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POPULATION GENETIC STUDIES IN AUSTRALIAN ABORIGINES OF THE NORTHERN TERRITORY. IV.

BLOOD GROUP GENETIC STUDIES ON POPULATIONS SAMPLED AT SIXTEEN LOCALITIES INCLUDING ARNHEM LAND AND GROOTE EYLANDT.[1]

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[1] Part of an Australian contribution to the Human Adaptability Project of the International Biological Programme.

400 Reprints Desired
Reprints and account
to the Director,
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3052, Victoria.

The present paper reports and discusses the distribution of the A_1A_2BO, MNSs, Rh, Duffy (Fy^a, Fy^b), Lewis (Le^a), Diego (Di^a) and the sex-linked Xg^a blood groups found in 1195 Aborigines living in 16 localities in the vast Northern Territory of Australia. However, only 175 blood samples from the north were tested for the Le^a group, and 352 from Central Australia for Xg^a. The preceding paper in this issue by Kirk, Blake, Woodie and Tibbs (1970) reports their findings on some 1500 Aborigines from 18 localities for two serum protein and eight red cell enzyme groups which include haptoglobins (Hp), transferrin (Tf), 6-phosphogluconate dehydrogenase (6PGD) red cell acid phosphatase (PHs), phosphoglucomutase (PGM), peptidase A and B, adenylate kinase (AK), lactate dehydrogenase (LDH) and malate dehydrogenase (MDH).

Kirk et al. (1969) and Simmons and Cooke (1969) reported their findings for the Malag tribe of Elcho Island, Northern Territory. Kirk and his associates tested 643 of these individuals for the Hp groups, 641 for Tf and PHs types, 594 for 6PGD, 595 for LDH and 296 for AK, while Simmons and Cooke tested 352 individuals for the A_1A_2BO, MNSs and Rh blood groups and a random sample of 179 for Duffy (Fy^a,Fy^b), Lewis (Le^a), P_1 and Diego (Di^a) blood groups.

Previous blood group surveys on Aborigines of the Northern Territory and adjacent localities have been reported as follows: Cleland (1927), (1930),(1931), (1932), (1933), Cleland et al. (1936), Cleland and Johnston (1938), Simmons et al. (1944), Wilson et al. (1944), Simmons and Graydon (1948), Sanger et al. (1951), Simmons et al. (1954), Kooptzoff and Walsh (1957), Simmons et al. (1957), Nicholls et al. (1965) and Simmons and Cooke (1969). Kirk (1965) published an excellent summary of the distribution of genetic markers in Australian Aborigines to that date.

MATERIALS AND METHODS

The blood samples tested in the present survey came from 16 localities in the Northern Territory as follows:- Millingimbi, Maningrida, Groote Eylandt, Bathurst Island, Darwin (Bagot Settlement), Mainoru, Bamyili, Roper River, Victoria River Downs, Robinson River, Yuendumu, Aileron, Amoonguna, Hermannsburg, Areyonga and Maryvale as shown in Figure 1, which also indicates 10 numbered tribal boundaries, namely: 1. Aranda, 2. Bidjandjadjara, 3. Gunwinggu, 4. Luridja, 5. Malag, 6. Nunggubuju, 7. Ranjbarngu, 8. Tiwi, 9. Waljbiri and 10. Wogaidj. Some additional tribal names listed below which appear in Tables 1-4 can be accurately located on tribal maps issued by the Australian Institute of Aboriginal Studies, Canberra. However, the locality mentioned also serves as a guide to tribal location. Throughout this paper the tribal spellings are those accepted by the Institute. Kirk et al. (1970) present a table showing the tribes associated with each locality sampled.

Locality	Tribe	A.I.A.S. Location Key
Maningrida	Gunavidji	N74
Groote Eylandt	Andiljaugwa	N151
Robinson River	Karwan	N155
Victoria River Downs	Mudbura	C25
Victoria River Downs	Ngaringman	C27

INSERT FIGURE 1

(Editor: Please use plate prepared for Dr. Kirk's paper).

The blood samples were collected in the Northern Territory as part of an epidemiological survey conducted by the Northern Territory Medical Service, Commonwealth Department of Health, Darwin.

The localities selected for sampling were government settlments, church missions and cattle stations in the northern coastal, northern inland and southern geographical areas of the Northern Territory. We have been advised that the sampling frame was designed to include all Aboriginal population aggregates numbering 50 persons or more, and the sample taken approximated 10 per cent of this population. At each locality households were selected by random numbers and all persons in the household

were sampled. Thus, both parents and at least some of their children were included in many of the households: non-related persons were also included if they were living in the household at the time of the survey. The number of households was adjusted wherever possible to give a total sample of approximately 100 individuals for each locality, but in some localities the number was considerably smaller.

In the present paper the blood groups are given only for Aborigines considered to be full-blooded, and where admixture was thought to be possible Miss D.E. Malley of the Academy of Science, Canberra, checked genealogies and also Welfare Department records in Darwin.

The blood samples were obtained by venepuncture and stored at 0-4°C. until collecting was complete at each locality. Some serum was removed from the clot for special studies, and the blood samples were air-freighted to Canberra in water-ice. The serum and portion of the clot were removed for the Canberra and Sydney studies, and the remainder of each clot was air-freighted to Melbourne in glucose-citrate preserving solution kept chilled in water-ice. Red cell suspensions were made up to 20% strength in glucose-citrate solution and tested as quickly as possible by the slide method described by Simmons et al. (1951) using either saline or albumin-agglutinating testing sera. The Xg^a tests were made by the indirect Coombs method and the reagents used were kindly provided by Miss Dorothy Henaman of Hyland Laboratories, Los Angeles, and by Dr. F.H. Allen of the New York Blood Center, New York.

Blood group frequencies were calculated by methods referred to by Simmons et al. (1961). The frequencies for Xg^a were calculated by the iterative gene counting method of one of us (J.J.G.) which gives the same values as the method described by Haldane (1963).

RESULTS AND DISCUSSION

The data in this survey are presented as follows: Table 1 A_1A_2BO, Table 2 MNSs, Table 3 Rh, Table 4 Duffy (Fy^a,Fy^b), Lewis (Le^a), Diego (Di^a), Table 5 Xg^a, Table 6 Details of admixed Aborigines discarded from the survey, Tables 7 and 8 Summary of earlier blood group studies in the Northern Territory, Table 9 The blood groups of a Northern Territory Aboriginal family in which a female child exhibiting

virtually complete, universal albinism was the example reported by Walker (1969).

The ABO Blood Groups

Table 1 presents the A_1A_2BO blood groups and gene frequencies for 1195 Australian Aborigines living in the Northern Territory.

In Tables 1-4 the data are presented on a north to south basis and as far as possible on an adjacent tribal basis for ease of gene frequency comparisons.

In the northern half of the Northern Territory the O frequencies range from 0.802 for miscellaneous tribes at Bamyili and 0.803 for Ranjbarngu mostly at Mainoru to 0.928 for the Ngaringman at Victoria River Downs. There was one exception from the 0.8 - 0.9 range, namely, the Gunavidji at Maningrida whose O was 0.722. In the southern half the four tribal groups have O frequencies as follows: 0.630 Luridja, 0.644 Waljbiri, 0.703 Bidjandjadjara and 0.744 Aranda, and without doubt the present frequencies confirm the results of earlier surveys summarized in Table 7 which shows O values in the southern region as low as 0.54 (Cleland, 1932), but mostly in the 0.6 - 0.7 range as we found. Simmons et al. (1964) have summarized in their Table 4 the ABO, MN and Rh gene frequencies for Queensland south of Cape York, the Cape York localities of Mitchell River, Edward River and Aurukun, Bentinck and Mornington Islands in the Gulf, and for the nearby mainland. The highest O values found were 0.94 at Aurukun and 0.93 at Mornington Island. Other values ranged from 0.76 to 0.85.

No example of A_2 appears in the series, but one A_2 Aranda at Hermannsburg and four A_2 Aranda at Areyonga were discarded because of racial admixture. A complete list of all the Aborigines discarded because of admixture is given in Table 6 with other relevant data.

There were five examples of group B and one of A_1B found in 1195 Aborigines and included in Table 1. These six Aborigines were as follows: One in 23 Andiljaugwa of Groote Eylandt, one in 47 of miscellaneous tribes at Roper River, one in 58 of miscellaneous tribes at Darwin, two of 14 Karwan at Robinson River, were of group B, and one of 21 Gunwinggu at Bamyili was of group A_1B. These six individuals

exhibited no visual evidence of admixture nor did their genealogies or records indicate that this was a possibility. The Karwan tribe was previously called Garawa or Karawa, the latter spelling having been used by Simmons et al. (1964) when it was suggested that the Karwan tribe may have been the main source for the dissemination of group B to other tribes in the Northern Territory and in Queensland. At that time the individuals examined by Dr. Norman B. Tindale exhibited no evidence of racial admixture. In the present survey three individuals of group B were discarded from the series because of admixture. In the Malag of Elcho Island (Simmons and Cooke, 1969) 10 of 352 aborigines were of group B giving a B frequency of 0.0143. In the present survey (Table 1) we tested 137 Malag from Millingimbi, Maningrida and the Roper River and did not find one example of group B. This apparent inconsistency may be really due to the Malag of Elcho Island acquiring B after becoming separated from their mainland tribal brothers or the latter may have lost their B merely by genetic drift. However, the probability that the difference was due to chance is 0.036 which, though smaller than the usually accepted level for statistical significance in biological work, is not really very remote. Simmons et al. (1962, 1964) reported and discussed in detail the remarkable B frequency of 0.228 found for 47 Bentinck Islanders who had been long isolated from human contact on Bentinck Island in the Gulf of Carpentaria, and these individuals were said to show no evidence of admixture. Still earlier, Simmons et al. (1958) had shown a B frequency of 0.14 at Mitchell River, 0.02 at Edward River and 0.03 at Aurukun settlements located in the Cape York Peninsula of Queensland. However, the Aborigines bled by Dr. D.C. Gajdusek in that multi-purpose survey had not been selected as to purity either by anthropological examination or genealogical study as far as we are aware, but were bled primarily for virus antibody studies. Simmons (1958) found that 14 of 110 (13%) Aborigines of admixed blood (so classified on physical and other grounds by Professor J.B. Birdsell in the Western Australian Aboriginal survey of 1953-54)possessed the group B antigen. In the original report - a lecture - the percentage was incorrectly given as 10.

INSERT TABLE 1

The MNSs Blood Groups

Table 2 presents the results for the MNSs blood groups and gene frequencies for 1195 Australian Aborigines presently living in the Northern Territory. Of the 1195 blood samples tested none was S positive. A series of 128 samples consisting of 14 Malag, 85 Nunggubuju and 23 Andiljaugwa were tested with anti-s and all were positive. Table 6 indicates that we discarded from the survey 27 S positive Aborigines in a total of 49 who were of mixed blood. Simmons (1958) has reported that 12 of 67 (18%) of 110 Western Australian Aborigines of admixed blood so classified by Professor J.B. Birdsell were found to be S positive on subsequent laboratory testing. It becomes obvious that the S antigen of the MNSs blood group system has been widely introduced by racial admixture to Aborigines living in Western Australia and the Northern Territory, and its presence when demonstrated by laboratory testing can be taken to denote racial admixture.

In the 137 Malag (this survey) r was 0.8212 while in the previous survey on 352 Malag blood samples r was 0.7372. In the ABO series there was a marked difference for O values when examined on a north and south basis for the Northern Territory. There is no similar cut-off in r values when similarly examined. In the north r varied from 0.522 to 0.848 and in the south from 0.609 to 0.866. At the Roper River (miscellaneous tribes) r was 0.543 and at the Robinson River (Karwan, etc.) r was 0.522 and these were the lowest r values in the series. In the remaining groups r in five fell roughly between 0.61 - 0.66, in six between 0.72 - 0.78 and in six between 0.80 - 0.87, so that no r pattern of values emerges for 19 tribal and miscellaneous groups in the Northern Territory (Table 2). Simmons (1958) made crude State totals for r and found the following frequencies, with recent values for r inserted in brackets:

Western Australia, 2070, $\underline{n}$ = 0.7556

Northern Territory, 900, $\underline{n}$ = 0.6884

(Northern Territory, 352, $\underline{n}$ = 0.7372, Malag, 1969)
(Northern Territory, 1195, $\underline{n}$ = 0.7343, present survey)

Queensland, Cape York, 267, $\underline{n}$ = 0.712

Queensland, Except Cape York, 715, $\underline{n}$ = 0.7852

Queensland total, 982, $\underline{n}$ = 0.7635

It is therefore clear that $\underline{n}$ values for Aborigines in three Australian States are very similar.

INSERT TABLE 2

The Rh Blood Groups

Table 3 presents the Rh groups and gene frequencies for 1195 Aborigines. The gene $\underline{R^o}$ was not detected in 137 Malag in the present survey, i.e. amongst Malag living on the mainland, but had a value of 0.0384 for 352 Malag recently tested on Elcho Island (Simmons and Cooke, 1969). The gene $\underline{R^o}$ was demonstrated in all Northern Territory groups except 85 Nunggubuju, 23 Andiljaugwa, 23 Gunavidji, 31 Ranbarngu in the north and 97 Bidjandjadjara in the south, so that it is widely distributed. The gene $\underline{R^z}$ was found in all groups tested except 104 Tiwi, so that it has an even wider distribution in the Northern Territory Aborigines. Only 3 examples of $\underline{R^zR^z}$ were demonstrated and these occurred in the Gunavidji (2 in 23) and in the Luridja (1 in 78). Simmons and Graydon (1948) first reported examples of $\underline{R^z}$ in Australian Aborigines and Simmons et al. (1953) reported three examples of homozygous $\underline{R^zR^z}$ found at Wiluna, Jigalong Mission and at Pilgangoora in Western Australia. The two surveys on 352 Malag living on Elcho Island and 137 living at Millingimbi, Maningrida and Roper River gave Rh frequencies as follows:-

No. tested = 352: $\underline{R^o}$ = 0.0384, $\underline{R^1}$ = 0.770, $\underline{R^2}$ = 0.0866, $\underline{R^z}$ = 0.0980

No. tested = 137: $\underline{R^o}$ = 0 , $\underline{R^1}$ = 0.7336, $\underline{R^2}$ = 0.2117, $\underline{R^z}$ = 0.0547

In the Elcho Islanders four Rh genes, $\underline{R^o}$, $\underline{R^1}$, $\underline{R^2}$ and $\underline{R^z}$ were demonstrated, while in the Malag of the mainland there was no $\underline{R^o}$, and $\underline{R^2}$ increased in value from 0.0866 to 0.2117, which further accentuates the gene frequency differences between the two groups classified today

as Malag. In the ABO groups we had found B = 0.0143 for Elcho Islanders while B was not detected in the Malag mainlanders who also possessed an N frequency of 0.8212, while the Elcho Islanders had an N frequency of 0.7372. These gene frequency differences in the ABO, MN and Rh blood group systems are sufficiently divergent to cause us to suggest that Elcho Island Malag have been subjected to racial admixture while the Malag of the mainland have resulted from a purer Australian Aboriginal Malag stock.

The R^1 gene in the northern area has values ranging from 0.600 for Nunggubuju to 0.935 for Ranjbarngu with two exceptions only, while R^2 ranged from 0.067 for Gunwinggu to 0.371 for miscellaneous tribes at Roper River. In the southern area R^1 varied only from 0.542 for miscellaneous tribes at Amonguna and Yuendumu to 0.6271 for Aranda, so that R^1 values in the south are generally lower than in the north. R^2 varied from 0.2960 for Aranda to 0.3941 for Waljbiri, thus presenting a more uniform range of frequencies in the southern area.

Variants of $Rh_o^u(D^u)$ were found in one Aborigine at Victoria River Downs and in one at Bamyili. The former, a female aged 10 of the Nudbura tribe was $Rh_1^uRh_o^u$ (CD^ue/cD^ue) and of "low-grade". Her mother was typed as Rh_1Rh_2 but her father was unfortunately not in the series tested. The variant found at Bamyili was of "high-grade" and of type $Rh_1^uRh_1^u$ (CD^ue/CD^ue). Owing to a duplication of two numbers in this series we are unable to pin-point the Aborigine concerned. In the Rh gene frequency calculations the former was included in the Rh_1Rh_o type and the latter in the Rh_1Rh_1 type as indicated in Table 3.

In the earlier series of 352 samples tested from Elcho Island there were three examples of $Rh_o^u(D^u)$ homozygous "high-grade" variants. Two occurred in type Rh_1Rh_1 and one in type Rh_2Rh_z. This was the first occasion an $Rh_o^u(D^u)$ variant had been found by us in red cells containing the Rh_z type, although we have reported a number of examples in types Rh_o, Rh_1 and Rh_2. A summary of "high-grade" and "low-grade" $Rh_o^u(D^u)$ variants found in the Pacific peoples to 1961 was made by Simmons et al. (1961). The summary covered Papua, New Guinea, New Britain, Australian Aborigines and Polynesians. Other occasional $Rh_o^u(D^u)$ variants have been reported in several surveys since 1961.

INSERT TABLE 3

The Duffy Blood Groups

Table 4 presents the results found for the Duffy (Fy^a and Fy^b), Lewis (Le^a) and Diego (Di^a) blood groups. A summary of previous results for the three blood group systems for Australian Aborigines has been made by Kirk (1965). In four surveys reported by Simmons et al. between 1954 and 1962 the Fy(a+) percentage was 100.

In the Elcho Island survey (Simmons and Cooke, 1969) Australian Aborigines were tested with both anti-Fy^a serum and anti-Fy^b serum for the first time, and of 179 Malag tested 83.8% were Fy^aFy^a, 15.1% were Fy^aFy^b and 1.1% were Fy^bFy^b. Thus, the Fy^b gene was demonstrated for the first time in Australian Aborigines. The gene frequencies were: Fy^a 0.9134, Fy^b 0.0866. In the present survey 137 Malag gave an Fy^a frequency of 0.9599 and Fy^b of 0.0401. Table 4 shows that the Fy^b gene was demonstrated in all the tribal groups tested except Nunggubuju, Andiljaugwa, Ranjbarngu in the north, and Bidjandjadjara in the south, but this does not necessarily mean total absence from these tribes owing to the small numbers involved and the general low frequencies of Fy^b. The Duffy gene frequencies for 1195 Australian Aborigines were: Fy^a 0.9640, Fy^b 0.0360.

The Lewis (Le^a) Blood Group

In the Malag of Elcho Island (Simmons and Cooke, 1969) 13 of 179, 7.3% were Le(a+). In the present survey only 175 samples from the north were tested and of these five, 2.9% were Le(a+). In the Nunggubuju 4 in 85, 5% were Le(a+) and of the Roper River 1 in 47, 2% was Le(a+). In four previous surveys in Australian Aborigines by Simmons et al. between 1954 and 1962 Le(a+) percentages ranged from 0 - 10. Simmons et al. (1954) found the following Le(a+) examples: Darwin 2 in 30, Elsey Station 2 in 9, Yuendumu 7 in 93, Ernabella 1 in 32, giving a total of 12 in 164, 7.3% Le(a+) demonstrated in the Northern Territory and South Australia. Simmons et al. (1957) tested 100 samples collected at Haast's Bluff, South Australia, and none was Le(a+). Simmons (1958) reported that 106 of 1536 samples, 6.9% from

Western Australian Aborigines were Le(a+), while Simmons et al. (1962) found 4 in 42, 10% of Bentinck Islanders Le(a+), and 0 in 67, 0% of Mornington Islanders, Gulf of Carpentaria, Le(a+). Kirk (1965) presented data for Vos and Kirk (unpublished) relative to the Le^a blood group for Aborigines in 15 localities in Western Australia and Queensland, and in the former, Le^a ranged from 0 - 20.6% and in the latter from 8.4 - 21%.

The Le^a blood group antigen although mostly of low frequency is widely distributed in Aborigines in the various Australian States. We have tested a limited number of Le(a-) samples with anti-Le^b serum with positive results. However we now know that the Le(a-b-) type occurs in Aborigines as in other races (Table 9).

The Diego (Di^a) Blood Group

In the Malag of Elcho Island (Simmons and Cooke, 1969) no example of Di(a+) blood was found in 179 blood samples tested. Previous surveys in Australian Aborigines by Simmons et al. and by Vos and Kirk (Kirk, 1965) have shown that no Di(a+) example had been found in 690 blood samples tested from Aborigines in Western Australia, South Australia and Queensland. In the present survey in the Northern Territory no Di(a+) was found in 1195 unmixed Aborigines tested. However, one blood sample in the series was found to be Di(a+) and this came from a male baby one year old at Robinson River. The mother and the alleged father were both Di(a-), and the possible explanation was sought through Miss D.E. Halley who subsequently questioned and examined the family. We had noted that when the tribal details were listed for us at the time of blood sample collection the alleged father, the mother and a five year old son were shown as Garawa (now Karwan) while the Di(a+) baby's tribe was simply shown as a ?. Dr. R.L. Kirk sent us the following report on Miss Halley's observations:

"She has not been able to obtain information from the mother of the one year old boy (320403), although she saw the child and did not report anything unusual about its appearance. However, there is one half-caste at Robinson River who is noticeably Chinese and the family 3204 was at one time on a neighbouring cattle station which

employed a number of Chinese. In addition, Miss Halley's informants tell her that the mother of 320403 is known to have other liaisons while her husband is in stock camp, and one possible explanation of the query set against the tribe for the baby is that the mother did not wish to name the father in front of her husband. In view of these facts I think it may safely be assumed that the Di(a+) reaction is not of pure Aboriginal origin."

The first report on Di^a tests in Pacific peoples was that of Simmons (1957) who found no Di(a+) example in 80 Polynesians, 112 Australian Aborigines of Central Australia, 50 Australian Aborigines of Cape York, Queensland, 23 Eastern Papuans and 74 natives of New Britain. The Di^a gene has been accepted as a Mongoloid marker gene since its discovery by Layrisse et al. (1955), but Simmons et al. (1968) reported finding a "natural" agglutinating example of anti-Di^a specificity in a white Australian female, and five examples of the Di^a blood group antigen in a white Australian family of Irish descent. The Australian finding lends support to the suggestion that the Di^a blood group is not exclusive to Mongoloids or peoples with Mongoloid admixture, but occurs as a low-incidence blood antigen in unmixed Caucasians, while unmixed Mongoloids and American Indians may possess it in higher and variable degree. Simmons (1969) further reviewed the racial distribution of the Di^a antigen, the finding of other examples of anti-Di^a antibody which had not been published, and the finding of two examples of anti-Di^b antibody antithetical to anti-Di^a in Los Angeles in 1967. At the time of writing the 1969 report Simmons had tested over 1000 New Guinea blood samples without finding a Di(a+) example. The 1000 blood samples from Australian Aborigines also reported in that paper as being Di(a-) represented progressive results abstracted at the time from the total of 1536 Northern Territory Australian Aborigines tested to date for the Di^a antigen by one of us (R.T.S.). In addition, Vos and Kirk (Kirk, 1965) have tested 528 Australian Aborigines and found none to be Di(a+).

As this report is being written we have just identified an incomplete example of anti-Di^a antibody in the serum of a patient, and the Di(a+) red cell antigen in a blood donor for the Blood Bank at the Singapore General Hospital, Singapore.

It should also be noted that when Di(a-) blood samples from Australian Aborigines and New Guinea natives have been tested by us with anti-Di^b antibody kindly provided by Miss Dorothy Hensman of Hyland Laboratories, Los Angeles, they have been found to be Di(b+) as expected. However, only a few samples have been tested to date.

INSERT TABLE 4

The X-Linked Blood Group Xg^a

Table 5 presents the results found for the Xg^a blood group antigen in a total of 352 Australian Aborigines living in Central Australia within the Northern Territory.

The Xg^a antigen and corresponding antibody were found and reported by Mann et al. (1962). This sex-linked blood group has since been the subject of a series of fine studies by Race, Sanger and many others which have resulted in much new genetic data being made available.

The Xg^a gene frequency presented in Table 5 was calculated as stated earlier by the iterative gene counting method of one of us (J.J.G.) which gives the same values as the formula published by Haldane (1963).

Race and Sanger (1968) have summarized the racial Xg^a gene frequencies to 1968 as follows: Northern European 0.66, Sardinians 0.76, Israelis 0.68, Indians, Bombay 0.65, Chinese, Singapore 0.46, Chinese, Mainland 0.60, Chinese, Taiwan 0.53, Chinese, Hakka 0.53, Aborigines, Taiwan 0.38, Chamorros, Mariana Islands 0.65, Negroes, New York and Jamaica 0.55 and Indians, Navajo 0.77. To this series we have now added the Australian Aborigines of Central Australia with an Xg^a frequency of 0.79, and this frequency is slightly higher than that for Sardinians 0.76, and Navajo Indians 0.77.

INSERT TABLE 5

Introduced Genes in Australian Aborigines

Table 6 provides a list of the Australian Aborigines living in the Northern Territory who were removed from the survey results because of racial admixture. The table presents for each individual the locality, the survey number, the tribe and the "introduced" blood group gene. It seems important that this data be placed on record so that the present observations and genealogical data will be available to those who conduct racial genetic surveys in the next one, two or more decades.

Simmons (1958) referred to the blood group serological results obtained in a survey of Australian Aborigines conducted in association with Professor J.B. Birdsell in Western Australia in 1953 and 1954. We tested at that time 1698 Aborigines selected anthropologically by Professor Birdsell as being unmixed, and 110 who were classified as being of mixed blood in the genealogical records sent to us before the testing commenced. The "introduced" genes in the mixed Aborigines were B of ABO system, S of MNS, r (cde), r^{w} (C^{w}) of the Rh system and the blood group gene K of the Kell system.

The serological blood grouping results of this early survey are presently being extensively and critically analysed by Birdsell in distant association with Simmons and Graydon, who provided the serological and statistical results respectively for this major blood group study. Many localities in Western Australia were visited by Birdsell, and he has complete data on both the mixed and the unmixed Aborigines of this State permanently in his files in the Department of Anthropology and Sociology at the University of California, Los Angeles. Thus, there are records for some of the known Aborigines of mixed blood presently living in Western Australia and in the Northern Territory, and we should aim to extend these blood group records to mixed Aborigines in South Australia and Queensland. Simmons (1966) discussed the introduction of "new" blood group genes to the Australian Aborigines of the various Australian States at a Symposium entitled "Change Among Australian Aborigines", and he concluded with the following remark:

> "It is known that Papuans, Malays, New Hebrideans, Polynesians, Chinese and Whites have contributed to the present aboriginal genetic make-up. The data presented show that the Australian aboriginal gene pool is definitely not static and never has been, and that change in aborigines is both real and constant."

In Table 6 it will be seen that there were four admixed Aborigines with the B antigen of the ABO system and all were located at Roper River. Of these, one was of the Alawa tribe, one was shown as Bunbar, a tribe not known to us, and the tribes of the other two were not ascertained. There were five examples of subgroup A_2 and four of these were found in a father and his three young daughters all of the Aranda tribe at Areyonga, while the fifth was found at Hermannsburg and again was of the Aranda tribe.

In Table 6 the survey numbers of 52 Aborigines of mixed blood are listed, and of these 50 were blood grouped. Of the 50 there were 27 (54%) with the S antigen of the MNSs system. One S positive was located at Maningrida, six were at the Roper River, twelve were at Victoria River Downs, two were at Amoonguna, two were at Hermannsburg and four were at Maryvale. The tribes involved were: Unknown 3, Malag 1, Ngalagan 1, Wandarang 3, Mara 1, Mudbura 1, Ngaliwuru 1, Gurindji 6, Ngaringman 2, and Aranda 8. Of the 27 S positives found there were 13 in five families. It will be recalled that the S antigen was not found in 1195 Northern Territory Aborigines classified as being of unmixed blood. (Table 2).

Simmons (1958) reported that the S antigen was not found in 1698 Aborigines of Western Australia who had been selected anthropologically as being of unmixed blood by Professor Birdsell. The S antigen, however, was found in 12 of 67 (18%) of Western Australian Aborigines selected as being of mixed blood. Thus, the S blood group antigen has become widely distributed in the Northern Territory and in Western Australia probably due to recent admixture. Its presence serves as a useful guide to racial admixture.

INSERT TABLE 6

Earlier ABO, MN and Rh Blood Group Studies

Table 7 presents a summary of the earlier reports on ABO, MN and Rh blood groups for Aborigines of the Northern Territory, Central Australia, the coastal islands of Bathurst, Melville and Elcho and for Groote Eylandt in the Gulf of Carpentaria. It does not include the data presented in Tables 1 - 3 of the present paper. The purpose of this table is to provide a gene frequency summary of this important area in Australia for ease of reference. The gene frequencies for the Aborigines of Cape York, for areas south of Cape York, for the Mornington and Forsyth Islands in the south of the Gulf of Carpentaria, and for the adjacent mainland have been summarized by Simmons et al. (1964) and by Kirk (1965).

Australian Aborigines have subgroup A_1 and no A_2. Tests for the A_1-A_2 subgroups of group A commenced in 1940 with the survey made by Wilson et al. (1944). The lowest A frequencies recorded in Table 7 and Table 1 are as follows:

Robinson River, Misc. tribes, Table 1,	0.045
Victoria River Downs, Ngaringman, Table 1,	0.07
Bathurst Island, Tiwi, Table 1,	0.07
Bathurst Island, Tiwi, Table 7,	0.14, 0.17
Groote Eylandt, Misc. tribes, Table 1	0.07
Groote Eylandt, Misc. tribes, Table 7,	0.08
Darwin, Misc. tribes, Table 7,	0.11
Darwin, Misc. tribes, Table 1,	0.18
Elcho Island, Malag, Table 7,	0.12
Roper River, Misc. tribes, Table 7,	0.14
Roper River, Misc. tribes, Table 1,	0.16

All the areas listed are in the north of the Northern Territory whereas all the Central Australian areas have higher A frequencies. The discussion on Table 1 in the text relates mainly to the distribution of O in various tribes in the north.

The frequency of gene n is consistently high ~~xxx~~ in Table 7 and ranges from 0.61 - 0.81.

The gene $\underline{R}^{o}$ was found in all localities except Alice Springs where a small series of only 23 samples were tested. However, in Table 3 $\underline{R}^{o}$ was absent from the Malag, but it was present in the series reported by Simmons and Cooke (1969). $\underline{R}^{o}$ was not found (Table 1) in 85 Nunggubuju, 23 Andiljaugwa, 23 Gunavidji, 31 Ranjbarngu and 97 Bidjandjadjara.

The gene $\underline{R}^{z}$ (Table 7) was not detected at Bathurst Island, Yuendumu or in 47 samples from 6 localities. In Table 3 it was again absent at Bathurst Island and it was not detected in 26 Mudbura at Victoria River Downs, but other tribes in this area possess $\underline{R}^{z}$. Tables 3 and 7 show that $\underline{R}^{z}$ has been found in 26 of 31 surveys so that this gene, rare in Caucasians, is widely distributed in Australian Aborigines.

INSERT TABLE 7

Earlier Studies on Other Blood Groups and Special Test Reactions

Table 8 presents a summary of the earlier surveys relating to the following blood groups: $Rh_o^u(D^u)$ variants, $rh^w(C^w)$, P_1, Le^a, Fy^a, Fy^b, K and Di^a, to saliva secretion and P.T.C. taste reactions. A more complete summary for Australian Aborigines in general has been made by Kirk (1965).

Table 8 should be used in conjunction with Tables 4 and 5 of the present survey.

Both "high-grade" and "low-grade" $Rh_o^u(D^u)$ variants occur in Australian Aborigines, the $rh^w(C^w)$ blood antigen has not been found, the P_1 blood group percentage is mostly in the 20 - 30 range, Le^a varies from 0 - 8 percent, saliva secretion follows the Lewis blood type mostly in the limited tests made, the Fy^a blood group is usually 100% and the Fy^b group has been demonstrated (Table 4) in 15 out of 19 surveys listed. The blood group K has not been found in limited tests in the areas under review, or in other parts of Australia (Kirk, 1965). Tasters and non-tasters of P.T.C. have been recorded, and about 50% appear to be tasters. The Di^a blood group has not been found in 1486 blood samples tested (Tables 4 and 8). Details of the Xg^a blood group tests are given in Table 5 and the results have been discussed earlier in the text.

INSERT TABLE 8

Blood Groups in a Case of Albinism in a Northern Territory Aboriginal Child

Table 9 presents the blood group results of studies carried out by one of us (R.T.S.) on a Northern Territory Australian Aboriginal family with an offspring exhibiting virtually complete universal albinism. This case with details of physical and other observations made has been reported by Walker (1969) together with a colour photograph of the mother and child. The present report is intended only to place on permanent record the blood groups of the Aboriginal father, mother and child. In all, 11 blood group systems were studied, and a number of rarer type antisera were used which have not been available previously for blood group studies on larger numbers of Aborigines. The additional antisera tests relate to the following blood groups:

The Lewis (Le) Blood Group: Tests with anti-Le^b serum disclosed that Aborigines have the type Le(a-b-).

The Lutheran (Lu) Blood Group: Tests made with anti-Lu^b serum showed that Lu(a-) Aborigines have the Lu^b blood group.

The Duffy (Fy) Blood Group: Tests made with anti-Fy^b serum were negative, but tests on other Aborigines have disclosed that some Aborigines have the Fy^b blood group.

The Kell (K) Blood Group: Tests made with anti-K, anti-k, anti-Kp^a and anti-Kp^b sera showed that Aborigines follow the most common Caucasian pattern of being K-k+Kp(a-b+)

The Kidd (Jk) Blood Group: Tests made with anti-Jk^b serum were negative, but tests on other Aborigines showed that some possess the Jk^b blood group.

The Diego (Di) Blood Group: Tests made with anti-Di^a and anti-Di^b sera disclosed that Di(a-) Aborigines are Di(b+).

The Xg^a Sex-Linked Blood Group: Tests made with anti-Xg^a serum showed that Aborigines like Caucasian and other races possess the Xg^a blood group. In the present family the father, mother and child were all Xg(a+).

The blood group results found in 11 blood group systems showed no incompatibilities between the mother-father and their albino child.

INSERT TABLE 9

SUMMARY

ABO, MNSs, Rh, Fy^a, Fy^b and Di^a blood group gene frequencies are presented and discussed for 1195 Australian Aborigines living in 16 localities in the Northern Territory of Australia including Bathurst Island off the north-west coast, and Groote Eylandt in the Gulf of Carpentaria. (See also our recent report on Elcho Island Aborigines).

Of the blood samples received 175 from the north were tested for the Le^a blood group, and 352 from the south for the sex-linked blood group Xg^a.

A list of the Aborigines who were removed from the survey because of racial admixture is presented, and the presence and varieties of "introduced" genes in this, and an earlier survey, is discussed.

Summaries of earlier blood group gene frequencies found in the Northern Territory and Central Australian Aborigines are presented for ease of reference for the ABO, MN, Rh and for other blood group systems.

The blood groups found in eleven independent systems are reported for a Northern Territory Aboriginal family with an albino child. The case report on this child and her parents was published in 1969 by Dr. A.C. Walker of the Darwin Hospital, Northern Territory.

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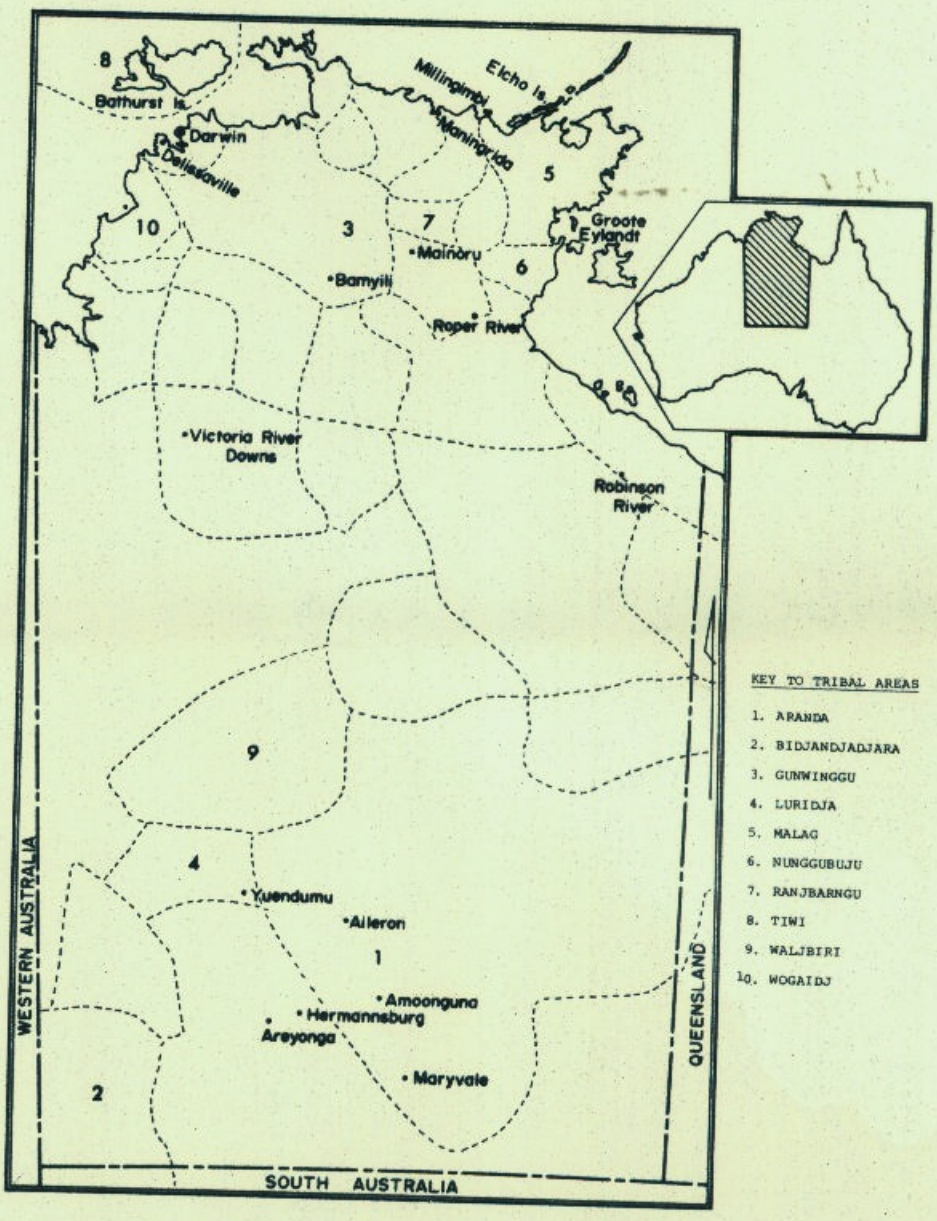

Fig.1 Map of Northern Territory of Australia showing localities and tribal areas mentioned in text.