

On the Blood Groups among the Ainu in Niikappu, Hokkaido

Shogo MISAWA and Yoshiko HAYASHIDA

*Department of Legal Medicine, Faculty of
Medicine, University of Tokyo*

Abstract The 40 pure Ainu (degree of admixture with the Japanese was less than 1/4), 68 mixed Ainu specimens (degree of admixture was 1/2 or more) and, as controls, 355 Japanese specimens obtained in Niikappu, Hokkaido, were studied for eight blood groups—ABO, MNSs, Rh, Q, Lewis (Le^a), Kell, Duffy (Fy^a) and Kidd (JK^a) blood groups. The gene or chromosome frequencies of these red cell antigens were estimated and were compared with those of other populations. The values obtained were seemed to have the following characteristics—high frequency of Fy^a gene, low frequency of Q gene and Rh negative type and lack of K gene. These results suggested that the Ainu had blood group characteristics more similar to those of Mongolians than of Caucasians, even if the relationship to the Caucasians could not be disproved. It would be of interest that the Ainu have different characteristics from the Japanese in consideration of the MN, Rh, Q, Lewis, Kidd blood groups. The significance of the high *r''* chromosome frequency or low *m* gene frequency has not been asserted.

INTRODUCTION

The Ainu now inhabit Hokkaido, Sakhalin and the southern Kurile Islands and have number less than 20,000, of whom more than 8,000 Ainu are residing in Hidaka area. They are believed to have once occupied most of the northeastern part of Honshu, the major island of Japan, from where they were gradually pushed northward or absorbed by ancestors of the Japanese. The Ainu differ from the Japanese linguistically, physically and morphologically and some authorities believe that they belong to a Caucasoid group. Although several doctrines concerning to their racial origin have been presented, none of them are conclusive. In recent years, as one approach to solve the problem, it is prevailing to investigate some

hereditary characters in the Ainu—blood groups, serum protein types, fingerprints and so on—to estimate their gene frequencies in order to be compared with those of other populations.

Many reports on the blood groups among the Ainu have been made and knowledges about their racial origin have been much increased. They were, however, mainly concerned with such classical blood groups as ABO, and MN, which were referred to in TANAKA (1959) and MATSUKI (1967). As for the more recently discovered blood groups, only a few reports have been available (SIMMONS *et al.*, 1953; KOBAYASHI, 1957; MISAWA *et al.*, 1968).

The present authors have reported on the distributions of eight blood groups—ABO, MNSs, Rh, Q, Lewis, Kell, Duffy

and Kidd, among the Ainu residing in Shizunai district. This paper deals with the same eight blood groups among the Ainu in Niikappu, Hidaka area, Hokkaido, Japan.

MATERIALS AND METHODS

1) Blood specimens: All blood specimens were obtained in Niikappu, a coastal district in the southwest Hidaka area and the next district to Shizunai (Fig. 1). Several small Ainu villages are located in Niikappu and specimens were collected from 61 Ainu students of Higashikawa, Wakazono, Asahi and Meiwa Junior High Schools and from 47 Ainu adults of Higashikawa, Wakazono, Izumi, Meiwa and Bansei villages.

Of the 108 Ainu, 40 were the relatively pure Ainu, of whom the degree of admixture with the Japanese was less than 1/4. Most of the remaining were 1/2 or more in the degree of admixture. For convenience, they were referred to as the pure Ainu and mixed Ainu in this paper,

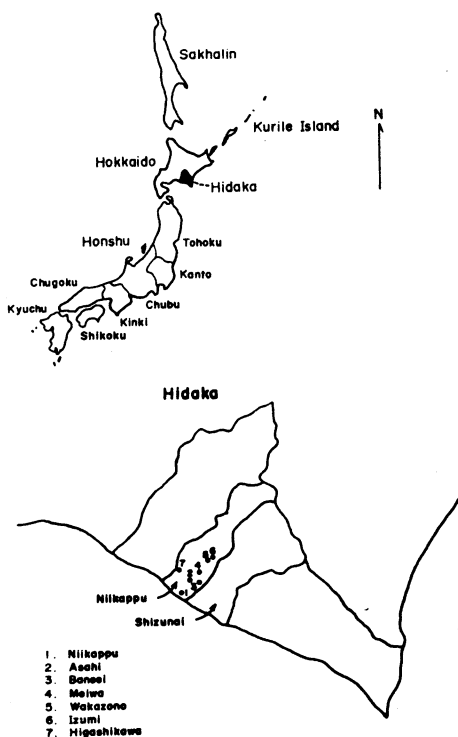


Fig. 1. Sketch map of Hidaka area with the positions of Ainu villages.

respectively. The mean degree of admixture of the all 108 Ainu was about 1/2. Three hundred fifty-five blood specimens

Table 1. Antisera and procedures used for the blood grouping test.

System	Antisera	Origin	Procedures of the test
ABO	Anti-A, Anti-B	Human	Saline slide, R. T.
	Anti-M, Anti-N	Rabbit	Saline slide, R. T.
MNSs	Anti-S	Human	Saline tube, R. T.
	Anti-s	Human	Antiglobulin (Coombs)
Rh	Anti-D(Rh ₀), Anti-C(rh')	Human	Bromelin slide*
	Anti-E(rh''), Anti-c(hr')	Human	Bromelin slide*
Q	Anti-Q	Human	Bromelin tube, 10-15°C
Lewis	Anti-Le ^a	Human	Saline tube, 10-15°C
Kell	Anti-K, Anti-k	Human	Antiglobulin (Coombs)
Duffy	Anti-Fy ^a	Human	Antiglobulin (Coombs)
Kidd	Anti-Jk ^a	Human	Antiglobulin (Coombs)

* Doubtful or weak reactions were checked by tube or indirect antiglobulin (Coombs) tests with different lots of antisera.

Table 2. The ABO blood groups and gene frequencies.

Population	Number tested	Phenotypes %				Gene frequencies		
		O	A	B	AB	<i>p</i>	<i>q</i>	<i>r</i>
pure Ainu	40	47.50	35.00	17.50	0.00	0.1963	0.0929	0.7107
mixed Ainu	68	32.35	35.29	23.53	8.82	0.2514	0.1768	0.5718
Japanese	355	30.70	38.31	21.70	9.30	0.2763	0.1693	0.5544

from the Japanese in the same region were also collected as controls and were compared with the Ainu.

Subjects were checked as to the Ainu ancestry by the official family record and in most cases through the interviews, or by the informations from the old men in the villages and the school teachers.

2) Blood grouping test: Blood specimens were obtained by venipuncture, mixed with a four to one ACD solution and were stored at about 4°C. The blood grouping test was carried out at the laboratory of Tokyo Medical and Dental University within a week after the venipuncture; all of the specimens were in excellent condition for examination. Blood cells were washed three times in saline before the blood grouping test. The antisera and methods of testing are summarized in Table 1.

3) Gene frequencies: For the estimation of the gene frequencies of the ABO groups, BERNSTEIN's method was used and for the analysis of the Rh and MNSs chromosome frequencies, the method described by MOURANT was applied with some modifications as the previous paper (MISAWA *et al.*, 1968).

RESULTS AND DISCUSSION

1) The ABO blood groups: Table 2

presents the results of the ABO grouping of the 40 pure Ainu, the 68 mixed Ainu and the 355 Japanese with the calculated gene frequencies.

The goodness of fit was tested by the following equation about the Ainu and Japanese.

$$\chi^2 = 2n \left(1 + \frac{r}{pq} \right) D^2 \quad (\text{d.f.} = 1)$$

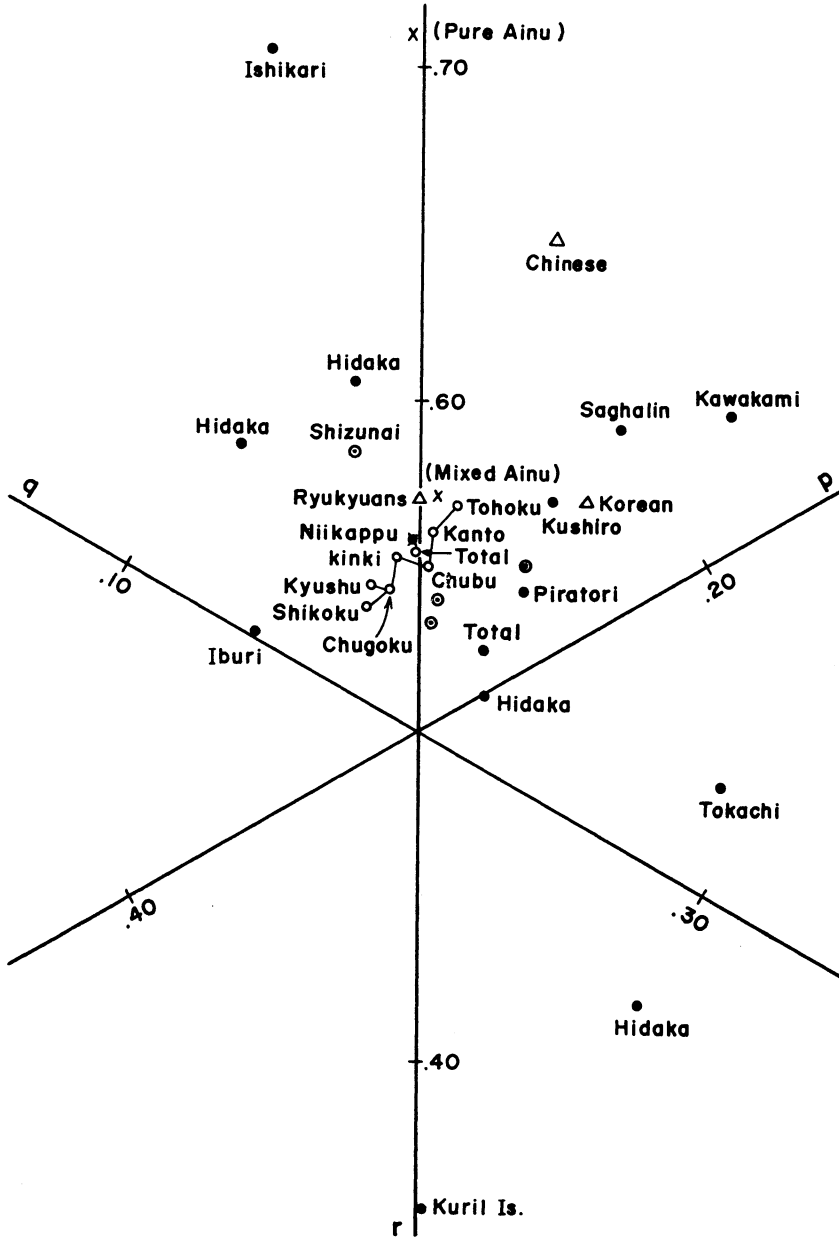
where *D* equalled $1 - p - q - r$, *n* meant a total number tested, and *p*, *q*, and *r* meant the gene frequencies of A, B, O, respectively. The results of the test suggested that the distribution of each population was in agreement with HARDY-WEINBERG's law (pure Ainu: $\chi^2 = 2.2114$, $0.20 > p > 0.10$. mixed Ainu: $\chi^2 = 0.0319$, $0.90 > p > 0.80$. Japanese: $\chi^2 = 0.0015 > p > 0.95$).

In the pure Ainu, the gene frequencies were $p = 0.1963 \pm 0.0470$, $q = 0.0929 \pm 0.0333$, $r = 0.7107 \pm 0.0481$, in the mixed Ainu, $p = 0.2514 \pm 0.0401$, $q = 0.1768 \pm 0.0344$, $r = 0.5718 \pm 0.0463$, in the Japanese, $p = 0.2763 \pm 0.0196$, $q = 0.1693 \pm 0.0159$, $r = 0.5544 \pm 0.0216$. The differences among the distribution of each population were not statistically significant, respectively. The results obtained in the analysis of the gene frequencies were similar to those reported by SIMMONS *et al.*, while the value of *r* of the pure Ainu was much higher (SIMMONS *et al.*, 1953, $p = 0.285 \pm 0.021$, $q = 0.212 \pm 0.019$,

$r=0.512\pm 0.012$).

triangular coordinate as shown in Fig. 2

The gene frequencies are mapped in a with those of the Ainu previously report-



x : Present work, ● : Ainu, ○ : Japanese, ⊙ : Ainu-Japanese, △ : Others

Fig. 2. Serological position of p , q , r .

Table 3. The MN blood groups and gene frequencies.

Population	Number tested	Phenotypes			Gene frequencies	
		M	MN	% N	<i>m</i>	<i>n</i>
pure Ainu	40	17.50	55.00	27.50	0.4500	0.5500
mixed Ainu	68	26.47	42.65	30.88	0.4780	0.5220
Japanese	341	31.96	52.20	15.84	0.5806	0.4194

ed. Those of the Japanese and of the neighboring populations are also indicated. Different values of the gene frequencies among the Ainu in different regions and sometimes even in the same region can be seen in Fig. 2. The position of the mixed Ainu in the present study is rather close to that of the Ryukyuan and Japanese in Tohoku district than that of the Japanese in other districts. The value of *r* increases in the population tested as the investigation is done in the northern part of Japan. An unequivocal explanation of this significance is difficult.

2) MNSs blood groups: Table 3 presents the results of the MN grouping test of the 40 pure Ainu, 68 mixed Ainu and 341 Japanese. The 50 specimens from the 40 pure Ainu and the 10 mixed Ainu with a low degree of admixture were further tested with both anti-S and anti-s serum.

The goodness of fit for the MN blood groups was tested by the following equation:

$$\chi^2 = \frac{n(c^2 - 4bd)^2}{(2b+c)^2(c+2d)^2} \quad (\text{d.f.} = 1)$$

Where, *b*, *c*, and *d* meant the observed number of type M, type MN and type N, respectively. The results indicated that the distributions of the pure Ainu, mixed

Ainu and Japanese were in agreement with HARDY-WEINBERG's law (pure Ainu: $\chi^2 = 0.4938$, $0.50 > p > 0.30$, mixed Ainu: $\chi^2 = 1.4375$, $0.30 > p > 0.20$, Japanese: $\chi^2 = 1.7615$, $0.20 > p > 0.10$).

The gene frequencies found were *m* = 0.4500, *n* = 0.5500 for the pure Ainu, *m* = 0.4780, *n* = 0.5220 for the mixed Ainu, *m* = 0.5806, *n* = 0.4194 for the Japanese (*m* for the gene *Ig^M* responsible to antigen M and *n* for the gene *Ig^N* to antigen N). The difference of the distribution of the Ainu as a whole was statistically significant from that of the Japanese. It was attractive that the frequency of the gene *Ig^M* in the pure Ainu or the mixed Ainu was lower than that in the Japanese tested and than the average frequency of the Japanese (*m* = 0.544, FURUHATA *et al.*, 1967). TANAKA (1959) has summarized all the data reported so far, and estimated the frequency of the gene *Ig^M* as 0.4488 in the pure Ainu and 0.475 in the mixed Ainu. It, therefore, appeared to be a feature of the distribution of the MN blood groups among the Ainu that the frequency of the gene *Ig^M* was less than 0.500.

The numbers of the phenotypes tested with anti-S and anti-s serum were as follows: - MSMS 0(0.0%), MSMs 2(4.0%), MsMs 9(18.0%), MSNS 0(0.0%), MNSs 5(10.0%), MsNs 19(38.0%), NSNS 1(2.0%),

Table 4. The Rh blood groups and chromosome frequencies.

Phenotypes	Pure Ainu		Mixed Ainu		Japanese		Chromosome frequencies	
	No.	%	No.	%	No.	%	Ainu as a whole	Japanese
CCDee	17	42.50	21	30.88	155	43.66		
CcDE	12	30.00	34	50.00	121	34.08	$R^1=0.5479$	$R^1=0.6000$
CcDee	2	5.00	3	4.41	29	8.17	$R^2=0.2291$	$R^2=0.2465$
ccDE	7	17.50	8	11.76	47	13.24	$R^z=0.0000$	$R^z=0.0000$
ccDee	0	0.00	0	0.00	1	0.28	$R^0=0.0000$	$R^0=0.0529$
CCdee	0	0.00	0	0.00	1	0.28	$r=0.0458$	$r=0.0000$
CcdE	1	2.50	0	0.00	0	0.00	$r'=0.0482$	$r'=0.0529$
ccdE	1	2.50	2	2.94	1	0.28	$r''=0.1282$	$r''=0.0529$
Total	40	100.00	68	99.99	355	99.99		

NSNs 5(10.0%), NsNs 9(18.0%).

3) The Rh blood groups: Table 4 presents the Rh types and chromosome frequencies found in the 40 pure Ainu, 68 mixed Ainu and 355 Japanese. The pure Ainu was so small in number for the estimation of Rh chromosome frequencies that the pure and mixed Ainu were combined and the chromosome frequencies for the Ainu as a whole were calculated. The calculated chromosome frequencies were $R^1(CDe)=0.5479$, $R^2(cDE)=0.2291$, $R^z(CDE)=0$, $R^0(cDe)=0.0458$, $r(cde)=0.0458$, $r'(Cde)=0.0482$, $r''(cdE)=0.1282$ for the Ainu as a whole, $R^1(CDe)=0.6000$, $R^2(cDE)=0.2465$, $R^z(CDE)=0$, $R^0(cDe)=0.0529$, $r(cde)=0$, $r'(Cde)=0.0529$, $r''(cdE)=0.0529$ for the Japanese.

The incidence of Rh negative individuals calculated from Table 4 was 5.00% for the pure Ainu, 2.94% for the mixed Ainu (3.71% as a whole) and 0.56% for the Japanese. This difference was statistically significant.

The present Rh survey of the Ainu having been summarized, the following features appear outstanding:—

1. The incidence of Rh negative individuals.

The incidence of Rh negative individuals obtained in the present study was considerably higher than the 0.36% in the Japanese (FURUHATA, 1966), the 1.21% in the Ryukyuan (NAKAJIMA *et al.*, 1967), the 0.17% in the Koreans (WON, 1960) and the 0.26% in the Chinese in Taiwan (NAKAJIMA *et al.*, 1967).

2. The high r'' gene frequency.

The 0.1282 was the highest yet reported for any race. For the frequency of the gene r'' in the Ainu, the 0.1272 and the 0.175 were reported by MISAWA *et al.* (1968) and SIMMONS *et al.* (1953), respectively.

3. The absence of type Rh₀(cDe).

4) The Q and Lewis blood groups: Table 5 presents the results of the Q and Lewis grouping test of the 40 pure Ainu, 68 mixed Ainu and 340 Japanese. The frequency of the gene Q was 0.0382 ± 0.0214 in the pure Ainu, 0.1340 ± 0.0292 in the mixed Ainu and 0.1938 ± 0.0152 in the Japanese. The distribution of the Ainu as a whole was significantly different from

Table 5. The Q and Lewis blood groups.

Phenotypes	pure Ainu		mixed Ainu		Japanese		Gene frequencies
	No.	%	No.	%	No.	%	
Q	3	7.50	17	25.00	119	35.00	pure Ainu : { Q = 0.0382 Le ^a = 0.5244
q	37	92.50	51	75.00	221	65.00	
total	40	100.00	68	100.00	340	100.00	mixed Ainu : { Q = 0.1340 Le ^a = 0.6184
Le(a+)	11	27.50	8	11.76	76	22.35	
Le(a-)	29	72.50	60	88.24	264	77.65	Japanes : { Q = 0.1938 Le ^a = 0.4626
total	40	100.00	68	100.00	340	100.00	

that of the Japanese.

The value obtained in the Ainu was lower than the 0.158 ± 0.036 of the Ainu reported by HIROTA *et al.* (1937), the 0.1748 ± 0.0020 of the Japanese (FURUHATA, 1966), and the 0.2070 ± 0.0155 of the Ryukyuan (NAKAJIMA *et al.*, 1967).

The frequency of the gene *Le^a* was estimated as 0.5244 ± 0.0499 in the pure Ainu and 0.6184 ± 0.0416 in the mixed Ainu. The combined result was calculated to be 0.5833 ± 0.0381 , which was in agreement with that of Shizunai (MISAWA *et al.*, 1968) and of the Hidaka (SIMMONS *et al.*, 1953). It was, however, significantly higher than that of the Japanese (0.4626 of the present result and 0.4716 of FURUHATA, 1966), the 0.4315 of the Ryukyuan (NAKAJIMA *et al.*, 1967), the 0.4477 of the Koreans (WON *et al.*, 1960) and the 0.4562 of the Chinese (MAKAJIMA *et al.*, 1967).

5) The Kell and Duffy blood groups:

The 40 pure Ainu and 68 mixed Ainu specimens were tested with anti-K, anti-k and anti-Fy^a serum (Table 6). All the pure Ainu specimens were K-k+, Fy(a+) type ($K=0.0000$, $Fy^a=1.0000$), while for the mixed Ainu, 67 specimens were K-k+, Fy(a+) except one K-k+, Fy(a-) type ($K=0.0000$, $Fy^a=0.8788$).

SIMMONS *et al.* (1953) have described that the frequency of K+ individuals was 15% in the pure Ainu and 8% in the Ainu-Japanese. Nevertheless in the present results, the frequency of the gene *K* seemed to be more similar to that of the Asiatic populations than to that of the Caucasian (FURUHATA *et al.*, 1961), and further there is a complete agreement between the data in Niikappu and those in Shizunai (MISAWA *et al.*, 1968).

6) The Kidd blood groups: The 28 pure Ainu specimens were tested with anti-Jk^a serum, 22 out of which were Jk(a+) and

Table 6. The kell and Duffy blood groups.

Phenotypes	pure Ainu		mixed Ainu		Gene frequencies
	No.	%	No.	%	
K-k+	40	100.00	68	100.00	pure Ainu { K = 0.0000 Fy ^a = 1.0000
K+k+	0	0.00	0	0.00	
K+k-	0	0.00	0	0.00	mixed Ainu { K = 0.0000 Fy ^a = 0.8788
Fy(a+)	40	100.00	67	98.51	
Fy(a-)	0	0.00	1	1.49	

6 were Jk(a-) type. The frequency of the gene Jk^a was estimated as 0.537 ± 0.067 , which differed 0.293 ± 0.031 among the Ainu in Shizunai (MISAWA *et al.*, 1968).

7) Relationship of the Ainu to the Caucasians and Mongolians. The gene frequencies of the MN, Rh, Q, Lewis, Kell and Duffy blood groups of the present study agreed fairly well to those previously reported (SIMMONS *et al.*, 1953; KOBAYASHI, 1957; MISAWA *et al.*, 1968).

Although the blood specimens for the present survey were mainly obtained from the Ainu-Japanese, the values themselves had the following characteristics—high frequency of Fy^a gene, low frequency of Q gene and Rh negative type and lack of K gene. These results seemed to indicate that the Ainu had blood group characteristics more similar to those of Mongolians than of Caucasians, even if the relationship to the Caucasians could not be disproved. From the present data, to presume accurately the origin of the Ainu population is difficult, nevertheless, it would be of interest that the Ainu have different characteristics from the Japanese in consideration of the MN, Rh, Q, Lewis, Kidd blood groups. The significance of the high r'' chromosome frequency or low m gene frequency has not been asserted but its study may present an important problem for the origin of the Ainu.

SUMMARY

The 40 pure Ainu (degree of admixture with the Japanese was less than 1/4), 68 mixed Ainu specimens (degree of admixture was 1/2 or more) and, as controls,

355 Japanese specimens obtained in Nikappu, Hokkaido, were studied for eight blood groups—ABO, MNSs, Rh, Q, Lewis (Le^a), Kell, Duffy (Fy^a) and Kidd (Jk^a) and the following gene or chromosome frequencies were obtained:—

1) ABO blood groups: In the pure Ainu, $p=0.1963 \pm 0.0470$, $q=0.0929 \pm 0.0333$, $r=0.7107 \pm 0.0481$; in the mixed Ainu, $p=0.2514 \pm 0.0401$, $q=0.1768 \pm 0.0344$, $r=0.5718 \pm 0.0463$. In the Japanese, $p=0.2763 \pm 0.0196$, $q=0.1693 \pm 0.0159$, $r=0.5544 \pm 0.0216$.

2) MNSs blood groups: In the pure Ainu, $m=0.4500$, $n=0.5500$; in the mixed Ainu, $m=0.4780$, $n=0.5220$. In the Japanese, $m=0.5806$, $n=0.4194$. In the fifty pure Ainu (forty pure Ainu and ten mixed Ainu with a low degree of admixture) specimens tested, phenotype MSMs 2(4.0%), MsMs 9(18.0%), MNSs 5(10.0%), MsNs 19(38.0%), NSNS 1(2.0%), NSNs 5(10.0%) and NsNs 9(18.0%).

3) Rh blood groups: In the Ainu as a whole, $R^1(CDe)=0.5479$, $R^2(cDE)=0.2291$, $R^z(CDE)=0$, $R^0(cDe)=0$, $r(cde)=0.0458$, $r'(Cde)=0.0482$, $r''(cDE)=0.1282$. In the Japanese, $R^1(CDe)=0.6000$, $R^2(cDE)=0.2465$, $R^z(CDE)=0$, $R^0(cDe)=0.0529$, $r(cde)=0$, $r'(Cde)=0.0529$, $r''(cDE)=0.0529$.

4) Q and Lewis blood groups: In the pure Ainu, $Q=0.0382 \pm 0.0214$, $Le^a=0.5244 \pm 0.0499$; in the mixed Ainu, $Q=0.1340 \pm 0.0292$, $Le^a=0.6184 \pm 0.0416$.

5) Kell, Duffy and Kidd blood groups: In the pure Ainu, $K=0.0000$, $Fy^a=1.0000$; in the mixed Ainu, $K=0.0000$, $Fy^a=0.8788$. Twenty-two out of the 28 specimens were Jk(a+) and 6 were Jk(a-) type.

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These studies have been continued since the present authors were in Tokyo Medical and Dental University.

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北海道新冠地方アイヌの血液型について

三沢章吾・林田良子

東京大学医学部法医学教室

北海道新冠地方のアイヌ108名(純血に近いアイヌ40名, 1/2, 1/4 程度の混血アイヌ68名, 日本人との平均混血度 1/2) について, ABO 式, MNSs 式, Rh 式, Q 式, Lewis (Le^a) 式, Kell 式, Duffy (Fy^a) 式, Kidd (Jk^a) 式の8種類の血液型を検査し, 次のような遺伝子あるいは染色体頻度を得た.

1) ABO 式血液型 純血アイヌ: $p=0.1963 \pm 0.0470$, $q=0.0929 \pm 0.0333$, $r=0.7107 \pm 0.0481$, 混血アイヌ: $p=0.2514 \pm 0.0401$, $q=0.1768 \pm 0.0344$, $r=0.5718 \pm 0.0463$.

2) MNSs 式血液型, 純血アイヌ: $m=0.4500$, $n=0.5500$, 混血アイヌ: $m=0.4780$, $n=0.5220$, 比較的純血に近いアイヌ50名について, M, N, S, s 抗原を調べると, MSMs 2名, MsMs 9名, MNSs 5名, MsNs 19名, NSNS 1名, NSNs 5名, NsNs 9名であった.

3) Rh 式血液型 アイヌ全体として頻度を計算すると, $R^1(CDe)=0.5479$, $R^2(cDE)=0.2291$, $R^2(CDE)=0$, $R^0(cDe)=0$, $r(cde)=0.0458$, $r'(Cde)=0.0482$, $r''(cdE)=0.1282$ であった.

4) Q 式, Lewis 式血液型, 純血アイヌ: $Q=0.0382 \pm 0.0214$, $Le^a=0.5244 \pm 0.0499$, 混血アイヌ: $Q=0.1340 \pm 0.0292$, $Le^a=0.6184 \pm 0.0416$.

5) Kell 式, Duffy 式, Kidd 式血液型, 純血アイヌ: $K=0.0000$, $Fy^a=1.0000$, 混血アイヌ: $K=0.0000$, $Fy^a=0.8788$. 純血アイヌ28名について Kidd 式血液型を調べると $Jk(a+)$ 型22名, $Jk(a-)$ 型6名であった.