaw (1953), show the phenotypes and the expected genotype frequencies, as well as the

³ Sera from Dade Reagents, Inc., Miami, Fla., were used for typing ABO, P, Kell, Kidd, Diego, Duffy and S blood groups. Sera from Ortho Pharmaceutical Corp., Raritan, N. J., were used for typing the ABO, Rh and MNS blood groups (part of them were kindly supplied by the corporation). Sera from Knickerbocker Blood Bank, New York, N. Y., were used for typing the P, Kell, Kidd, Duffy and S blood groups.

TABLE 1

Villages surveyed and linguistic groups to which they belong

MAIN LINGUISTIC GROUP	SUBGROUP	VILLAGE	CASES	TOTAL
Chol	Chortí	Olopa	10	30
		Jocotán	10	
		Camotán	10	
	Lacandón Chol		0	
Pocomam	Kekchí	Cobán	11	80
		Carchá	12	
		Lanquín	11	
		Chaal	1	
		Chamelco	2	
		Senahú	1	
		Cahabón	2	
	Pocomchí		0	
	Pocomam Oriental	San Luis Jilotepeque	10	
		San Pedro Pinula	10	
	Pocomam Central	Palín	10	
		Chinautla	10	
Quiché	Quiché	Nahualá	10	80
		Santa Lucía Utatlán	10	
		San Mateo	10	
		San Andrés Xecul	10	
	Cakchiquel	Sumpango	10	
		Santa María de Jesús	10	
		Patzún	10	
		Comalapa	10	
	Tzutujil		0	
	Uspanteca		0	
Mam	Mam	San Juan Ostuncalco	10	70
		Concepción CH	10	
		San Pedro		
		Sacatepéquez	10	
		San Sebastián		
		Huehuetenango	10	
	Aguacateca	Aguacatán	10	
	Jacalteca		0	
	Kanjobal		0	
	Chuj			
	Ixil	Santa María Nebaj	10	
		Chajul	10	
Maya	Lacandón del Norte		0	0
		Yucateco	0	
		Mopán	0	
Caribe	Caribe Araguaco		0	0
Total No. of cases				260

expected chromosome and gene frequencies. The Guatemalan Indians have a high chromosome frequency of CDe (R^1) and cDE (R^2), and a low relative frequency of cdE (r''), CdE (r^y) and Cde (r'). According to Mourant (1954), "the American Indians and Eskimos have high and

TABLE 2

The Rh blood group

	PHENOTYPE FREQUENCIES		
	NO.	OBSERVED	EXPECTED
ccde	1	0.0040	0.0009
ccDe	3	0.0120	0.0701
ccDE	35	0.1480	0.0949
CcDe	12	0.0510	0.2028
CcdE	7	0.0300	0.0037
CcDE	94	0.4000	0.2743
CCde	2	0.0090	0.0019
CCDe	63	0.2680	0.1466
CCDE	17	0.0720	0.1981
CCdE	1	0.0040	0.0026
ccdE	0	0.0000	0.0013
Ccde	0	0.0000	0.0027
Total	235	0.9980	0.9999

TABLE 3

The Rh blood group

EXPECTED CHROMOSOME FREQUENCIES		EXPECTED GENE FREQUENCIES	
cde	0.063	C	0.591
Cde	0.051	c	0.409
cdE	0.000	D	0.886
cDe	0.063	d	0.114
CDe	0.475	E	0.348
CDE	0.065	e	0.652
cDE	0.283		
CdE	0.000		

approximately equal frequencies of CDe and cDE; cDe and CDE are often present but d in any combination is infrequent or absent." The high frequency of cDE appears to be confined to the American Indians, Polynesians and Eastern Asiatics.

ABO Blood Group: Table 2, which includes previously unpublished data from our Institute, shows that, on the whole, the Guatemalan Indians are predominantly group O people. The O gene frequency is similar to that found in previous studies of Guatemalan Indians by Cabrera (1950) and Matson and Swanson (1959), but it differs in the Black Caribs of Livingston, Guatemala, according to a previous study by Scrimshaw, Méndez, Flores, Guzmán and León (1961) which showed gene frequencies of .723, .137 and .150 for the O, A and B genes, respectively. The presence of some A and B genes among certain Indians is probably due to a degree of racial crossing. According to Mourant (1954) it is possible that the South and Central American Indians may have been exclusively group O before the coming of the Europeans.

MNSs Blood Group: Table 5 shows the results obtained in the MNSs group. The Ms chromosome is the most common and ranges from .4951 in the Quiché group to .7695 in the Chol; this chromosome is lower in both Europeans and African Negroes. In some aboriginal Malays and Chinese (Mourant, 1954), it is quite similar to that observed in the present study. However, differences are not frequent among American aborigines (Mourant, 1954; Matson and Swanson, 1959) except in a few tribes (Sandoval and Henckel, 1954; Matson, Koch and Levine, 1954; Pantin and Kallsen, 1953).

In our study, the Chol and Mam groups have higher Ms chromosome frequencies than the other groups, and there is a significant difference ($P < 0.05$) in the relative frequency of this Ms chromosome when the combined Pocomam-Quiché are compared with the combined Chol-Mam groups.

P Blood Group: Only anti P_1 (anti P) sera were used in testing this system. As shown in table 6, the P_1 gene frequency varies from .3239 in the Mam to .5170 in the Chol group with a total average of .4282. The P system has not been studied before in the Guatemalan Indians. The frequency of the P_1 in the Mayan Indians from Mexico is similar (Matson and Swanson, 1959).

The frequency of the two genes among many other races does not vary greatly from that of the Guatemalan Indians. Apparently the P_1 is slightly lower in some Asiatic people (Lehmann and Cutbush, 1952) and higher in African (Barnicot and Lawler, 1953; Henningsen, 1950; Shapiro, 1953) and American Negroes (Miller, Tannor and Hsu, 1950). The frequency of the P_1 gene is significantly less ($P < 0.05$) among the Mam groups than among the other three Indian groups, which are similar.

TABLE 4

The ABO blood group

GROUPS OF POPULATION	NUMBER STUDIED	OBSERVED PHENOTYPE FREQUENCIES								EXPECTED GENE FREQUENCIES		
		A		B		AB		O		A	B	O
		No.	Frequency	No.	Frequency	No.	Frequency	No.	Frequency			
Chol	24	3	.1250	0	.0000	0	.0000	21	.8750	.0646	.0000	.9354
Pocomam	132	7	.0530	4	.0303	0	.0000	121	.9167	.0269	.0153	.9578
Quiché	129	1	.0078	1	.0078	0	.0000	127	.9844	.0039	.0039	.9922
Mam	70	3	.0429	2	.0286	0	.0000	65	.9285	.0217	.0144	.9639
Total	355	14	.0394	7	.0197	0	.0000	334	.9409	.0199	.0099	.9702

TABLE 5
The MNSs blood group

GROUPS OF POPULATION	NUMBER STUDIED	OBSERVED PHENOTYPE FREQUENCIES										EXPECTED CHROMOSOME FREQUENCIES					
		MMS		MNS		MNs		MMs		NNS		NNs		MS	NS	Ns	Ms
		No.	Freq.	No.	Freq.	No.	Freq.	No.	Freq.	No.	Freq.	No.	Freq.				
Chol	30	2	.0667	2	.0667	6	.2000	18	.6000	1	.0333	1	.0333	.0306	.0566	.1433	.7695
Pocomam	80	24	.3000	11	.1375	19	.2375	19	.2375	3	.0375	4	.0500	.2207	.0547	.2203	.5043
Quiché	80	22	.2750	18	.2250	14	.1750	21	.2625	2	.0250	3	.0375	.2424	.0684	.1941	.4951
Mam	70	6	.0857	9	.1285	22	.3143	26	.3714	4	.0571	3	.0428	.0434	.1031	.2183	.6352
Total	260	54	.2077	40	.1538	61	.2346	84	.3231	10	.0385	11	.0423	.1521	.0733	.2017	.5729

Kidd Blood Group: The commercial anti Jk^a sera was used in testing for the Kidd (Jk^a) antigen. Only a weak agglutination was observed with the commercial antisera, although positive and negative controls were satisfactory. The total average of the Jk^a gene is .3091 as shown in table 7 which in itself is lower than the ones described elsewhere

TABLE 6
The P blood group

GROUPS OF POPULATION	NUMBER STUDIED	OBSERVED PHENOTYPE FREQUENCIES		EXPECTED GENE FREQUENCIES	
		P + P ₁ P ₁ + P ₁ P ₂	P — P ₂ P ₂	P ₁	P ₂
Chol					
No.	30	23	7		
Frequency		0.7667	0.2333	0.5170	0.4830
Pocomam					
No.	80	59	21		
Frequency		0.7375	0.2625	0.4876	0.5124
Quiché					
No.	80	55	25		
Frequency		0.6875	0.3125	0.4409	0.5591
Mam					
No.	70	38	32		
Frequency		0.5429	0.4571	0.3239	0.6761
Total					
No.	260	175	85		
Frequency		0.6731	0.3269	0.4282	0.5718

(Mourant, 1954) with the exception of a group of Chinese studied in New York (Rosenfield *et al.*, 1953) which show a frequency of .3103. The Jk^a gene is quite similar among the Chol, Pocomam and Quiché groups, but is lower ($P < 0.01$) in the Mam group.

Matson and Swanson (1959) reported higher values among Guatemalan Indians for the Jk^a gene. The difference could be a result of some false negatives due to the weak agglutination observed with the commercial antisera used in our work.

Kell Blood Group: Nearly all the Indians, with the exception of one case in the Chol group, were Kell negative (see table 8). These findings agree with values reported by others in aboriginal populations from America (Matson and Swanson, 1959; Chown and Lewis, 1953), with the exception of some Brazilian Indians reported by Pantin and Jun-

TABLE 7

The Kidd (Jk^a) blood group

GROUPS OF POPULATION	NUMBER STUDIED	OBSERVED PHENOTYPE FREQUENCIES		EXPECTED GENE FREQUENCIES	
		$Jk^a +$ $Jk^aJk^a + Jk^aJk^b$	$Jk^a -$ Jk^bJk^b	Jk^a	Jk^b
Chol					
No.	30	19	11		
Frequency		0.6333	0.3667	0.3945	0.6055
Pocomam					
No.	40	25	15		
Frequency		0.6250	0.3750	0.3876	0.6124
Quiché					
No.	80	48	32		
Frequency		0.6000	0.4000	0.3675	0.6325
Mam					
No.	70	23	47		
Frequency		0.3286	0.6714	0.1806	0.8194
Total					
No.	220	115	105		
Frequency		0.5227	0.4773	0.3091	0.6909

queira (1952) who demonstrated relatively high K frequency of .1241. The presence of $K+$ genes in one of our cases is due presumably to some Caucasian admixture.

Duffy Blood Group: As shown in table 9, there is no difference in the distribution of the Duffy system among the four Indian groups studied. The Fy^a gene was present in the total population with an average relative frequency of .5443. This value is lower than the one reported by Matson and Swanson (1959) in Mayan Indians and higher than the

values reported for European whites (Race and Sanger, 1952) and African Negroes (Shapiro, 1953). The latter show very low values.

Diego Blood Group: The anti Di^a serum was obtained through Dr. M. Layrisse from the Banco de Sangre, Caracas, Venezuela. The Di^a gene frequency, as shown in table 10 is higher among the Chol group (.2929) and lower among the Pocomam (.1126) with an average relative

TABLE 8

The Kell blood group

GROUPS OF POPULATION	NUMBER STUDIED	OBSERVED PHENOTYPE FREQUENCIES		EXPECTED GENE FREQUENCIES	
		K + KK + Kk	K — kk	K	k
Chol					
No.	30	1	29		
Frequency		0.0333	0.9667	0.0168	0.9832
Pocomam					
No.	80	0	80		
Frequency		0.0000	1.0000	0.0000	1.0000
Quiché					
No.	80	0	80		
Frequency		0.0000	1.0000	0.0000	1.0000
Mam					
No.	70	0	70		
Frequency		0.0000	1.0000	0.0000	1.0000
Total					
No.	260	1	259		
Frequency		0.0038	0.9962	0.0019	0.9981

frequency of .1680. The Quiché and Mam groups show intermediate values. The Diego factor studied previously in Guatemala (Matson and Swanson, 1959) in 46 cases from the Quiché group, showed a gene frequency of .1739 which is quite similar to the value found in the present study. There is a significant difference ($P < 0.05$) between the Chol and the other three groups.

The Di^a frequency reported for the Chol group is probably one of the highest found up to now and is very close to that of the Brazilian

Caingangue and Carajá Indians (Layrisse and Wilbert, 1960). This factor, which has been well studied by these authors, has not been found among the Caucasian whites and African Negroes but is present in the American Indians and Asiatic Mongoloids. As suggested by them, the

TABLE 9
The Duffy (Fy^a) blood group

GROUPS OF POPULATION	NUMBER STUDIED	OBSERVED PHENOTYPE FREQUENCIES		EXPECTED GENE FREQUENCIES	
		$Fy^a +$ $Fy^a Fy^a + Fy^a Fy^b$	$Fy^a -$ $Fy^b Fy^b$	Fy^a	Fy^b
Chol					
No.	30	26	4		
Frequency		0.8667	0.1333	0.6349	0.3651
Pocomam					
No.	80	63	17		
Frequency		0.7875	0.2125	0.5390	0.4610
Quiché					
No.	80	65	15		
Frequency		0.8125	0.1875	0.5669	0.4331
Mam					
No.	70	52	18		
Frequency		0.7429	0.2571	0.4929	0.5071
Total					
No.	260	206	54		
Frequency		0.7923	0.2077	0.5443	0.4557

presence of this gene in the American aborigine could be considered as evidence of a probable genetic relationship with Asiatic Mongoloids.

SUMMARY

Two hundred and sixty non-related Guatemalan Indians of Mayan extraction were selected according to the four major linguistic groups prevalent in the area; namely, Chol, Pocomam, Quiché and Mam, and studied for the distribution of the blood factors ABO, MNSs, P, Kell, Kidd, Duffy and Diego. The number tested, as well as the phenotype

and gene frequencies for each group, are presented. In the particular case of the ABO and Rh blood groups, some previously unpublished data are also included. Tables for the phenotype, genotype, chromosome and gene frequencies observed are presented, as well as a map localizing the surveyed areas.

TABLE 10

The Diego (Di^a) blood group

GROUPS OF POPULATION	NUMBER STUDIED	OBSERVED PHENOTYPE FREQUENCIES		EXPECTED GENE FREQUENCIES	
		Di ^a + Di ^a Di ^a + Di ^a Di ^b	Di ^a — Di ^b Di ^b	Di ^a	Di ^b
Chol					
No. Frequency	30	15 0.5000	15 0.5000	0.2929	0.7071
Pocomam					
No. Frequency	80	17 0.2125	73 0.7875	0.1126	0.8874
Quiché					
No. Frequency	80	25 0.3125	55 0.6875	0.1708	0.8292
Mam					
No. Frequency	70	23 0.3286	47 0.6714	0.1806	0.8194
Total					
No. Frequency	260	80 0.3077	180 0.6923	0.1680	0.8320

Most common, over-all gene and chromosome frequencies found were: CDe .475; O .9702; Ms .5729; P₂ .5718; Jk^b .6909; k .9981; Fy^a .5443; and Di^b .8320.

In the particular case of the Mam group, some unexpected differences were observed in the P, Kidd and MNSs groups. It is possible that this group is genetically different from the others, but further studies are necessary to establish this fact.

ACKNOWLEDGMENTS

We are greatly indebted to the Instituto Indigenista de Guatemala for its most valuable cooperation in the selection of the individuals studied, and especially to Mr. Francisco Rodríguez Rouanet, Chief of the Technical Department of this Institution, as well as to the technical investigators, Mr. J. Martín Ordóñez Ch., Mr. Lorenzo Castañeda F., Mr. Rosalío Saquic C., and to Mr. Hipólito Menchú, who helped us in the selection of the cases.

We express also our thanks to Dr. Miguel Layrisse for making available the anti-Diego serum.

LITERATURE CITED

- AGUIRRE, F., O. B. TANDON AND N. S. SCRIMSHAW 1953 Distribution of blood groups in Guatemalan Indians. *Rec. Genet. Soc. America*, 22: 63.
- BARNICOT, N. A. AND S. D. LAWLER 1953 A study of the Lewis, Kell, Lutheran and P blood group systems and the ABH secretion in West African Negroes. *Am. J. Phys. Anthropol.*, 11: 83-90.
- CABRERA, M. A. 1950 Breve estudio sobre la repartición de los grupos sanguíneos entre nuestra población y la evolución de la investigación de la paternidad por medio de ellos, en nuestro país. *Salud y Asistencia, Guatemala*, 3(10): 16-17.
- CHOWN, B. AND M. LEWIS 1953 The ABO, MNSs, P, Rh, Lutheran, Kell, Lewis, Duffy and Kidd blood groups and the secretor status of the Blackfoot Indians of Alberta, Canada. *Am. J. Phys. Anthropol.*, 11: 369-383.
- GOUBAUD CARRERA, A. 1946 Distribución de las lenguas indígenas actuales de Guatemala. *Boletín Instituto Indigenista, Guatemala*, 1(2-3): 5-16.
- HENNINGSEN, K. 1950 Etude d'ensemble du facteur sanguin P. *Rev. hemat.*, 5: 276-284.
- LAYRISSE, M. AND J. WILBERT 1960 El Antígeno del Sistema Sanguíneo Diego. Publicado por la Fundación Creole y la Fundación Eugenio Mendoza. Editorial Sucre, Caracas, Venezuela.
- LEHMANN, H. AND M. CUTBUSH 1952 Subdivision of some southern Indian communities according to the incidence of sickle-cell trait and blood groups. *Tr. Roy. Soc. Trop. Med. and Hyg.*, 46: 380-383.
- MATSON, G. A., E. A. KOCH AND P. LEVINE 1954 A study of the hereditary blood factors among the Chippewa Indians of Minnesota. *Am. J. Phys. Anthropol.*, 12: 413-426.
- MATSON, G. A. AND J. SWANSON 1959 Distribution of hereditary blood antigens among the Maya and non-Maya Indians in Mexico and Guatemala. *Am. J. Phys. Anthropol.*, 17: 49-74.
- MILLER, E. B., H. D. TANNOR AND C. F. HSU 1950 The P factor and its variants in Caucasians, Negroes and Chinese. *J. Lab. and Clin. Med.*, 36: 230-233.

- MOURANT, A. E. 1954 The Distribution of the Human Blood Groups. 1st ed. Charles C. Thomas, Springfield, Illinois.
- PANTIN, A. M. AND P. C. JUNQUEIRA 1952 Blood groups of Brazilian Indians. *Am. J. Phys. Anthropol.*, 10: 395-406.
- PANTIN, A. M. AND R. KALLSEN 1953 The blood groups of the Diegueño Indians. *Am. J. Phys. Anthropol.*, 11: 91-96.
- RACE, R. R. AND R. SANGER 1952 The inheritance of the Duffy blood group: an analysis of the 110 English families. *Heredity*, 6: 110-119.
- ROSENFELD, R. E., P. VOGEL, N. GIBBEL, G. OHNO AND G. HABER 1953 Anti-Jk^a: three new examples of the isoantibody. Frequency of the factor in Caucasians, Negroes and Chinese of New York City. *Am. J. Clin. Path.*, 23: 1222-1225.
- SALZANO, F. M. 1957 The blood groups of South American Indians. *Am. J. Phys. Anthropol.*, 15: 555-579.
- SANDOVAL, L. AND C. HENCKEL 1954 The ABO, MNS and Rh-Hr blood groups of the Mapuche Indians of Cautin Province, Chile. *Human Biology*, 26: 324-329.
- SCRIMSHAW, N. S., J. MÉNDEZ, M. FLORES, M. A. GUZMÁN AND R. DE LEÓN 1961 Diet and serum cholesterol levels among the "Black Caribs" of Guatemala. *Am. J. Clin. Nutrition*, 9: 206-210.
- SHAPIRO, M. 1953 Blood groups and skin colour. Their genetics in human anthropology. *J. Forensic Med.*, 1: 2-10.