Overview

Nutrition and health (1948) of Aborigines in settlements in Arnhem Land, northern Australia

Margaret McArthur, Brian P. Billington and Kelvin J. Hodges
Overview written by Prof. Raymond L. Specht

American-Australian Scientific Expedition to Arnhem Land
Nutrition Unit, Australian Institute of Anatomy, Canberra, Australia

During the American–Australian Scientific Expedition to Arnhem Land in 1948, a nutritionist (Margaret McArthur), a medical officer (Brian Billington), a biochemist (Kelvin Hodges) and also the 'flying dentist' (John Moody) observed the nutrition and health of Aborigines in the settlements on Groote Eylandt, at Yirrkala and at Oenpelli, Northern Territory. The results of their research were published in the *Records of the American–Australian Scientific Expedition to Arnhem Land Volume 2 Anthropology and Nutrition.* (Melbourne University Press, 1960).

Although seasonal and regional variations in food supply were a constant problem for nomadic Aborigines living on 'bush tucker' gathered from marine, freshwater and terrestrial ecosystems, the variety of food provided a well-balanced diet according to the international recommendations of 1948.

In contrast, improvements in the 1948 diet of Aborigines in the settlements were strongly recommended.

1 An increase in the quantity of food given to older children and adolescents.
2 Regular distribution of fresh fruit and vegetables throughout the year from settlement gardens.
3 Regular supplies of fish, meat and other animal products, particularly for children, adolescents, pregnant and lactating mothers.
4 Increased production of milk and greater care in its handling.
5 Greater use of whole grain cereals in preference to refined products.

Key words: Aborigines, dietary levels, food consumption, health, nutrition, physique.

Introduction

The National Geographic Society–Smithsonian Institution–Commonwealth of Australia Expedition to Arnhem Land, Northern Territory, was planned as a result of negotiations between representatives of the Australian Government and the National Geographic Society of Washington, DC, USA.

The Australian Government realised that such an expedition afforded a great opportunity, both to better the good relations between Australia and the USA, and to investigate one of the least known parts of Australia, Arnhem Land, where little was known of its natural history and ethnology. To further these aims, the Minister for Information arranged for a comprehensive study of the region by a party of American and Australian scientists — an anthropologist, an ethnologist, an archaeologist, a botanist/ecologist/ethnobotanist and three zoologists to study mammals, birds, reptiles and fish. A nutrition unit consisting of a nutritionist, a medical officer and a biochemist was appointed by the Australian Institute of Anatomy, Canberra, to study the health and nutrition of Aborigines.

The Expedition of ten scientists, two photographers and three support staff spent 7 months in the field from April to October 1948. Four volumes of the *Records of the American –Australian Scientific Expedition to Arnhem Land* were published by Melbourne University Press (1956, 1958, 1960, 1962),[1–4] several articles appeared in the National Geographic Magazine (1946–1949)[5–9] and five films[11–13] on the culture of Arnhem Land Aborigines were produced. *Personal Experiences on the Coast of Adventure*[14] (edited by Ray and Alison Specht) were collated at Southern Cross University, Lismore, for the Fiftieth Arnhem Land Reunion (Sydney, 27–28th June 1998).

The results of the research of the Nutrition Unit of the Australian Institute of Anatomy were published in the *Records of the American–Australian Scientific Expedition to Arnhem Land Volume 2 Anthropology and Nutrition*[3] (Melbourne University Press 1960). The nutrition studies and ethnobotany of nomadic Aborigines[15] in coastal and inland localities of Arnhem Land, undertaken by Margaret McArthur, Fred D McCarthy and Ray L Specht, are summarised in the following paper in this journal. Three reports on the nutrition and health of Aborigines in Arnhem Land settlements in 1948 are reproduced in this issue of *Asia Pacific Journal of Clinical Nutrition*:

1. Food consumption and dietary levels of the Aborigines at the settlements[16] by Margaret McArthur (1960).
2. Report of the biochemical assessments of nutritional status[17] by Kelvin J. Hodges (1960).

Correspondence address: RL Specht, Emeritus Professor of Botany, The University of Queensland, 107 Central Avenue, St Lucia, Queensland 4067, Australia.
Tel: 61 7 3870 2240
Email: r.specht@mailbox.uq.edu.au
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3. The health and nutritional status of the Aborigines[18] by Brian P. Billington (1960).

The general pathology of the Aborigines in the settlements — trauma, tropical ulcers, respiratory diseases, venereal disease, yaws, eye lesions, skin diseases, leprosy, malaria, filariasis, and internal parasites — is included in the following facsimile reproduction of Billington's article[18] in Volime 2 of the Records of the American–Australian Scientific Expedition to Arnhem Land (1960).

The report[19] on the dental and periodontal conditions of Aborigines who were examined in the Arnhem Land settlements during 1948 by the 'flying dentist' John E. H. Moody has not been reproduced in this issue of the *Asia Pacific Journal of Clinical Nutrition*.

Almost 40 years after the Arnhem Land Expedition of 1948, John Cawte examined the mental health of Aborigines of Elcho Island and Groote Eylandt in Arhen Land. The results of his studies are reported recently published books (1996, 2000).[20,21]

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ARNHEM LAND: ANTHROPOLOGY AND NUTRITION *

2. FOOD CONSUMPTION AND DIETARY LEVELS OF THE ABORIGINES AT THE SETTLEMENTS

by MARGARET MCARTHUR

THIS REPORT deals with the four settlements for aborigines in Arnhem Land which were visited by the nutrition group. It is impossible to give an accurate assessment of the diet of the natives because of the fluctuations in the number living at the settlements, the great seasonal variations in the foods that can be grown locally, and the variation (due to the unreliability of shipping) in foodstuffs imported into the area. An attempt has been made to give a general report, covering food intake for several years where possible.

The two sources of food for the natives are the rations distributed by the settlements and the naturally occurring foods which they gather for themselves. The aborigines have been encouraged, not against their will it would appear, to abandon their former nomadic life and settle at the stations. It is difficult to tell from the figures available how frequently and for how long the aborigines leave the settlements, but the general impression is that the vast majority spend all but a few weeks there each year. Since practically all of those at the settlements draw rations for five or six days each week, these rations form by far the greater part of the food they eat.

At all settlements rations are distributed three times daily just before meal-time. At Umbakumba the natives are fed for the five and a half working days and when supplies are plentiful rations are also distributed during the week-end. At Angoroko and Oenpelli rations are given for the five working days, and those who attend church on Sunday are also fed. On Saturday they are encouraged to collect their own food from the surrounding country. At Yirrkalla the natives who are working are fed for the whole period of their employment; the remainder may stay at the mission, but they have to find their own food. Small groups sometimes go away to other areas where food is more plentiful. Everybody who attends church on Sunday receives rations.

Because of the distance of these settlements from the centres of Australian industry and commerce, shipping is infrequent, irregular and expensive. Consequently the foods which are bought for consumption by the native population are cereals and cereal products such as flour, wheat, and rice. These can be considered as the staple foods of the aborigines at the settlements; when other foods produced locally are lacking they may receive nothing but these.

The production of some form of supplementary food is undertaken at all settlements. The vegetable gardens are a communal concern at each station; individual plots have been allocated to some natives in the past, but the general impression seemed to be that this system did not work out satisfactorily. In all cases the Europeans, who may be assisted by half-castes, direct the work.

At Umbakumba, where the gardens had been neglected during the years of Mr Gray's absence, the natives were working to restore them to full production. The station was established in 1938, and from June 1941 to December 1945 the

* The following is reproduced courtesy of the State Library of South Australia.

garden was reported to have produced sufficient for two meals per day (with the addition of marine products) for all the natives for approximately six months of the year. Just before the expedition left in July 1948, sweet potatoes were being harvested. The crops, which continued until November-December, were reported by Mr Gray to exceed all previous years. From figures supplied by Mr Gray for the period from March 1948 to March 1949, the mean daily gross production of vegetables per head of population has been calculated. The figures are:

Cassava	15·5 oz.
Sweet potatoes	7·5 oz.
Other fruit and vegetables	7·5 oz.

The main foods grown are cassava and sweet potatoes. One-half of the 7·5 oz. of 'other fruit and vegetables' was water-melons. Bananas, lettuce, cabbages, tomatoes, beans, turnips, swedes, onions, carrots and papaws were also grown. Except for cassava which can be dug the whole year round, the vegetables are harvested from May till October, although with irrigation the season can be extended for a month or two. For the remaining six months of the year the only fresh vegetable is cassava; the bulk of the diet during this period consists of flour, whole wheat and blue peas.

The principal source of animal protein at Umbakumba is marine products. A party of men is sent to the nearby North East Islands each week for turtle and turtle eggs. Varying numbers are brought in throughout the year, but in July, August and September the number of turtles and turtle eggs reaches its maximum. In 1947, during these months, up to ten or twelve turtles were brought in each day. In addition, unless there is urgent work to be done in the garden, two men are sent fishing in the lagoon each day. A goat was being killed each fortnight for meat, but little remained for distribution to the camp after the needs of the staff and the dormitory children were met. The herd of bullocks is being built up to provide food. Hen eggs are included in the ration several times a week in season.

At Angoroko the following meal pattern is adhered to for the greater part of the year. Stores were low during our visit and it was modified.

Breakfast: Ground-wheat porridge, sweetened with golden syrup or honey; damper; tea and sugar.

Dinner: Wheat porridge or rice; fresh vegetables or golden syrup or honey; damper; tea and sugar.

Supper: Damper and fish; tea and sugar.

If there is not enough fish for everybody, the men and the girls' dormitory are given priority. The women and children have porridge, sweet potatoes or cassava if there is no fish. The damper is normally made from two parts of white flour to one part of ground wheat.

The seasonal production of fresh vegetables is similar to Umbakumba. The same variety of vegetables is grown during the dry season. Papaws, pineapples and small quantities of pumpkins are harvested in addition to cassava during the wet season. Peanuts, which are harvested in May, June and July, have been grown successfully in recent years. From the average population figures for the period

January 1944 to June 1948, the mean daily production per head has been calculated. The figures are:

Cassava	3·8 oz.
Sweet potatoes	2·6 oz.
Other fruit and vegetables	0·5 oz.

In addition the peanut crop in 1948 was 4 tons 6 cwt. The weight of fish which was caught had declined in the months prior to the expedition's visit. Until that time the truck went to the beach each day to transport the catch to the station. As this was too costly the fishermen now have to walk the four miles up the river from the coast and they will catch only as many fish as they can comfortably carry. Turtles are the other important marine food eaten, together with small amounts of turtle eggs, dugong, wallaby, and bullocks. The herd of cattle is being built up to supply food.

The distribution of food at Yirrkalla mission was mainly left to several native men who have a position of some authority at the settlement. This is in contrast to all other establishments where the food is distributed by Europeans or half-castes who are on the staff. No information could be obtained about the number of natives living at the station in the years since its establishment, nor about the diet on which they have been fed. The garden, which was very small in July-August 1948, had been severely damaged by cyclones some months before, and it was impossible to make any estimate of its normal production. At the time of our visit to Yirrkalla there were some sweet potatoes in storage, and these were being given as rations. A few water-melons were given to the children, and cassava and pineapples were almost ready for harvesting. The quantities of pumpkins, tomatoes, Chinese cabbages and pie-melons were insufficient for a distribution to the natives. About a dozen coconut palms have been grown successfully, but the extensive banana plantation had been ruined in the cyclones. Foods being given as rations to the natives were army biscuits, flour (a mixture of two parts of white flour to one part of whole wheat), rice, meat and vegetable stew, and sweet potatoes.

At Oenpelli the diet in August-October 1948 consisted of white flour, rice, tea and sugar, buffalo and beef. No vegetable garden was under cultivation at the time, but in the past two years a variety of fruit and vegetables had been grown. The main crops grown were sweet potatoes, cassava, yams, and peanuts. Pumpkins, melons, several different varieties of beans, tomatoes, papaws, custard-apples and mangoes were produced in smaller quantities. The same seasonal variation applies at Oenpelli as at Groote Eylandt. Separate weights for individual foods have not been recorded, but the total production of fresh fruit and vegetables over the previous two and a half years amounted to approximately one ounce per head per day. The mean daily intake per head of animal products (beef and buffalo) for the same period has been calculated as 9 oz. (excluding bone). The beef is from the station herd. Large numbers of buffalo are killed, primarily for the hides, but those slaughtered near the mission are used as food. The stock boys on tailing duty

also add to the diet of their families with wild game which is abundant around Oenpelli. Wild goose eggs are very plentiful on the plains at the end of the wet season and the aborigines eat them in large numbers.

All stations have goat herds for milk. The surplus left after the requirements of the Europeans at the stations have been met is given to the native children. At Angoroko and Yirrkalla there was no surplus. At Umbakumba the dormitory children were given up to half a pint per head on alternate days. Each day the children of pre-dormitory age at Oenpelli, and the expectant and nursing mothers were given about 8 oz. each, and at night the dormitory children were given an 8-oz. cupful, the boys one night and the girls the next. When the supply is sufficient both boys and girls at Umbakumba and Oenpelli are given milk each day. Another instance of the special feeding of a particular group is carried out at Angoroko. When the supply of vegetables is insufficient for the whole settlement, the young children of one to two years are given a serving of cooked vegetables for the midday meal. The pregnant women are given papaw when the supply is not sufficient for general distribution.

An additional source of food which is available at Yirrkalla is the store conducted by the mission. The men, in addition to their rations, are paid 2s. per week when they are working, and the women may be paid in cash for their baskets and mats. The men also make tools and weapons for sale. This money may be spent on food. Flour, rice, sugar, golden syrup, jam, unsweetened condensed milk, canned meat, and vegetable stew are sold at the store at prices well below cost, but unfortunately no records of sales are kept and it was not possible to ascertain what quantities of the various foods were purchased by the natives.

EATING HABITS

The manner in which the natives group together to eat varies at the different stations. Where dormitories exist for the children they receive separate rations. At Umbakumba the food was cooked before being distributed to the children and they sat at tables to eat it, but on the other stations most of the rations were distributed raw. Under these conditions the older boys and girls generally cooked the food and the children ate it outside their dormitories. At Umbakumba, breakfast and dinner were eaten by the men in a number of groups in one area, and the women and children sat in groups some distance away. For the evening meal both men and women retired to the native camp and sat in their family groups. At Angoroko the single men ate with the dormitory boys, but at Oenpelli they ate with the married people. At both stations the family groups, excluding the dormitory children, ate all meals together, generally near their sleeping quarters. At Yirrkalla family groups included the older children as there were no dormitories.

METHODS OF COOKING

The cooking methods used are a combination of their native methods and new habits they have learnt from Europeans. Except at Yirrkalla, flour is most commonly made into a damper; at Yirrkalla it is boiled to a thick paste and eaten as

such. Rice and whole wheat are boiled in water. The ground wheat given at Angoroko is made into porridge and distributed cooked.

The few fresh vegetables which were seen being cooked were all boiled in water. However, these aborigines when questioned said that they sometimes cook them in the hot sand and ashes in the same way as they cook their native vegetables. Their reason for not cooking them always by this method was that many of the roots are too big, and even the small ones take too long to cook when they are hungry. They therefore cut them into small pieces and boil them in fresh water. The water is discarded. Where tomatoes, beans and carrots are supplied, the Europeans say that the aborigines eat them raw. Small amounts of sweet potato are eaten raw while cutting the vegetables for cooking.

As fish is a food that occurs abundantly in the diet of natives living away from the settlements, it is not surprising to find that when it is provided in rations it is cooked by the native method of grilling on the coals. Sometimes, however, it may be boiled if a suitable container is available. Meat, since it is cut into pieces for distribution, is almost always boiled, in contrast to the cooking by dry heat of the intact carcasses of bush animals.

NATURALLY OCCURRING FOODS

The quantity of food which is collected from the bush during the week-end varies from place to place. Even before the establishment of the settlement at Umbakumba the surrounding area was poor in vegetable foods. According to the aborigines, the immediate environment at Yirrkalla was not a good food area either. This is in contrast to Angoroko and Oenpelli which were close to good supplies of food during most of the year. However, most varieties of these naturally occurring vegetable foods are diminishing in supply in the area around the settlements. Being nomadic, the original inhabitants of the areas left sufficient plants to ensure the subsequent harvest, particularly as they moved in relatively small groups. Large settled populations might be expected to eat out many of the foods that grew within one day's walk of the stations, and this is exactly what is happening. With the passage of time, the supply of native foods which the aborigines can obtain during the week-end is diminishing. Animal products are similarly affected although not to quite the same extent. Game will be driven away from the immediate environment, but even the limited use of firearms by the aborigines is not likely to affect the numbers killed in comparison with the period of pre-European settlement, because of the diversion of the population from hunting to agriculture. The supply of fish of course would not be affected. In general, however, the establishment of permanent settlements means that the natives will have to depend to an increasing extent on the supply of food from the stations to provide an adequate diet.

There is further evidence to support this claim. It was noticed at all of the stations that part of the food which was given as rations during the week was kept by at least some of the families as a reserve for use during the week-end,

even if the only foods which had been distributed were flour and rice. Just how widespread was this habit it was difficult to judge, or even to what extent it was dependent on the availability of naturally occurring foods. It has often been assumed that primitive people have a superior instinct which forces them to seek sufficient variety in their diet to supply adequate amounts of the various nutrients. Dietary and health surveys which have been carried out among primitive communities in different parts of the world have failed to substantiate this claim, and in the present survey it was found that it most certainly does not apply to the aborigines who are in the process of adopting a new way of life. At all of the stations the men and women who had the closest contact with the new economy were less interested in the aboriginal methods of food gathering.

The following is a brief description of week-end food gathering. It is based on observations made during the visit of the nutrition unit to the four settlements.

At Umbakumba the dormitory girls were taken for a picnic during the week-end. They sometimes gathered small quantities of vegetable foods, but in the main they concentrated on small fish and shellfish. In this they closely followed the habits of the women who remained at the settlement over the week-end. Sometimes a group of women, with or without their husbands, went to other parts of the island for the week-end to gather vegetable foods, but the majority stayed at the settlement while the expedition was camped there. The men, generally speaking, were not enthusiastic about finding their own food in the week-end but some of them went fishing in the lagoon. The dormitory boys were normally provided with rations unless they were taken for a picnic on the boat, in which case they caught fish for themselves.

At Angoroko the dormitory girls went with the adults who were in charge of them. The women and girls gathered vegetable foods, and the man who usually went with them was generally successful in providing some sort of animal food for the girls. The women from the camp gathered vegetable foods but considerable numbers of the younger women, particularly those with the longest mission contact, frequently remained in camp. Varying numbers of the men and boys went fishing.

At Yirrkalla the men went fishing, or less often they hunted for wallabies; the women and girls gathered vegetable foods, and practically all of the women left the camp.

At Oenpelli the men fished in the billabong or hunted kangaroos. The women sometimes left the camp in search of vegetable foods or sometimes they stayed in the camp and gathered lily rhizomes from the billabong at the station. The dormitory girls followed the same pattern of activity as their mothers, and the boys went either with their mothers or their fathers. Oenpelli was the only station which had a supply of naturally occurring food close at hand, which could be gathered during the working week. Each day during the rest period of several hours which followed the midday meal, varying numbers of the women went into the billabong for lily rhizomes and stems. It was noticed that the women who worked making articles from pandanus leaf were more enthusiastic about this than the women who were

employed doing domestic work. Each woman could gather several pounds weight of rhizomes in this time.

ASSESSMENT OF DIETS

Because of the great variation in the nature and quantity of the food which is gathered in the week-end, it is impossible to make an accurate estimate of its food value. The main emphasis in this section will therefore be given to the rations which the aborigines receive from the settlements.

Not enough is yet known about the nutritive requirements of primitive people. Anomalies have been shown in research work dealing with some nutrients when the intake of a few native people and white people is correlated with the development of deficiency states. In the light of present knowledge it seems reasonable to assume that such differences may be adaptations to an existing native dietary. Until it is proved that such adaptations are carried over when not only the diet but the whole way of life is altered to that of Western civilization, it is advisable to use the results of work on dietaries of Western countries as an indication of the requirements of primitive peoples. This has been done in assessing the diets at the settlements. The basis for the assessment is the Recommended Dietary Allowances of the Food and Nutrition Board, National Research Council, America (1948). The figures for physically active men and moderately active women have been corrected for the mean weight of 121·1 lb. (54·93 kg.) for aboriginal men and 89·5 lb. (40·61 kg.) for the women. These figures are the results of weighings made by the medical officer in Arnhem Land. In each of the four stations, children of all ages receive the same fixed ration until, at the age of 13-14 years, they are given adult rations. As the aboriginal children show approximately the same height for age as white Australian children (see Section 3, Graphs 1 and 2) their requirements have been regarded as being the same. The mean weights of white Australian schoolchildren used in this comparison are on the whole lighter than the weights quoted in the recommended allowances, and a corresponding reduction has been made.

There is no evidence to support the assumption that for the same age and height aboriginal children should have a weight comparable with white Australian children. The average weights found for any particular group of people (in this case white Australian children) cannot be automatically assumed to be optimal even for the group in question. The relationship between normal and optimal weights has never been investigated. The use of weights for white Australian children as the basis of estimating the requirements of aboriginal children is therefore purely arbitrary. For adult aborigines the recommended allowances have been corrected to their mean weights which are very much below the corresponding weights for white Australians. So also are the weights for the children, but it is possible that the children may be failing to grow at the same rate as white children because of inadequate nutrition. It is for this reason that the recommended allowances for the aboriginal children are based on the weights of white

children of corresponding age and height, while for the adults they are based on the actual weights of the aboriginal adults.

The use of recommended allowances perhaps requires a little explanation. To say that the intake by a group of a particular nutrient falls above or below the recommended allowance means no more than just that. The allowances cannot in any way be regarded as a basis for deciding whether the intake of any nutrient is adequate or not. The only test of this is whether a deficiency state exists in the subjects under review. For this reason, the evidence from the food consumption survey, and the clinical and biochemical investigations has been correlated to arrive at a picture of the nutritional status of the population. This correlation will be found in Section 6.

1. Calories

The corrected recommended allowances are 2,350 for adult men and 1,750 for adult women, giving a mean of 2,050. As men and women receive the same ration, values will be compared with this mean.

At the time of the visit by the nutrition unit to Umbakumba and Angoroko, supplies at both were exhausted. The rations being distributed to adults at that time at both settlements were slightly below the mean recommended allowance for calories. At Oenpelli they were even lower, but towards the end of our stay at this station the rations were considerably increased. At Yirrkalla the normal ration for adults was approximately the same in calories as the mean recommended allowance.

The rations for children at the different stations have a calorie content of 1,600-1,800 calories. In the dormitories the younger children will presumably eat less than this amount and the older children more. Taking white Australian children of the same height as aboriginal children as the standard, and correcting the recommended allowances for the slightly lower weight of these white children, the mean allowance for calories of children of 5-14 years is calculated to be approximately 2,200 calories. Assuming that the aboriginal dormitory children are evenly distributed over this age range, this figure can be compared with the figure calculated for their rations. For adolescents of 13-20 years the recommended allowances exceed those for adults, whereas at the settlements they receive only adult rations.

Until they are 15-18 months of age, breast milk is the main food of the infants. From the time they get their teeth they are given rations by the settlements; the foods given are the same as the rest of the population receive, and these foods are gradually introduced into the diet of the infants. Breast-feeding continues generally till the child is at least two years of age, but in many cases it goes on for three years or longer unless another pregnancy supervenes. Although the growth rate curve shown in Section 3, Graph 7, is compiled from only a small number of weighings, it is likely that a curve of this nature would be fairly general for infants on this type of diet. For the first five to six months of life the infants increase in weight very rapidly, but thereafter they fail to gain weight at the same rate as

white children. This decreased rate of growth in the second six months is likely to be due in part to insufficient food of the right type.

2. Protein

Although no details are available for Yirrkalla there did not appear to be any organized effort by the mission to obtain animal protein of any kind. When they were not working the men frequently went fishing, but the catch was rarely more than enough for the fishermen and consequently there was no surplus for sale to the mission. This meant that the working men received no animal foods. Their protein therefore came almost exclusively from wheat, biscuits and occasionally sweet potatoes. A source of protein as restricted as this can certainly be improved by the inclusion of regular supplies of fish and meat; in addition a wider range of vegetable foods would provide a greater variety of vegetable protein.

The lack of regularity in the supply of animal foods is the major criticism of the diets at the other stations from the point of view of the protein intake. The figures for the mean daily consumption calculated from estimated intake over a period of several years are 60-110 gm. per head, but since protein is required each day for repair and growth of tissue, it is desirable that the necessary variety of both animal and vegetable protein should be included in each day's diet. Protein in excess of the body's immediate requirements is used as fuel to provide energy, and is not stored as protein as a reserve for future use. Regular intake of both animal and vegetable protein is therefore important, particularly for children, adolescents, and pregnant and lactating women. Their requirements are relatively much greater than those of normal adults.

3. Minerals

(a) *Iron.* It is impossible to give a precise assessment of the diets because it is now thought that iron is stored in the body. Consequently a dietary survey carried out over a short period will not give a true reflection of intake unless the particular diet pattern which is observed is maintained for a long period. As the diets at the settlements may vary greatly throughout the year, an assessment of their iron content is impossible.

The rations which were being distributed at Umbakumba during our visit had an iron content of approximately 14 mg. per day for adults and 10 mg. for children. At Angoroko, Yirrkalla and Oenpelli the iron content of the rations was 6-9 mg. per day for adults and 4-7 mg. for children; these intakes are below the recommended allowances. The main reason for the difference in the iron intake between Umbakumba and the other three settlements was the amount of whole wheat in the rations. This was higher than usual at Umbakumba because of a shortage of other foods. At Angoroko the small amount of wheat in the diet during the period of our visit was due to a temporary shortage of wheat, so that the normal intake would probably be higher. At Oenpelli where white flour, rice, and beef are the main rations throughout the year it is likely that the intake of iron remains much

the same as the figure given above. There is no information on the variation in the diet at Yirrkalla.

On a diet consisting mainly of breast milk until the age of 15-18 months, and thereafter on a diet which contains a moderate to large proportion of refined cereals, the infants would have an iron intake below the recommended allowance.

The recommended allowances of iron during adolescence and pregnancy are higher than for normal adults. Moreover, the recommended allowances in all cases are for healthy people and do not take into account increased demands due to disease. Hookworm infestation causes a loss of iron from the body which has to be made up by a greater intake from food. This means that at Oenpelli and to a lesser extent at Yirrkalla greater intakes of iron would be needed to offset the losses due to hookworm.

Beans, meat, green leafy vegetables and whole cereals are the best common sources of iron but, of the less common foods, liver and eggs are good sources of this mineral.

(b) *Calcium.* Those children and adolescents who receive 8-10 oz. of milk per day have a calcium intake of 0·28-0·35 gm. from this source. In addition, a diet consisting of wheat, flour, and rice would contribute 0·11-0·15 gm. of calcium per head per day. Vegetables would be another source of calcium when they are in season. The mean daily intake for children from these sources would be in the region of 0·45-0·50 gm. This is approximately one-half to one-third of the recommended allowance for children and adolescents. At the present time the pregnant and lactating women fall well below the recommended intake of calcium and so do the children who receive no milk.

4. Vitamins

(a) *Vitamin A.* It is impossible to say what quantity or proportion of the vitamin A intake of the aborigines on the settlements is derived from animal and vegetable products. As they always eat the liver of fish, they probably receive substantial quantities of vitamin A from this source. Animal livers are regarded as a delicacy, but the distribution of these is more restricted among the aborigines. Whole milk also contains vitamin A, but not skimmed milk, and as the milk is normally heated and the cream removed before it is given to the natives it is probable that the amount of vitamin A obtained from this source is low. Yellow fruit and vegetables and to a lesser extent green vegetables contain the precursor of vitamin A but, as it is not possible to give consumption figures for these foods, the vitamin A content of the diets cannot be estimated. Vitamin A is stored in the body, so irregularity in supplies might not lead to signs of vitamin A deficiency.

(b) *Thiamine (vitamin B_1).* On a diet consisting predominantly of flour the intake of thiamine would be 0·7-1·0 mg. per day and if a 2:1 mixture of white flour and wholemeal flour is used it will be 1·2-1·5 mg. per day. These quantities, in relation to the present calorie consumption, are roughly the same as the recommended allowance. Replacement of part of the flour and wheat in the diet by

amounts of fish, meat, and vegetables of equal calorie content would maintain this ratio of thiamine to calories.

(c) *Nicotinic acid.* At the stations where the aborigines are given the equivalent of one meal per day of whole wheat (7 oz. for adults) the recommended allowance of nicotinic acid is contained in this foodstuff. This applied at Umbakumba and Angoroko at the time of our visit. At Yirrkalla the amount was slightly less, and at Oenpelli white flour and white rice were the cereals distributed. At Oenpelli the mean daily meat ration would contain the recommended allowance of nicotinic acid, but no account is taken of the irregularity of distribution.

For equal calorie portions whole wheat has a slightly lower nicotinic acid content than meat but is much richer than flour and vegetables. Dairy products contain only very small amounts of nicotinic acid.

(d) *Riboflavin.* The riboflavin content of the diets which were being distributed varied considerably. Those consisting of white flour or flour and rice were the lowest; they contained only about 0·2 mg. riboflavin per day. Wheat, fish, and beef raise the riboflavin content when substituted for flour, and it would be from these foods that the bulk of the supply of riboflavin would be derived.

At Angoroko the mean daily consumption of fish would contain about one-sixth of the recommended allowance of riboflavin, and about one-third would be provided by cereals with small additions from fresh vegetables. The diet at Umbakumba was similar but, in addition, the children received milk every second day. However, riboflavin in milk is destroyed by exposure to sunlight; closed containers which exclude light should be used to prevent destruction of this vitamin. Because of this factor the contribution of riboflavin made to the diet by milk at Umbakumba and Oenpelli cannot be estimated. The mean daily meat ration per head at Oenpelli would contain approximately half of the recommended allowance of riboflavin, but the white flour and white rice in the diet would contribute little. The rations being issued at Yirrkalla were lower in riboflavin than those at any of the other settlements, because they included neither fish, meat, nor milk.

(e) *Ascorbic acid (vitamin C).* The supply of vitamin C in the present diets is irregular. As no observations were made of the quantities of the various foods eaten from the gardens during the season of greatest productivity nor of the methods of cooking employed, it is not possible to estimate the vitamin C intake during this time. Judging by the records which were supplied by the settlements, Umbakumba has the greatest production of fresh vegetables per head of population, followed by Angoroko and Oenpelli in that order. No records were available for Yirrkalla, but it is likely that it falls between Angoroko and Oenpelli.

Umbakumba has one of the biggest vegetable gardens, but when the nutrition unit was at this station the harvest of vegetables had not begun. For the preceding three months, while the gardens were being restored, flour, wheat and dried peas had constituted the rations of vegetable origin. The surrounding country is poor in naturally occurring foods, and only by leaving the station for several days at

least could the women gather any appreciable quantity of vegetables. Few of the women left for such periods, and the men had all been employed for six months at the settlement. The children, too, had all been at the station for the preceding six months.

During our visit to Angoroko the rations consisted in the main of flour and ground wheat, but pumpkin, sweet potatoes, fresh peanuts and small amounts of cow-peas and cassava were also included from time to time. Pumpkins and melons had been harvested during the preceding two months but the main harvest was not yet ready. The ration for a meal is approximately one pound of sweet potatoes and one and a half pounds of pumpkin. The ascorbic acid content of these quantities is of the order of 110 mg. and 45 mg. respectively. In addition, the supply of native foods gathered in the week-ends during the early part of the dry season (i.e. the two or three months preceding our visit) would probably be a significant factor in the ascorbic acid intake of many of the aborigines, as the supply of garden produce during this period was not sufficient to allow a regular distribution in the rations.

At Yirrkalla much of the garden had been destroyed in two cyclones earlier in the year and had not been restored. Sweet potatoes were the only fresh vegetable included in the rations of the natives while the expedition was at Yirrkalla. The ration for a meal was about one and quarter pounds per head. Nothing is known of the diet of the natives at the settlement during the preceding months. Some, but not all, of the women who were not rationed by the settlement went out each day to forage for native foods. These foods would contribute to their ascorbic acid intake.

While the expedition was at Oenpelli, the rations of the aborigines consisted of flour, rice, and meat. There was no vegetable garden, and the records for the preceding two and a half years show that the production of fresh fruit and vegetables during this period had been very low when calculated on the basis of a daily distribution. The supply of naturally occurring vegetables was limited because it was near the end of the dry season.

CONCLUSIONS

Though most of the Europeans in charge of the settlements are aware of the need to grow fresh food for consumption by the native population, the need for providing a diet which is regarded as adequate by European standards did not seem to be generally appreciated. There are probably several reasons for this.

The aborigines in their own environment do not seem, to the casual European observer, in any way fastidious about their food. Because they eat some foods that a European would not eat, an inferior diet is considered good enough for the aborigines. It is true that they are less fastidious than Europeans under normal conditions (although the aborigines, too, have their standards), but for this reason their diet could in fact be better balanced than that of many Europeans. There is no refinement of food, no storage, no overcooking, little waste and no leaching of

vitamins and minerals in cooking water. It should be obvious that wood grubs are none the less nutritive to the aborigines because white men find them repulsive. For a comparison of the two types of diet the reader is referred to the results of the food consumption survey of groups of aborigines living on naturally occurring foods which is contained in Section 6.

Another claim which is made is that, since the natives, for a variety of reasons, do considerably less work than Europeans, they do not earn and therefore do not deserve a decent diet. The fact that the natives do not work as hard as they might may mean that they need a smaller quantity of food; but even if it is reduced in quantity the diet must include adequate amounts of all the nutrients. General lethargy can be a symptom of inadequate nutrition; it is appreciated that with these aboriginal communities there are important psychological factors involved too. In the change from a nomadic to an agricultural life the natives cannot be expected to be immediately successful, but when they see themselves being fed on a diet which is obviously very different from that of the Europeans, they can be left in little doubt about the position to which they are relegated. This is not likely to encourage them to greater efforts.

However, many of the difficulties facing the settlements are appreciated. With the present condition of transport to these areas in the Northern Territory, perishable foods clearly cannot be imported from other states or even from distant areas within the Territory. But the type of country in Arnhem Land is such that only small areas are suitable for agricultural purposes. Lacking the funds for mechanical equipment, the settlements have to depend on native labour for tasks which could be more efficiently and much more extensively done by machinery. This limits the size of the gardens. Until recently agriculturists have not been included in the staff of the settlements, and it is not intended as a reflection on missionaries to say that in these days of specialization they can hardly be expected to possess the knowledge of agriculture required, particularly for a type of country so different in potentialities from that of the southern states of Australia from which most of them come.

Another factor which was noticed at some of the settlements is the growing tendency to direct native labour to pursuits other than gardening with the intention of making the settlements more self-sufficient financially. This weakens the labour force for food production, and while no doubt there are good reasons for the move, it must be pointed out that if it is carried through without an alternative plan to maintain and extend the present production of food it is likely to defeat its own purpose. This should not be interpreted as a claim that food is the only important factor in the life of the aborigines during this transition period. There is, however, no need to stress the point that a decent way of life cannot be built for improperly nourished bodies.

REFERENCE

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ARNHEM LAND: ANTHROPOLOGY AND NUTRITION

5. REPORT OF THE BIOCHEMICAL ASSESSMENTS OF NUTRITIONAL STATUS

by K. J. Hodges

Biochemical tests of serum protein, haemoglobin, plasma ascorbic acid, and the ascorbic acid content of breast milk were carried out to assist in the assessment of the nutritional status of the aborigines. The scope of the work which could be done was limited by the time factor, and the methods had to be rapid and reliable and to involve only apparatus that was portable and robust.

As many as possible of the subjects who were examined by the medical officer were subjected to the biochemical tests for serum protein, haemoglobin, and plasma ascorbic acid. A total of 451 estimations were made of haemoglobin and serum protein, and 405 estimations of plasma ascorbic acid. After they had assembled, the natives rested for 20-30 minutes before blood samples were taken. Two to three cubic centimetres were withdrawn by venepuncture from adults; on children under two years the finger-prick technique was used after the hand had been warmed.

The specific gravity of the whole blood was determined immediately. The remainder of the blood was put into two small capillary tubes for protein estimation and an oxalated Durham tube for the plasma ascorbic acid determination. The capillary tubes were sealed with wax and centrifuged within two to five hours, and the specific gravity of the serum was determined within eight hours of collection. The blood in the Durham tube was centrifuged immediately (in the hand centrifuge this took 20-40 minutes) and 0·1 ml. aliquots of plasma were pipetted into metaphosphoric acid.

SERUM PROTEIN AND HAEMOGLOBIN

Haemoglobin and serum protein levels of the blood were calculated from the specific gravity of whole blood and serum. The estimations of specific gravity were made by the gradient tube method of Linderstrom Lang as modified by Lowry and Hunter.[1] Copper sulphate standards prepared according to the method of Phillips *et al.* were used because of the greater ease of their preparation under field conditions. No difference could be detected between the two sets of standards when they were used in the gradient tube. Fresh standards were prepared at each station and compared with those which had been used at the preceding station; complete agreement was obtained in every instance. Small aliquots were taken from the stock solutions of the standards at the beginning of each week in order to minimize the effect of evaporation on the specific gravity of the standards.

The precautions recommended by Lowry and Hunter, Phillips, Kagan[2] and Hynes[3] were adhered to in order to avoid variation in plasma protein values. These precautions include: (i) collection of the blood within one minute of the application of the tourniquet; this was strictly adhered to; (ii) serum was preferred

1. Lowry and Hunter (1945), p. 465.
2. Kagan (1942), p. 1457.
3. Hynes (1946), p. 590.

to oxalated plasma in estimating specific gravities, because it gives more accurate results; (iii) only non-haemolyzed serum was used; (iv) the blood was taken after a rest period of 20-30 minutes.

Serum protein values are based on the specific gravity equivalents given by Lowry and Hunter. It was found that the serum protein values calculated in this way agreed with the values obtained by the semi-micro Kjeldahl method of Hiller.[4]

Haemoglobin values were obtained from the line chart of Phillips which is based on the equation:

$$\text{Haemoglobin} = 46{\cdot}1 \left(\frac{G_B - G_P}{1{\cdot}0970 - G_P} \right)$$

G_B = specific gravity of whole blood.
G_P = specific gravity of plasma.

The method of Phillips gives specific gravity values which are 0·0016 lighter than those obtained in the gradient tube, and this value was subtracted from all specific gravity readings before using the above formula. The factor 0·0005 was added to the corrected serum specific gravity values, to obtain plasma specific gravity.

Serum Protein Results

Thoughout this paper significance has been determined at the 5 per cent level. The results divided according to sex and age are given in Table 1. No significant differences were found between the various groups of nomadic aborigines and their corresponding age and sex group at the stations to which they returned. The results for these nomads have therefore been considered jointly with the results of the station at which they were tested. Considering first the mean values for the whole population which was examined at each settlement, the results at Oenpelli are significantly greater than those at Yirrkalla and these in turn are greater than the values found at Umbakumba and Angoroko. There is no significant difference between the latter two stations. The results of the various age groups at each settlement show no difference between the sexes. Trevorrow[5] and the Committee on Haemoglobin Surveys in Great Britain also found no difference between the sexes. However, when the different age groups at each settlement are compared, the children under 15 years at Umbakumba and Angoroko have significantly lower serum protein levels than the adults at their respective stations. This is not so at Yirrkalla and Oenpelli. The mean values for adults at both Umbakumba and Angoroko do not differ significantly from the levels found for either the adults or the total population at Yirrkalla. The higher mean value for the total population at Yirrkalla compared with Umbakumba and Angoroko is due, therefore, to the inclusion at the latter two stations of the children for whom plasma protein values were found to be very much lower than for their adults. The frequency distribution of serum protein for the total population examined at the four stations is shown in Fig. 1.

Low plasma protein values are found in patients suffering from famine starvation, and it has been supposed that less severe protein deficiencies will be reflected

4. Hiller (1948), p. 1401.

5. Trevorrow (1941-2), p. 471.

Table 1

Serum Protein (gm. per cent) by Age and Sex

		Total examined			0-2 years			2-15 years			16 years +		
		Mean	S.D.	Number	Mean	S.D.	Number	Mean	S.D.	Number	Mean	S.D.	Number
Umbakumba	M	7·19	0·74	72	6·76	0·99	7	7·09	0·94	22	7·18	0·35	9
	F							7·06	0·38	19	7·69	0·59	15
Angoroko	M	7·28	0·58	134	7·05	0·42	14	7·11	0·60	25	7·57	0·54	18
	F							7·04	0·32	37	7·55	0·66	40
Yirrkalla	M	7·51	0·54	171	7·61	0·48	10	7·60	0·49	19	7·46	0·45	38
	F							7·51	0·55	47	7·50	0·47	57
Oenpelli	M	7·85	0·61	74	—	—	—	7·81	0·47	7	7·99	0·45	28
	F							7·66	0·39	11	7·80	0·80	28

Table 2

Haemoglobin (gm. per cent) by Age and Sex

		0-2 years			2-15 years			16 years +		
		Mean	S.D.	Number	Mean	S.D.	Number	Mean	S.D.	Number
Umbakumba	M	10·38	0·94	7	13·17	0·71	22	15·41	1·14	9
	F				13·57	0·99	19	13·18	1·18	15
Angoroko	M	10·39	1·66	14	12·93	0·78	25	14·87	1·31	18
	F				12·67	0·86	37	12·69	1·14	40
Yirrkalla	M	9·95	0·92	10	11·87	0·93	19	14·14	1·16	38
	F				11·67	0·97	47	12·14	1·18	57
Oenpelli	M	—	—	—	12·61	1·30	7	15·11	1·10	28
	F				12·22	0·95	11	11·77	1·75	28

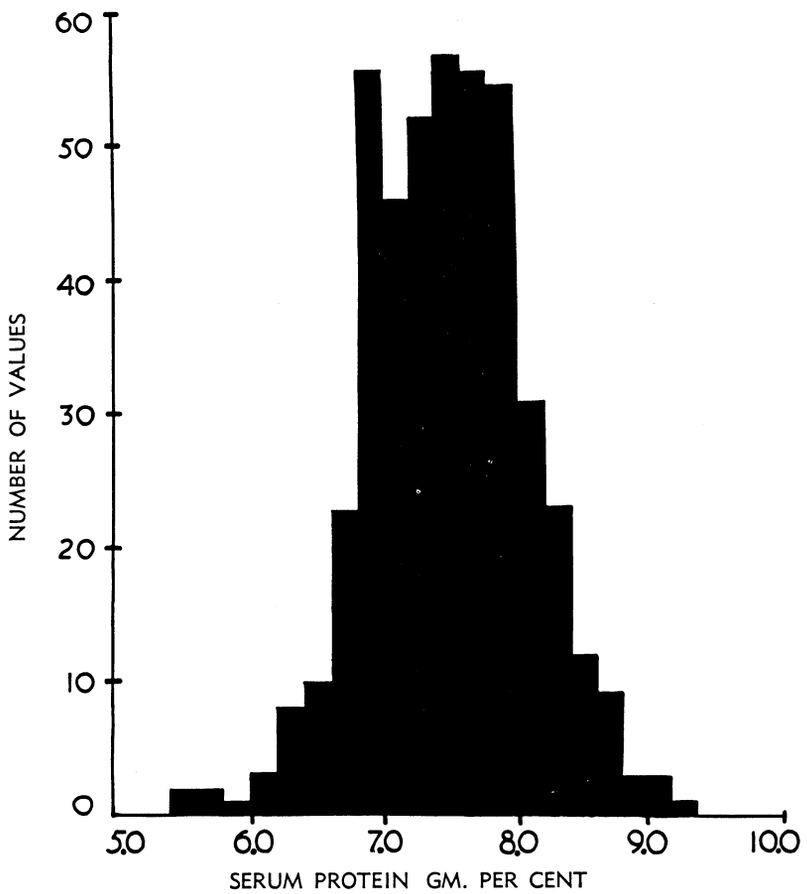

FIG. 1. Frequency distribution of serum protein (total examined)

by a less marked lowering of plasma protein. Values quoted in the literature for serum protein levels in groups of normal individuals vary considerably. The Committee on Haemoglobin Surveys in Great Britain obtained a mean of 6·56 (S.D. 0·40) gm. per cent for 353 blood donors in England, and 6·78 (S.D. 0·39) gm. per cent for 100 Canadian soldiers who were stationed in England. The Committee tabulates values from the literature and concludes that their results are lower than those generally found. Trevorrow, using a micro-Kjeldahl method, made 284 estimations on individuals from 4 to 40 years of age; in this group of normal healthy people the 'adult' level of 6·94 (S.D. 0·47) gm. per cent was reached by the age of 4 years. Kagan reports a mean value of 6·7 gm. per cent for 150 normal adults, using the falling drop method for estimating specific gravity. He considers that values greater than 7·5 gm. per cent or less than 6·0 gm. per cent should be considered abnormal until proved otherwise. Youmans[6] in a survey of 776 individuals

6. Youmans (1943), p. 995.

found a mean of 6·95 gm. per cent; the figures were based only partly on Kjeldahl determinations, as a large number were obtained by a biuret technique. In a survey of 439 normal subjects living at an altitude of 8,500 feet, Robinson *et al.*[7] found a mean value of 7·75 gm. per cent by the biuret method.

The results of several investigations on non-Europeans are interesting. The mean serum specific gravities (estimated by Van Slyke's copper sulphate method) reported by Hynes (1946) for Indians, are equivalent to 7·06 gm. per cent for 171 recruits (range 5·6-8·1 gm. per cent) and 6·85 gm. per cent for 90 trained soldiers (range 5·9-7·8 gm. per cent). Milam,[8] using the semi-micro-Kjeldahl technique on oxalated plasma, found a mean protein content of 7·19 gm. per cent for 1,135 white people, and a mean of 7·44 gm. per cent for 426 coloured people living in the same area. The coloured persons had a significantly higher total protein and globulin level than did the white people, but the albumin level was higher among white persons.

The Indian Army recruits examined by Hynes had eaten a good diet for only two to three weeks after a lifetime of protein semi-starvation, and yet had higher values than did trained soldiers of the same race and the 21 young European men on the station. Both of these latter groups were fed on a very much higher protein diet than the recruits had had up to the time of their enlistment. Relatively high serum protein levels, determined by the same technique as the present estimations, were also obtained in New Guinea, where a large section of the population has a low protein intake, almost entirely vegetable in origin.[9]

While the Arnhem Land expedition was camped at Yirrkalla, 11 European members of the expedition had a mean serum protein of 7·23 (S.D. 0·42) gm. per cent, compared with 7·51 (S.D. 0·54) gm. per cent for 171 aborigines. The diet of the Europeans contained a greater variety and a larger amount of protein than did the diet of the natives. In Canberra the method gave a mean value of 7·19 (S.D. 0·34) gm. per cent for 24 healthy middle-class Europeans.

It is likely, therefore, that the results of serum protein estimations for the aborigines cannot be simply interpreted as an assessment of their state of protein nutrition. Assuming that dehydration is not likely to be a factor, two possible complications may be involved. Kagan[10] found serum protein values (due to an increase in the globulin fraction) above 7·5 gm. per cent very common in some forms of chronic infection, including venereal disease. A widespread chronic infection may thus be responsible for the high values, or there may be some constituent of a non-protein nature in the serum which raises its specific gravity. We have no information on this latter point and we are therefore unable to say whether there is such a factor. The medical officer gives details, in Section 3, of the incidence of the chronic infections he diagnosed at the four settlements.

At Umbakumba and Angoroko he found no cases of primary or secondary yaws, the infective stage of the disease having been eradicated from the island

7. Robinson (1944), p. 299.
8. Milam (1946), p. 288.
9. New Guinea Survey (1947).
10. Kagan (1943), p. 309.

several years ago. As the children up to 15 years at these two stations have lower serum protein values than any other sex or age groups at the four stations, it is possible that yaws infection could be a factor in raising serum protein levels. The population which was examined at Yirrkalla is the only one in which a considerable incidence (21 per cent) of yaws infection was found. A comparison has been made of serum protein levels of those with and without yaws at this settlement. The mean serum protein value of those showing obvious yaws lesions was 7·42 gm. per cent compared with 7·52 gm. per cent for the rest of the population. However, in Section 3 the medical officer discusses the difficulty of diagnosis and the probability that many cases of secondary and tertiary lesions of yaws have been omitted because of it. The results for Oenpelli, where the highest serum protein figures were recorded but where a relatively low incidence of yaws was found, also indicate that, if yaws is a factor raising the serum protein level, it is not the only factor involved.

Of the other chronic infections found among the aborigines, neither leprosy nor tuberculosis was found to be sufficiently widespread to account for the high serum protein values. As far as is known, the effect of hookworm on serum protein has not been investigated. Hookworm infection was heavy only at Oenpelli. At this station, those with a hookworm burden of 4,000 or more eggs per gram of faeces had a mean serum protein of 7·71 (S.D. 0·60) gm. per cent, compared with 7·97 (S.D. 0·61) gm. per cent for those with a hookworm burden of less than 4,000 eggs per gram.

From the information available, therefore, no satisfactory explanation can be given of the magnitude or variation in serum protein levels found among the aborigines.

Haemoglobin Results

The results of the haemoglobin estimations according to age and sex are given in Table 2. By this method nine adult male members of the expedition (after five months in the tropics) were found to have a mean haemoglobin of 14·90 (S.D. 1·36) gm. per cent. Seven European adult males in Canberra had a mean of 16·35 (S.D. 0·57) gm. per cent, and sixteen adult females had a mean of 13·86 (S.D. 1·12) gm. per cent.

There is no significant difference at any station between the values for boys and girls aged from two to fifteen years. However, at all stations the values for this age group are significantly higher than the values for the babies up to two years, and significantly lower than the figures for adult males. The figures for girls of 2-15 years and adult females are not significantly different. The adult females are significantly lower than the men at all settlements.

Infants—birth to 2 years. The finding that haemoglobin values in the 0-2 year age group are below those of children of 2-15 years is not surprising. In Table 3 the infants of 0-2 years are classified according to the ranges of haemoglobin values used by Davidson *et al.*[11] They regard 11·0 gm. per cent or greater as satisfactory;

11. Davidson (1942), p. 505.

9·7-11·0 gm. per cent as subnormal; 8·4-9·7 gm. per cent as moderate anaemia; and below 8·4 gm. as severe anaemia. It will be seen that 64 per cent of the infants have haemoglobin levels below what Davidson classifies as satisfactory, and 32 per cent fall into the anaemia range. According to Davidson a haemoglobin level of 11·9 ± 0·7 gm. per cent is widely accepted as the ideal for infants of 2-23 months. Only 26 per cent of the Arnhem Land infants had haemoglobin values falling within this range.

TABLE 3

HAEMOGLOBIN (GM. PER CENT) FOR INFANTS 0-24 MONTHS

Haemoglobin gm. %	Number of infants	Percentage
11·0 or greater	11	35·5
9·7-11·0	10	32
8·4-9·7	8	26
8·4 or less	2	6·5

A nutritional anaemia in infants fed mainly on milk and cereals has been recognized among white populations for many years. Until 15-18 months milk is the main food of the aboriginal infant, and breast-feeding is continued until he is about 3 years of age unless another pregnancy intervenes. Mackay and Goodfellow found in their investigation that nutritional anaemia appeared earliest in infants of low birth weight. In Graph 7 of Section 3 are contained the only known reliable figures of birth weight and growth rate for Arnhem Land infants. Compared with the mean for white Australian infants these native babies grew more rapidly for approximately the first five months of life, despite their lower birth weight, and thereafter their growth rate decreased by comparison. If these figures can be assumed to be typical of the aboriginal population at other settlements, it is highly likely that most of the anaemia in infants is nutritional in origin. Mackay and Goodfellow found a rise in haemoglobin level in infants given an iron supplement; the basic diet of the infants in their investigation would contain more iron than that of the aboriginal infants.

Children 2-15 years. The Committee on Haemoglobin Surveys concluded from their survey in Great Britain that 'the general picture is one of a rise from the age of 1 up to the age of 6 or 7 followed by a plateau of little change up to the age of 10 to 11, and then a steady rise. The haemoglobin level in schoolboys rises to a maximum at ages 16 to 19. . . . At about 12 to 13 the girls begin to fall behind the boys.' The mean haemoglobin levels at different ages for males and females in Arnhem Land are shown in Figures 2 and 3. The numbers on the histograms are the number of values from which the mean for that age has been calculated. The numbers for each age group are very small, but in the present series the trends appear to be different from those found in England. For males there is a plateau from 2 to 7 years then a gradual rise till 22 years. For females after a plateau (or perhaps a slight drop) from 2 to 7 years, there is a rise till the age of 15 years.

TABLE 4

HAEMOGLOBIN (GM. PER CENT) FOR CHILDREN 2-4 YEARS INCLUSIVE

		10·2 and under		10·2-11·7		11·7 and over	
		%	No.	%	No.	%	No.
Umbakumba	M	—	—	—	—	—	—
	F	—	—	—	—	100	1
Angoroko	M	—	—	—	—	100	3
	F	—	—	10	1	90	9
Yirrkalla	M	—	—	57	4	43	3
	F	12	1	44	4	44	4
Oenpelli	M	—	—	—	—	100	1
	F	—	—	100	1	—	—

Davidson[12] considers haemoglobin levels of 13·1 ± 0·7 gm. per cent as normal, and values under 11 gm. per cent as anaemic for children in the 5-12 year group. Table 5 contains an analysis of the haemoglobin levels of the aboriginal children 5-15 years on the basis of these groups; the 12-15 year group has been included here rather than with the adults because the haemoglobin levels have not reached the adult level at these ages. As there are no recommended standards for children of 2-4 years the mean of the standards for the 0-2 and the 5-12 year groups has been used. The proportion of children examined in the 2-4 year group varies at the different settlements and inclusion of this group with the older children would therefore affect the results for each station differently. They have therefore been separated.

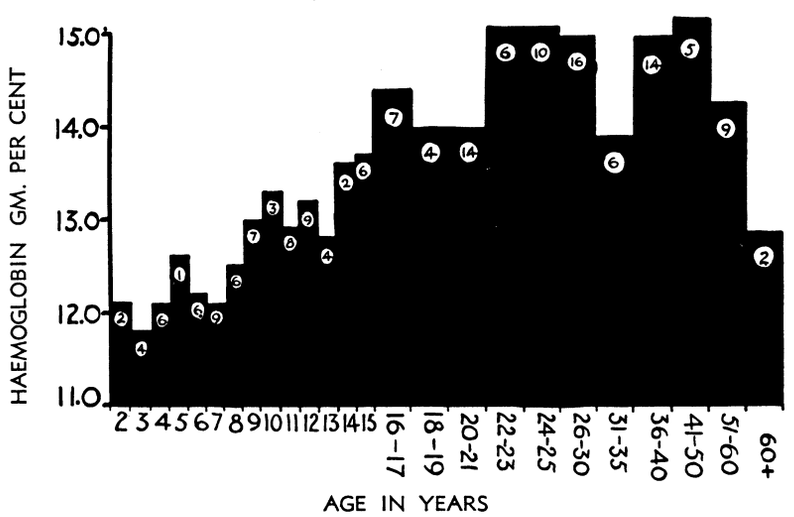

FIG. 2. Variation of haemoglobin with age (males)

12. Davidson (1943), p. 95.

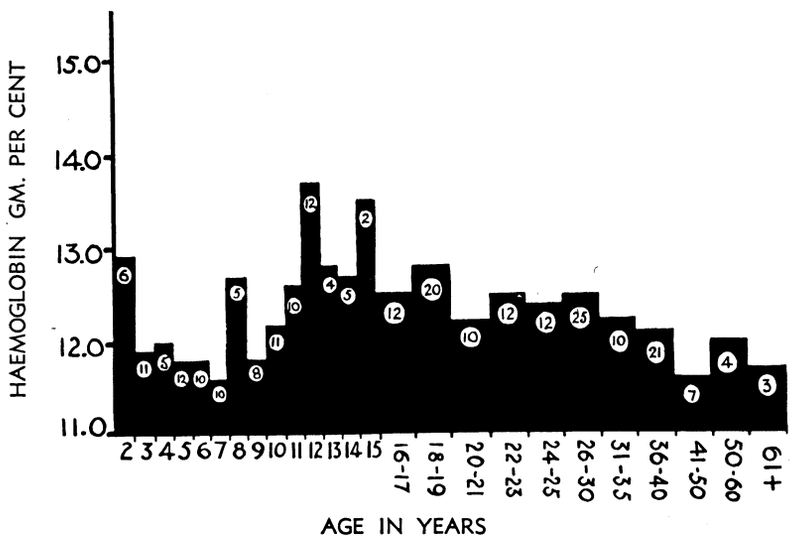

FIG. 3. Variation of haemoglobin with age (females)

At Yirrkalla there are roughly 60 per cent, and at Angoroko and Oenpelli about 30 per cent of the children in the subnormal and anaemic groups. At Umbakumba the figure is approximately 10 per cent.

TABLE 5

HAEMOGLOBIN (GM. PER CENT) FOR CHILDREN 5-15 YEARS INCLUSIVE

		10·9 and under		11·0-12·3		12·4 and over	
		%	No.	%	No.	%	No.
Umbakumba	M	—	—	5	1	95	21
	F	—	—	11	2	89	16
Angoroko	M	—	—	23	5	77	17
	F	3	1	41	11	56	15
Yirrkalla	M	8	1	58	7	34	4
	F	21	8	45	17	34	13
Oenpelli	M	—	—	33	2	66	4
	F	20	2	10	1	70	7

Adult males. The significantly greater values for men than for boys are in accordance with findings for European males. In Great Britain, the Committee on Haemoglobin Surveys found that the maximum value for males was reached between 16 and 19 years and thereafter remained constant until after 50 years of age. Beyond this age a slight fall was noticeable. In the present series the maximum was not reached until slightly later, at about 22 years of age. This level remained constant until about 50; the few values for men over 50 years show a

decrease from the maximum (see Fig. 2). The classification of haemoglobin values for adult males suggested by Davidson has been used in compiling Table 6. Normal, but not necessarily optimal values, are those of 13·1 gm. per cent or greater; subnormal from 11·8-13·1 gm. per cent; and 11·7 gm. per cent or less are classified as 'clinical anaemia'. Eleven per cent of the Arnhem Land men who were examined failed to reach the normal range.

TABLE 6

HAEMOGLOBIN (GM. PER CENT) FOR ADULT MALES 16 YEARS AND OVER

	11·7 or less		11·8-13·0		13·1 and over	
	%	No.	%	No.	%	No.
Umbakumba	—	—	—	—	100	9
Angoroko	—	—	11	2	89	16
Yirrkalla	3	1	10	4	87	33
Oenpelli	—	—	7	2	93	26

Adult females. The significant difference between adult males and females in this series is similar to the results found by other workers. Wardlaw [13] summarized the results of eleven investigators in eight countries. He calculated the ratio of the mean haemoglobin of women to men to be 87 per cent; the values of the different surveys vary from 83 per cent to 93 per cent. The values for Arnhem Land are: Umbakumba and Angoroko 85 per cent, Yirrkalla 86 per cent, and Oenpelli 78 per cent. The lower haemoglobin values found among women are attributed to the effects of menstruation and child-birth. The Committee on Haemoglobin Surveys found among British women an initial rise in the under 20 group to a peak at 20-29, after which the mean values, both for the single and the married women, tend to fall slightly at the ages of 30-39 and 40-49, but show recovery at the higher ages of 50 and above. In the women examined in Arnhem Land the maximum was reached by about 15 years of age; beyond this age there was a gradual decrease in the haemoglobin level. (See Fig. 3.) The values in the Arnhem Land series include all of the women who were examined; the numbers are not sufficient to separate the pregnant women and those with varying numbers of children.

Davidson adopts 12·4 gm. per cent or more as average normal (but not necessarily optimal) for adult women. Below 11·0 gm. per cent is classified as 'clinical anaemia'. Table 7 gives the Arnhem Land values grouped on this basis. Considerably greater numbers of the women from Umbakumba and Angoroko fall into the normal range than at Yirrkalla and Oenpelli. However, the overall picture shows that fewer women than men at each station reach the range classified as normal for Europeans.

Locality variations. In Table 8 the results shown in Tables 4, 5, 6 and 7 are combined in order to compare the overall picture at the four settlements. At

13. Wardlaw (1941), p. 103.

TABLE 7

HAEMOGLOBIN (GM. PER CENT) FOR ADULT FEMALES 16 YEARS AND OVER

	11·0 or less		11·1-12·3		12·4 and over	
	%	No.	%	No.	%	No.
Umbakumba	—	—	33	5	67	10
Angoroko	7	3	25	10	68	27
Yirrkalla	18	10	34	19	48	27
Oenpelli	36	10	21	6	43	12

Umbakumba the position appears to be fairly satisfactory, but Yirrkalla, Oenpelli and to a lesser extent Angoroko all need improvement.

The main nutrients required for the maintenance of satisfactory haemoglobin levels are iron and protein. The assessment of the iron and protein contents of the diets is discussed in Section 2. It is not possible to assess the intake of iron for other than the short period during which the expedition visited the settlements. To what extent the low haemoglobin levels are due to an iron deficiency in the diet it is therefore not possible to say. In the case of the infants up to two years the evidence strongly suggests an iron deficiency, but this may not be the only factor involved. Yirrkalla is the only station where the protein content of the rations appears to be low, but at some of the others it is irregular. As we have seen, the serum protein results cannot be regarded as a reliable indication of the adequacy or otherwise of protein levels.

TABLE 8

ANALYSIS OF HAEMOGLOBIN VALUES FOR ABORIGINES (EXCLUDING INFANTS 0-2 YEARS) AT FOUR SETTLEMENTS

	Anaemic		Subnormal		Normal	
	%	No.	%	No.	%	No.
Umbakumba	—	—	12	8	88	57
Angoroko	3	4	24	29	73	87
Yirrkalla	13	21	34	55	53	84
Oenpelli	16	12	16	12	68	50

Another factor which was present at some stations and which is known to affect the haemoglobin level is the presence of infections such as malaria and hookworm. The medical officer found that the incidence of malaria is not of sufficient intensity at any of the stations to affect seriously the health of the natives.

In an investigation of the influence of hookworm on haemoglobin levels, Hill and Andrews[14] found that, in white residents of South Georgia, U.S.A., hookworm counts of 2,000-4,000 eggs per cc. caused a slight drop in the haemoglobin level, but the effect became more marked in the 4,000-8,000 egg count class. At still higher hookworm burdens the fall in haemoglobin becomes even more rapid. Hynes[15] found no effect of 'heavy' hookworm infestation on haemoglobin levels

14. Hill and Andrews (1942), p. 499.

15. Hynes (1946a), p. 119.

unless the subjects also showed poor muscle development. Bearup and Lawrence (Report of New Guinea Nutrition Survey) found no effect comparable to that recorded by Hill and Andrews, although they point out that the number of men with high counts in their series is too small for great reliance to be placed on their findings.

At Yirrkalla, 33 per cent of the population examined had hookworm, but there were no counts greater than 2,000 eggs per gm. At Oenpelli almost 95 per cent of the population which was examined was found to be infected with hookworm. As there were so few aborigines not infected at this station, haemoglobin values for adult males were compared for those with hookworm counts above and below 4,000 eggs per gm. For 5 men with counts of from zero to 4,000 eggs per gm. the mean haemoglobin was 15·24 (S.D. 0·26) gm. per cent, compared with a mean of 14·87 (S.D. 0·53) gm. per cent for 13 men with hookworm counts above 4,000 eggs per gm., but the difference is not significant. It is possible that the numbers are not sufficient, and hookworm may be responsible for some of the lower haemoglobin levels recorded at Oenpelli.

PLASMA ASCORBIC ACID

The dichlorophenol-indophenol visual titration method used by Farmer and Abt[16] as described and slightly modified by Pecover[17] was selected because of its suitability for use in the field. Difficulties encountered by Rienits (Report of New Guinea Nutrition Survey) in determining the end point were noted and avoided. Glazed titration tiles with very shallow depressions were used, and the titration was done in open shade.

Results. The results of the plasma ascorbic acid estimations on a sex and age basis are given in Table 9. The percentage distribution of the values at the four stations is shown in Table 10. The reasons for this subdivision are the difference in activity and to some extent in the diet of the different sex and age groups. Comparisons of the results for different sex and age groups at each station and for the total population examined at the four stations have been made by the *t* test. All differences which are given as significant have been determined at the 5 per cent level.

The two groups of aborigines who came to Umbakumba and Oenpelli respectively after having spent some months as nomads are included in the figures for the respective settlements. The group that returned to Oenpelli consisted of eight adults and one adolescent. Their mean plasma ascorbic acid was 0·16 (S.D. 0·17) mg. per cent and is significantly higher than the mean value of 0·08 (S.D. 0·08) mg. per cent for the adults at Oenpelli mission. However, as there are only nine people in the group no great importance can be attached to the difference. Only eight estimations could be made on the group of nomads who returned to Umbakumba. Their mean value of 0·53 (S.D. 0·07) mg. per cent is not significantly higher than that of the adults at Umbakumba who had a mean of 0·47 (S.D. 0·16) mg. per cent.

16. Farmer and Abt (1936), p. 146.

17. Pecover (1947), p. 175.

TABLE 9

PLASMA ASCORBIC ACID (IN MGM. PER CENT) ACCORDING TO SEX AND AGE

		Total examined			0-2 years			2-15 years			16 years +		
		Mean	S.D.	Number	Mean	S.D.	Number	Mean	S.D.	Number	Mean	S.D.	Number
Umbakumba	M	0·43	0·12	63	0·44	0·07	3	0·43	0·11	21	0·47	0·10	9
	F							0·37	0·09	16	0·50	0·16	14
Angoroko	M	0·37	0·13	118	0·43	0·15	10	0·35	0·10	24	0·31	0·11	18
	F							0·40	0·17	29	0·38	0·10	37
Yirrkalla	M	0·40	0·16	116	0·46	0·33	4	0·42	0·20	14	0·43	0·15	30
	F							0·37	0·14	28	0·39	0·16	40
Nomads	M	0·30	0·12	38	0·38	0·11	5	0·29	0·13	3	0·29	0·15	5
	F							0·26	0·10	13	0·32	0·14	12
Oenpelli	M	0·09	0·10	70	—	—	—	0·14	0·10	7	0·11	0·13	26
	F							0·10	0·07	10	0·06	0·05	27

TABLE 10

PERCENTAGE DISTRIBUTION OF PLASMA ASCORBIC ACID LEVELS

Plasma ascorbic acid (mg. per cent)	Umbakumba	Angoroko	Yirrkalla	Nomads	Oenpelli	Total
0·00-0·19	—	10	6	24	81	21
0·20-0·39	43	47	48	52	16	42
0·40-0·59	49	37	30	24	3	30
0·60+	8	6	16	—	—	7

At Yirrkalla, estimations of plasma ascorbic acid were made on several groups of nomads numbering 38 in all. The nutritionist had investigated the food consumption levels of one of these groups at Port Bradshaw but the other group had come from the Caledon Bay area. It is not known how long their journey to the mission station had taken, nor of what their diet had consisted when they were camped at Caledon Bay. Although these nomads may not constitute a homogeneous group from the point of view of recent dietary history, they can be distinguished from their kinsmen at Yirrkalla station and they have consequently been considered separately as one group.

Comparing the values for the total population examined at each settlement, the mean plasma ascorbic acid of the aborigines at Oenpelli is significantly lower than that of the natives at each of the other three settlements. The results for Umbakumba are significantly greater than the Angoroko values.

At each station, values for adult males and adult females were compared and also the values for males of 2-15 years and females of 2-15 years. If there was no significant difference in the sexes, the adults were compared with the children, and the children of 2-15 years with the infants of 0-2 years. At Umbakumba the adults and the infants both show values which are significantly greater than the values for the 2-15-year-old children. At Angoroko, the values for the adult females are significantly greater than for adult males, but neither group of adults is significantly different from the children. At Yirrkalla and Oenpelli no sex or age differences were found. Within the group of nomadic aborigines, the infants have significantly higher values than the children of 2-15 years, but there is no sex difference among either children or adults and no age difference between these two latter groups.

At Oenpelli a group of eight adult women, after their plasma ascorbic acid values had been determined, were given a 25 mg. tablet of ascorbic acid twice daily for three days and the estimation was repeated. Their mean value, after the three days, of 0·21 (S.D. 0·13) mg. per cent is significantly greater than their initial plasma ascorbic acid of 0·08 (S.D. 0·05) mg. per cent.

The interpretation of plasma ascorbic levels has given rise to much discussion without any clear agreement as to their significance. In groups such as those investigated in Arnhem Land the results must be regarded with considerable reserve. There is no regular pattern of food consumption from week to week; the rations distributed by the settlements vary according to the season, location of the settlement, and the extent of the production of fresh fruit and vegetables. The results of plasma ascorbic acid estimations carried out over a period of only a few weeks can be interpreted therefore only in terms of fairly recent food intake.

The food consumption and dietary levels of the natives living at the four settlements are discussed in Section 2. The low level of plasma ascorbic acid among the natives at Oenpelli is not surprising in view of their recent dietary history.

For the natives at Angoroko, the mean plasma levels are higher than might be expected on such an irregular intake of vitamin C, but, in the quantities in which they are given, some of the fresh foods would contribute substantial amounts of

this vitamin. The higher values shown by adult females at Angoroko compared with males may perhaps be due to the fact that the women were employed harvesting the crops, and the men on the heavier work of preparation of extensions to the garden. When harvesting peanuts the women and the children certainly ate some of the product, but it is doubtful whether they would have the same scope when harvesting root crops. Perhaps the most likely explanation is that they and their children ate a larger quantity of the native foods which they gather in the week-ends.

It is not apparent why the natives at Yirrkalla mission had a higher mean plasma ascorbic acid level than did the group of nomads who visited the station, unless it is attributed to very recent high intakes from sweet potatoes by the mission natives. Those nomads who came in from Port Bradshaw had, until about a week before the tests were made, been eating considerable quantities of vegetable foods each day (see Section 6). On the journey to the station their consumption of vegetable foods was low, and the supply of vegetables was poor around the camp they established for the four days preceding their departure to this mission.

The relatively high levels of plasma ascorbic acid at Umbakumba cannot be explained on the basis of recent dietary history. In a test carried out by the Vitamin C Subcommittee of the Accessory Food Factors Committee of the Medical Research Council[18] seven volunteers consuming only 11 mg. of ascorbic acid per day had an average plasma ascorbic acid of 0·03 mg. per cent after 31 days on this intake. Their plasma level fluctuated between 0·01 and 0·05 mg. per cent during the experimental period of over one year. Although these findings cannot be applied indiscriminately, it is hard to see from what source the Umbakumba natives, at the time they were tested, could have received sufficient ascorbic acid to give a mean plasma level of 0·43 mg. per cent. For six to eight months of the year, the natives at this settlement appear to have a good intake of ascorbic acid, but the Vitamin C Subcommittee found in their experiment that the plasma ascorbic acid levels fell below 0·1 mg. per cent within three to four weeks when once the intake was reduced to 11 mg. per day or less. Crandon[19] reports a similar finding in a study of experimental scurvy on an adult man.

Borsook[20] summarizes the evidence for regarding plasma ascorbic acid levels of less than 0·4 mg. per cent as indicating a deficiency state. This figure is based largely on experiments in which saturation level is regarded as optimal. The Vitamin C Subcommittee considers that so long as there is no evidence to support the view that an intake of more than 30 mg. daily has beneficial effects, there is no basis for recommending an intake greater than that amount. In their series an intake of 30 mg. per day would correspond to a plasma ascorbic acid of approximately 0·15 mg. per cent. About 70 per cent of the aborigines examined at Oenpelli had plasma ascorbic acid levels below this figure, but the medical officer found no clinical manifestations of scurvy at this station. It is not unlikely, however, that the disease may occur if the present ration is maintained. What ascorbic acid

18. Vitamin-C Requirement (1948), p. 853.
19. Crandon (1940), p. 353.
20. Borsook (1943), p. 115.

the natives were receiving at the time of these tests, and for many months before this date, must have been derived from naturally occurring foods. As pointed out in Section 2, the amount of food the natives gather for themselves must diminish as their period of settlement increases.

At all of the settlements, it would be desirable to spread the consumption of fresh vegetables more evenly throughout the year, so that the rations given to the aborigines would not be completely devoid of ascorbic acid for three to five months of the year, as is largely the case at present.

ASCORBIC ACID IN BREAST MILK

This investigation was carried out at all stations, except Umbakumba, by the nutritionist, Miss McArthur, to ensure the co-operation of the native women.

Collection of samples. Samples were obtained from all women with babies under the age of about 12 months and from as many as possible of the mothers with infants above this age. Analyses were made on all samples available because Winikoff[21] found that there is no constant variation in the ascorbic acid content of first, middle and end milk. In point of fact, these terms have little meaning with a group such as this, as the babies are suckled whenever they cry. In a few instances women with older children could not produce enough milk for the test, although they still suckled their children. None of the women refused to give milk. The milk was expressed by hand by the women themselves. Quantities up to 20 ml. were taken and only one sample was insufficient in quantity for a duplicate test. The samples were collected between 9 and 10 a.m. and between 2 and 2.30 p.m. All of the tests at each station were done on the same day, but at Angoroko and Yirrkalla half were done in the morning and half in the afternoon. The milk was put into brown glass bottles and stored in a black box at room temperature while awaiting analysis. All the samples were titrated within one and half hours of collection. All except three of the women had been living at the settlement for at least several months prior to the investigation. The three exceptions were women who had been away from the mission station for five months. They had been living in the bush on naturally occurring food, as their ancestors have done for centuries, and had returned to Yirrkalla only two days before the tests were made. These three women belong to the same clan as most of the natives living at Yirrkalla. They were among the nomads referred to above.

Method of analysis. The method used was the dye titration using dichlorophenol-indophenol. The technique of Winikoff was followed. Fresh stock solutions were prepared at each station.

Results. The mean, standard deviation, and range of values are given in Table 11. The results of the milk analyses were compared with values for plasma ascorbic acid of the mothers and babies which had been made some two to three weeks earlier. There is no correlation between the plasma and milk ascorbic acid values for 34 women; for 16 mothers and their babies the correlation coefficient is 0·46

21. Winikoff (1946), p. 205.

($P = 0{\cdot}075$). The difference of the mean values (using the t test) for the nomads and the Yirrkalla women was highly significant. The results at Angoroko are very significantly greater than those at both Yirrkalla and Oenpelli.

The mean values for all groups shown in Table 11 are very much lower than the values found in New Guinea (Report of New Guinea Nutrition Survey). Forty-five of the forty-nine samples analysed had an ascorbic acid content below 4 mg. per cent. If this is accepted as the minimum content which is essential for adequate nutrition of the infant, the general level is very unsatisfactory and contrasts sharply with the results in New Guinea.

TABLE 11

MEAN, STANDARD DEVIATION, AND RANGE OF VALUES OF ASCORBIC ACID IN MILK

	Number of samples	Mean ascorbic acid (mg. per cent)	Standard deviation	Range of values (mg. per cent)	Plasma ascorbic acid of population	
					Mean	S.D.
Angoroko	22	3·40	0·84	1·83-5·87	0·37	0·13
Yirrkalla	15	2·14	0·36	1·66-2·86	0·40	0·16
Nomads	3	3·68	0·41	3·23-4·01	0·30	0·12
Oenpelli	9	2·15	1·03	0·59-3·80	0·09	0·10

Munks[22] found that the analysis of a single sample does not provide an accurate measure of the ascorbic acid content of human milk during a 24-hour period. It is likely that this would apply to these aborigines because of the types of food they are given, and also because those who are fed by the settlements have adopted the meal pattern of eating three times a day. Unfortunately it was not possible to take samples of milk over a 24-hour period.

As was the case in New Guinea, the mean ascorbic acid level in breast milk does not bear any direct relationship to the mean plasma ascorbic acid level of the population tested at each settlement. Again no correlation was found between the plasma ascorbic acid level and the milk ascorbic acid for a group of 34 women, nor can the correlation of ascorbic acid in milk and plasma for the group of 16 mothers and infants be considered significant. This latter result is in contrast with the finding for New Guinea, but the food pattern of the two native communities is so very different that such a disparity is not surprising.

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22. Munks (1945), p. 176.

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REPORT OF THE NUTRITION UNIT

3. THE HEALTH AND NUTRITIONAL STATUS OF THE ABORIGINES

by B. P. BILLINGTON

THE AIM of the work carried out was to assess the nutritional status, from clinical and biochemical points of view, of the aborigines living in the four places visited in Arnhem Land. In addition, data were collected on the incidence of disease.

It was found impossible to deal with family units for the following reasons:

(1) Although families on the whole slept and ate together (except children of 'dormitory age'), the daily life of the natives did not revolve around the family unit but rather around the work on the mission station.

(2) The nutrition unit had no authority to instruct natives to attend. It was the practice to arrange for the attendance for examination through the settlement staff who directed the natives' activities.

(3) The natives themselves did not respond implicitly to settlement directions. On many occasions the required group of natives did not appear, and other arrangements had to be made somewhat rapidly. In addition some records were begun but not completed owing to the sudden disappearance of the natives into the nearby scrub while the examinations were being made.

The following principles were adopted in selecting natives to be examined: (1) As many as possible of all ages and both sexes were seen; (2) a comparatively large proportion of aborigines up to the age of 16 years was included in the survey; (3) any groups which returned to the settlements after having spent some months as nomads were included whenever possible; they were always examined within several days of their return.

The procedure which was followed was to assemble the group of natives at the field laboratory after breakfast-time. Blood was withdrawn by venepuncture in all cases possible and passed to the biochemist for testing; the finger-prick technique was employed on small children. The natives were then subjected to a clinical examination.

Height and weight were measured. The only accurate records of age were for some children up to the age of ten years at Umbakumba, Yirrkalla and Angoroko where the date of birth had been recorded. The records at Oenpelli were not made available. Most of the figures for age throughout this report are, therefore, estimates only, but it is considered with confidence that the error of estimation is less than one year up to the age of 12, two years from 13 to 40, and five years above 40.

The assessment of general physical and nutritive state included muscular tone and development, and the degree of subcutaneous fat. The eyes, lips, tongue, teeth and gums were inspected for clinical evidence of disease or nutritional disorder. The neck and axillae were palpated for glandular enlargements. The abdomen was palpated and the spleen felt for any enlargement. Degree of symmetry of chest expansion was noted by inspection and palpation, and the chest was auscultated. The condition of the skin, and of appendages of the trunk and limbs was assessed.

Patellar tendon reflexes were tested and the squatting test made. Records were kept of any evidence of diseases such as yaws, leprosy, tinea, scabies and tuberculosis. Mantoux tests were made at a later stage on as many of the aborigines as possible.

A drop of blood was collected at the end of each clinical examination and thin and thick films were made for examination for malaria. In addition, some thick blood films were made at night-time for examination for micro-filaria. After the medical examination, all subjects were given a waxed paper carton, in which to bring along the following morning a sample of their faeces for examination for helminth ova.

The population at the settlements varied during the period when the tests were made, but approximate numbers are given in Table 1.

TABLE 1
PERCENTAGES OF POPULATION EXAMINED CLINICALLY

Station	Total number in station	Clinically examined	
		Number	Percentage
Umbakumba	163	87	53
Angoroko	200	144	72
Yirrkalla	220	184	84
Oenpelli	150	111	74
Total	733	526	72

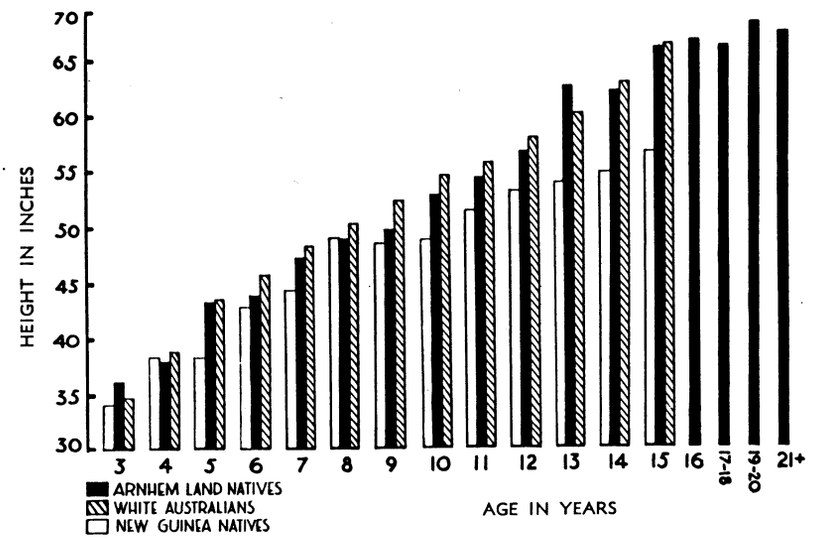
GENERAL PHYSIQUE OF ADULTS

The physique of the adults of a community is the result of several aetiological factors, one of which is nutrition. It is impossible to state to what extent the state of nutrition during the growing period affects height, weight, and muscular development of the adult.

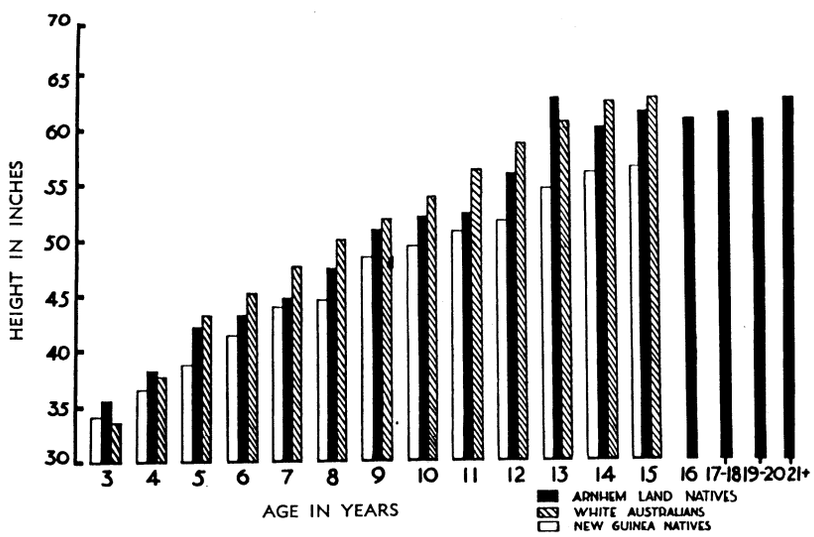
The nutritional history of the Arnhem Land adult natives studied was not uniform. They had had different degrees of contact with a new economy. As explained in Section 1, the stations visited had been in existence for different lengths of time. Moreover, the background of each adult was different as regards the length of time he had been associated with the settled community and his degree of intimacy with it. Included in the population, therefore, were adults who had grown up in the settlement and had continued to live there, adults who had grown up in the bush and only attached themselves to the settlement in their maturity, and adults who had spent varying periods of childhood, adolescence and adulthood in both the nomadic and settled ways of life.

Despite these variations, the adults of all four stations provided a surprisingly uniform pattern as regards general development and physique.[1] Graphs 1 and 2 show height for age for Arnhem Land aborigines from three to twenty years compared with white Australian schoolchildren and New Guinea natives. The figures for white Australians were obtained from the Health Record of the Lady Gowrie

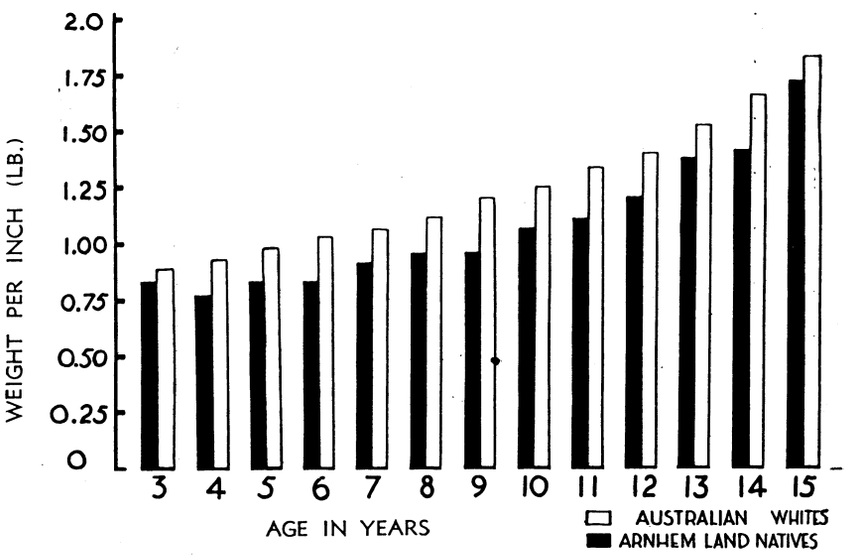
1. Pl. 1C; Pl. 2B.



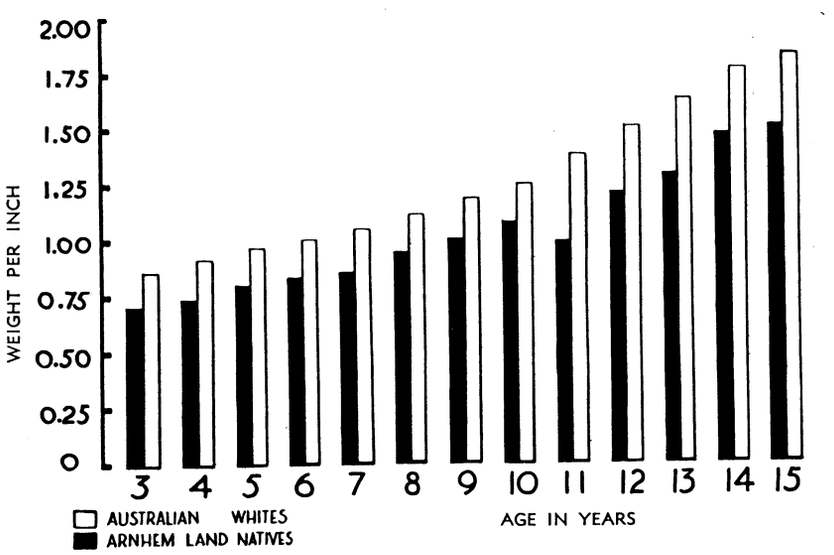
GRAPH 1. Height for age. Males, 3-20 years



GRAPH 2. Height for age. Females, 3-20 years



GRAPH 3. Mean weight (lb.) per inch of height for Arnhem Land and white Australian boys, 3-15 years



GRAPH 4. Mean weight (lb.) per inch of height for Arnhem Land and white Australian girls, 3-15 years

Child Centres[2] and from a survey of New South Wales schoolchildren by Machin.[3] Figures for the middle of each age period were used. Figures for New Guinea natives are contained in the report of the New Guinea Nutrition Survey Expedition 1947.[4] The figures from which all graphs in this section have been drawn are listed in the Appendix. Although the numbers in the younger age groupings are relatively small, and the ages in many instances are only an estimate, the graphs show little difference in height between Arnhem Land aborigines and white Australians. However, there is a marked difference between the aborigines and the New Guinea natives.

As the Arnhem Land children differ slightly in height from white Australian children, mean weight (in pounds) per inch of height for children of 3-15 years in the two groups is compared in Graphs 3 and 4. It will be seen that with increasing age the increase in mean weight per inch for the aboriginal boys parallels that of white Australian boys, but the aboriginal girls show a slower increase than white girls in the 10-15 age group. In Graphs 5 and 6 the weight of aborigines and white Australians of the same height and age are shown. The values for white Australians used in these graphs are taken from the Table of Average Weights (according to age, height and sex) issued by the Life Offices' Association for Australasia. The difference in weights between the two groups is again more marked in the women than in the men. The men reach their maximum weight at 20-24 years and maintain that weight for a considerable period. The decrease in weight with age after early adult life is particularly noticeable in the women; the skin of the abdomen hangs loosely in folds, showing an obvious loss of subcutaneous tissue.[5] Table 2 shows the incidence of this condition among female aborigines

TABLE 2

INCIDENCE OF OBVIOUS MARKED LOSS OF WEIGHT IN FEMALE ABORIGINES OVER THIRTY-SIX YEARS OF AGE

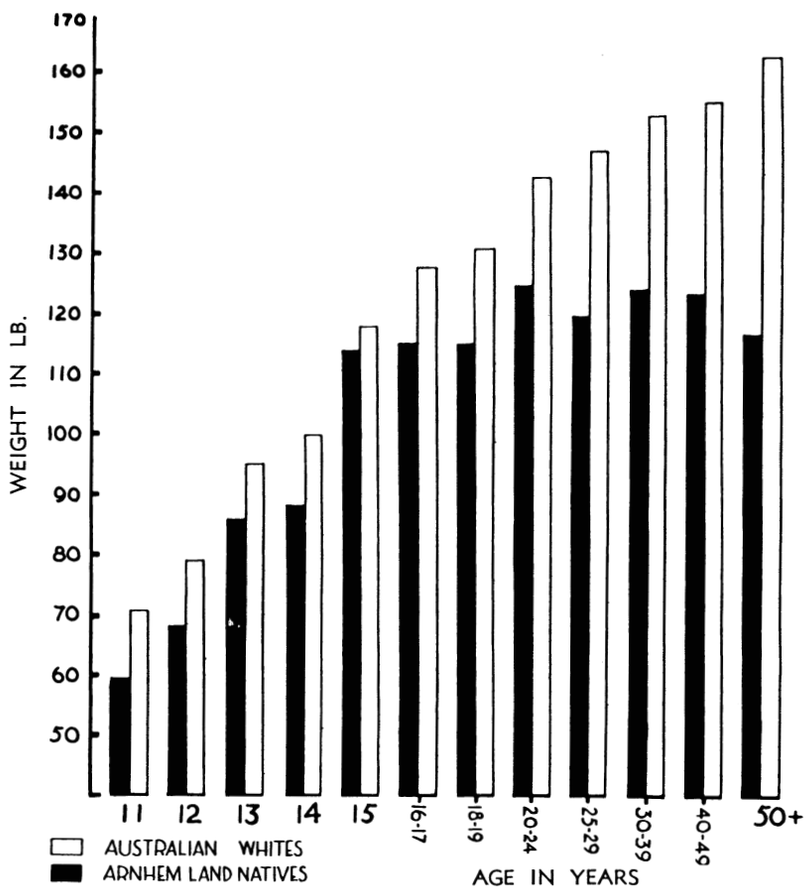
Station	Number examined	Number with loss of weight
Umbakumba	9	4
Angoroko	14	8
Yirrkalla	30	22
Oenpelli	20	9
Total	73	43 (59%)

over the age of 36 years. The incidence is highest at Yirrkalla; at this station only was the condition also noticed in women in the 26-35 age group.

FAT DISTRIBUTION IN ADULTS

In no instance was an obese adult encountered. The people are lean; in the men there is minimal subcutaneous fat, although, in a few who were examined directly after they had spent some months living in the bush (i.e. nomadically), an increase in subcutaneous fat was noted in excess of that seen in the men living

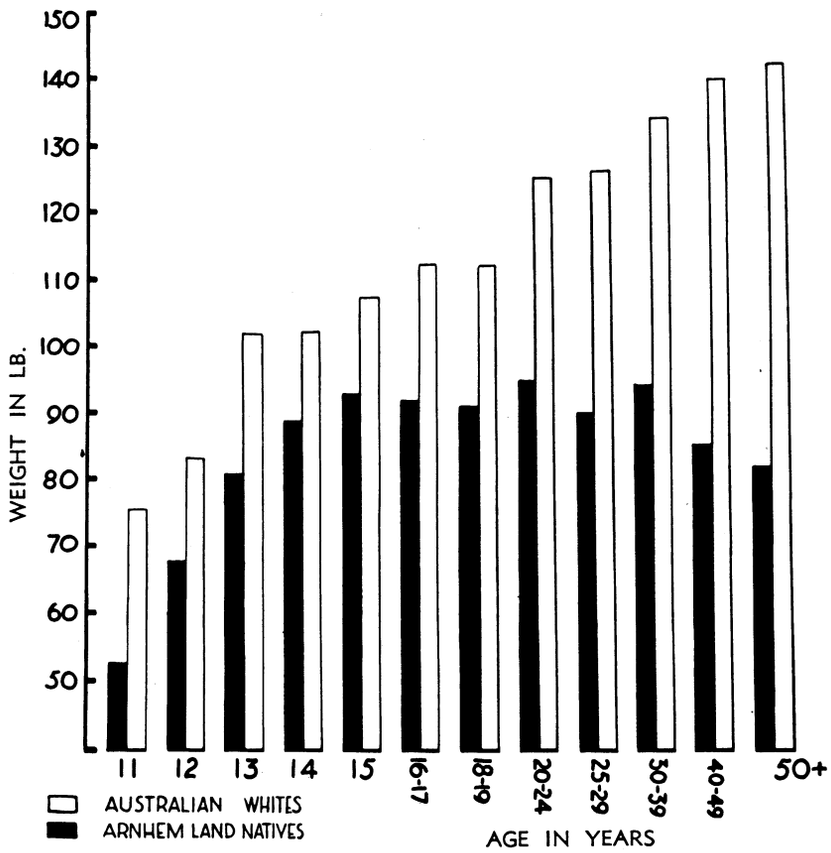
2. Clements (1945), p. 57.
3. Machin (1939), p. 128.
4. *Report, New Guinea Survey* (1947), p. 167.
5. Pl. 3B.



GRAPH 5. Corresponding weight for same height and age of Arnhem Land and white Australian males, 11-50+ years

on the settlements. The women, on the other hand, did show, in a few instances, a deposit of fat which was considered to be in excess of the average seen in the other women. These cases were entirely limited to women in the 19-35 age group.

Localized collections of fat in the nature of lipomata were noticed in the axillae of five women on Groote Eylandt. In each instance, soft spherical bilaterally symmetrical tumours, varying from one to two and a half inches in diameter, were situated on the anterior wall of the axilla. In one instance, two were found in each axilla. They were sessile in all cases, and the distribution in the upper reaches of the milk line gave them the appearance of supernumerary breasts (although no rudimentary nipples were seen). In all cases the women were otherwise lean. The appearance suggests localized areas of fat deposition which had become metabolically autonomous.



GRAPH 6. Corresponding weight for same height and age of Arnhem Land and white Australian females, 11-50+ years

MUSCLE DEVELOPMENT AND TONE IN ADULTS

The general picture of muscular development and tone in the adults was good at all four stations. As age progresses there is but little diminution of tone, no doubt due to the active life led right up to a final incapacity.[6] The general build is athletic. Shoulders, thighs, and muscles of the vertebral column are well developed and strong. Carriage, posture and gait are excellent. It was noted that both men and women prefer to carry loads on their heads; women carry large stacks of wood in this way, and their bark baskets and carrying-bags, which they use for food, are carried on or around the head, giving considerable grace to their gait. Movements in all cases were well co-ordinated and performed with apparently a minimum of effort. Thick muscular men are uncommon; the emphasis is on sparseness, although tall thin men were not seen. The men showed excellent tone of the

6. Pl. 2B; Pl. 3A.

abdominal muscles, but in women the abdominal musculature lost tone progressively with parity, although peripheral musculature remained unaffected. Some seven per cent of all adults showed development and tone well below average and approximately ten per cent showed development well above average.

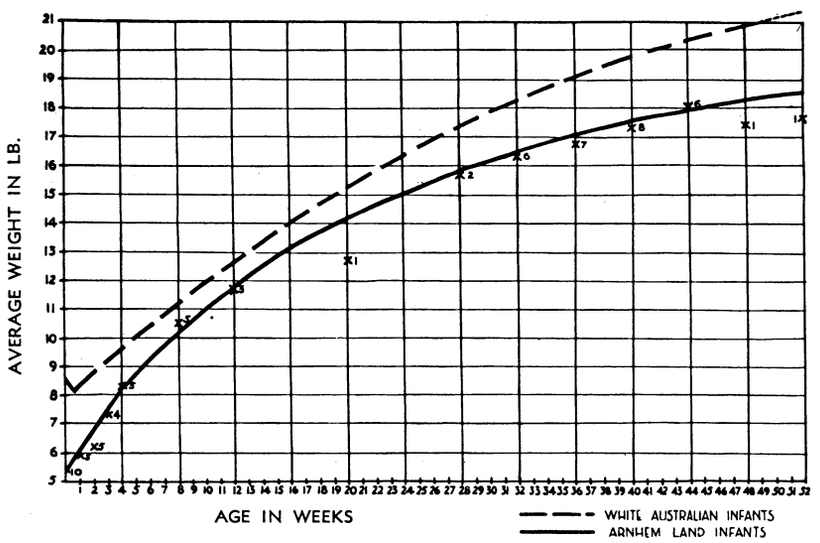
PREGNANCY AND LACTATION

From observation, puberty appears to occur in the aboriginal female at about fourteen years of age, and in the male approximately a year later. Under the former cultural pattern girls began to live in their husbands' camps before they reached puberty, but at most stations it is now the practice of the officer-in-charge to keep the girls in the dormitory for varying lengths of time after puberty, before allowing them to go to their husbands. After the completion of the first pregnancy, lactation ensues, and this frequently goes on unabated until the next pregnancy supervenes. One woman was still suckling her two-year-old son although she was approximately 22 weeks' pregnant. Without a subsequent pregnancy, lactation usually lasts from two to three and a half years. The milk is fairly ample throughout the latter part of this period. The number of children born to any one woman is not excessive, but lactation is almost continuous (except for actual pregnancies) until the woman ceases to bear more children. Miscarriages are not uncommon and some appear to be self-induced. Added to this reproductive strain, the women formerly carried on their normal daily activities with no more than one or two days' respite after parturition. Nowadays they rest in the camps at the settlements for at least a week after the birth of their babies. At the age of approximately 35, when reproduction appears to cease, women in Arnhem Land are senile by European standards. They are still strong and wiry; their somatic activity proceeds unaltered; but they have lax, protuberant abdomens with loss of elasticity of the skin, and often loss of much subcutaneous fat.

INFANCY, CHILDHOOD AND ADOLESCENCE

Many of the younger children have been born and raised, fed and taught at the settlements. Even those in the older age group have lived the greater part of their lives at the settlements, and only a few of those now living at the settlements have spent a considerable number of years as nomads. The children have therefore a more uniform background than the adults.

At Angoroko, Sister Villiers of the mission has found a mean birth weight of 5 lb. 6·3 oz. for a group of ten infants, and a mean birth length of 19·8 inches for a group of eight infants. She has also weighed several infants periodically. The records are incomplete because in some instances the women left the mission to go and live in the bush for a time, but her figures plotted in Graph 7 show no drop in weight directly after birth; the birth weight is doubled in just over two months. The data are compiled from weighings of sixteen babies, and the figures on the graph refer to the number of readings for each age used in calculating the



GRAPH 7. Weight for age, Arnhem Land and white Australian infants, 0-1 year

mean for that age. The curve for white Australian infants is based on the findings of Clements.[7]

The babies are plump and apparently grow rapidly; most are walking by the time they are twelve months old, and the anterior fontanelles have closed by this time.[8]

Between the ages of two and ten years, although the general physique of the majority is satisfactory, there is a considerable proportion (approximately 25 per cent) of children with poor muscular development.[9] This is especially noticeable in the buttocks, and is accompanied by a protruding abdomen. This latter condition in a mild form was seen in a number of children whose tone and development were otherwise good.[10] At Oenpelli, where hookworm disease is of sufficient intensity to menace health in the growing period, no increase in the proportion of children with poor development was found. In children the tendency was to leanness, although some 15-20 per cent showed a deposition of subcutaneous fat.[11]

In the adolescent group,[12] a considerable proportion of the males exhibited the long, rangy, lightly covered build, a 'shooting-up' phase, where muscular growth and fat deposition fail to keep pace with bony growth.

SIGNS INDICATING DEFICIENCY OF SPECIFIC NUTRIENTS

1. CALORIES

Insufficient calorie intake produces a weight loss or a low level of weight for height. Its diagnosis is usually dependent on the comparison of the height-weight

7. Clements (1933), p. 543.
8. Pl. 4C.
9. Pl. 3C.
10. Pl. 1E.
11. Pl. 2D; Pl. 3D.
12. Pl. 2A; Pl. 2C.

relationship with a set of standards. However, despite the fact that these standards are normally the average figures for apparently healthy people and represent a cross-section of the particular community, there is no evidence to indicate that they are optimal even for the group in question. Such standards for white Australians are obviously useless as a basis for deciding whether the aborigines are above or below standard; they are included in the graphs merely for comparison.

Keys[13] has reviewed the data dealing with calorie under-nutrition and starvation, including the results of the Minnesota experiment. But most of this deals with the effects of a gross inadequacy of food following a period of relative plenty, and it is likely that the results cannot be compared with the effects of a much smaller deficiency extending over many years. In view of these factors no definite statement is possible of the adequacy or otherwise of the calorie intake of the aborigines.

However, some points of interest may be noted. Graphs 3-6 show that for given age and height the males show considerably less discrepancy from white Australians than do the females. It seems difficult to attribute this to heredity and in view of the relative position of the sexes in aboriginal society, it is possible that it may be the result of discrimination in the allocation of food supplies. The evidence cited for loss of subcutaneous fat in women beyond early adult life seems to support this.

The apathy and lack of desire for activity were noticeable features of the majority of the adults at all settlements. However, there are several possible reasons which could be advanced as explanation for these characteristics, and it is impossible to say how important is the nutritional factor. When necessary, practically all of the adults could undertake long walks, but such activity was rarely called for and did not extend over more than a couple of days. The children were generally alert and spent a considerable part of the day playing.

The lack of interest in gathering naturally occurring foods may seem to indicate no great desire for food, but it must be remembered that in general considerable distances had to be walked, under conditions of heat which were not conducive to great physical effort, and for a prize of uncertain magnitude.

2. Protein

In the presence of an adequate intake of calories, signs of protein deficiency in children are probably limited to interference with growth. This may be represented as a failure to grow at the normal rate, or a failure to reach the full adult level. Because of the short stay at each settlement, rates of growth could not be investigated, but the poor development of some children could be due to a mild inadequacy of protein during the growing period.

It is not known whether in general the musculature of the young women is fully developed before the onset of the first pregnancy. If it is not, then the slight build of the women may be due in part to an inadequate protein intake. However, Ashley-Montagu (1939) has summarized the evidence for the existence in man of

13. Keys (1948), p. 500.

what he calls 'the adolescent sterility interval', the effect of which would appear to be the postponement of child-bearing until women are capable of bearing healthy children without serious ill-effects to their own health. If there is such a period in the lives of the majority of aboriginal women, the period of adolescent growth would be less likely to be affected by the demands of pregnancy and lactation.

In adult life, early signs of inadequate protein intake are harder to detect. In a protein deficiency the tissue reserves, especially the muscles, yield protein to the blood and tissue fluids, to maintain the serum protein level within normal range. When the deficiency becomes severe it seems that a limit is reached in the extent to which the muscles can yield protein, and then the serum level falls and oedema follows. Thus muscular wasting is an early sign of protein deficiency and oedema a late sign.

The result of serum protein estimations are given in Section 5. No clinical signs of gross inadequacy of protein were detected in any of the natives.

3. Minerals

(a) *Iron.* Deficiency of iron in the diet may result in anaemia. Haemoglobin estimations were made; results and discussions will be found in Section 5.

(b) *Iodine.* Iodine deficiency is manifest clinically by simple endemic goitre. No enlargement of the thyroid gland was seen.

(c) *Calcium.* Seven cases of 'bow leg' deformity were noted, all in multiparous women of between twenty and thirty-five years of age. It is impossible to say to what extent calcium deficiency in the growing period, or during pregnancy or lactation may have been an aetiological factor. It may well be that during the almost continuous pregnancy-lactation cycle occurring in the female after puberty, calcium intake in the diet is insufficient to supply the demands of the foetus and mammary glands, and the calcium deposition in bones is called upon with a resultant softening and deformity of bone. In no case was the deformity severe.

Two cases of 'pigeon breast' deformity were seen, one in a woman of approximately 25 at Yirrkalla, and the other in a girl of eight at Angoroko, but the aetiology of pigeon breast is not clear.

(d) *Calcium-Vitamin D.* No X-ray apparatus was taken on this survey to detect early bony changes of rachitic origin. No clinical cases of florid rickets in infancy were seen, due no doubt to the staple diet of breast milk till 15-18 months, combined with the benefit of the ultra-violet radiation of sunlight unhampered by clothing in the entirely open-air environment. No cases of bony deformity in male adolescents and adults were seen which could have had a rachitic basis.

4. Vitamins

(a) *Vitamin A.* The ophthalmic signs of vitamin A deficiency are poor dark-adaptation, xerophthalmia and Bitot's spots. No apparatus for testing dark-adaptation was taken into the field. Careful naked-eye examination was made

for xerophthalmia and Bitot's spots, but nothing to suggest vitamin A deficiency was detected in any of the 526 Arnhem Land natives examined.

The dermatological signs of vitamin A deficiency are dryness and xerosis of the skin, with lack of lustre. In these people, who generally speaking do not wash regularly, such signs are somewhat difficult to interpret. From 5 to 9 per cent of natives at the different settlements had abnormally dry skin. This condition was seen in all groups except the males of 10-55 years, but no case of frank xerosis was seen.

Follicular keratosis is generally attributed to a vitamin A deficiency. However, the Vitamin C Subcommittee of the Medical Research Council (1948) found that it developed in subjects on a vitamin C deficient diet and, in their tests, was cured when vitamin C was given. Hackett (1946) describes some follicular keratosis as an atypical secondary skin lesion of yaws, and as yaws is an indigenous disease in Arnhem Land it is not possible to ascribe the presence of follicular keratosis to any one cause. Follicular keratosis was noted in some 15 per cent of the Arnhem Land natives. The sites most commonly implicated were the infra-patellar and lateral aspects of the leg, the radial and dorsal aspects of the forearm, and around the neck (Plate 1D). There was no apparent significant incidence in any particular age or sex group, except that no case was noted in a child under six years.

(b) *Thiamin.* Patellar tendon reflexes were tested and the squatting test made on all subjects. No case of abnormality was seen, nor was there any sign of a peripheral neuritis, or any cases of oedema that could be ascribed to a thiamin deficiency.

(c) *Nicotinic acid.* Naked-eye inspection of the tongue revealed a few cases with abnormalities. As with New Guinea natives, pigmented tongue papillae were regarded as a racial characteristic associated with the dark-skinned. Most tongues were pink and clean, with normal size and distribution of papillae. However, four children at Oenpelli between the ages of three and ten had red tongues with atrophy of papillae which suggested a nicotinic acid deficiency. Only one case of pellagrous dermatitis was seen. This was in a woman of over 60 at Oenpelli who, crippled by the residua of a hemiplegia, rested in the native camp all the time, did not attend for food hand-outs and was incapable of gathering food for herself. She also showed a typical red tongue with atrophic papillae indicating nicotinic acid deficiency, marked angular stomatitis, and a collar of follicular keratosis.

(d) *Riboflavin.* Riboflavin deficiency is recognized clinically by vascularization of the cornea, angular stomatitis and cheilosis. In no instances were eye changes or cheilosis seen. However, at Umbakumba and Angoroko a condition resembling angular stomatitis was seen in a number of natives (38-40 per cent); the incidence was lower among adults than among children and adolescents. In appearance the lesions varied from mild to marked thickening, with paleness of the mucosa at the corners of the mouth, and sometimes a cracking and superficial scar formation.[14] It may have been due to a riboflavin deficiency.

14. Pl. 4D.

(e) *Ascorbic acid.* Ascorbic acid levels in plasma and milk were estimated and the results are discussed in Section 5. Mention has already been made of the occurrence of follicular keratosis which may be linked with an early ascorbic acid deficiency. Later symptoms are the effect on the gums (submucous and subperiosteal haemorrhages with subcutaneous bruising) and delay in wound healing. In infants, scurvy shows the same manifestations except that there are no obvious gum lesions in the absence of teeth, and tender bones with slightly swollen joints and haematuria are more prominent clinical features.

In Arnhem Land no clinical cases of florid scurvy either in infants or adults were seen. No X-ray check could be made for radiological evidence of scurvy in infants. Haemorrhages either subcutaneous or submucous attributable to ascorbic acid deficiency were absent. Although wounds are common and are usually poorly protected from dirt and from flies (which are very numerous in the area), the only delay in wound healing that was observed was at Yirrkalla in July and August. This applied particularly to the small second and third degree burns which are so common. Secondary infection of wounds is remarkably small.

Some comment must be made on the condition of the gums in the Arnhem Land aborigines. In both male and female from the age of six years upwards an early firm swelling or hypertrophy of the gingival tissue was noticed in the great majority of cases examined.[15] In about 15 per cent of the population which was examined, bleeding could be induced with light pressure. Very few of these showed red or hyperaemic gums and in no case were the gums spongy. Following on the early stages of swelling, there is recession and retraction of the gum from the tooth as age progresses, with the formation of deep pockets, which on pressure yield copious quantities of sordes and in some cases frank pus.[16] There is later a recession of interdental papillae and finally a generalized atrophy of gingival tissue; these factors, together with dental attrition and caries lead to exfoliation of teeth in some cases.[17] The incidence of this type of periodontal disease was found to be universal at all stations visited, and was progressive with age. A more detailed description of the dental conditions of the aborigines is given in Section 4 of the report; it is to be noted that figures for periodontal and dental conditions taken independently by me agree entirely with those reported by Moody in that section. A similar cycle and a similar incidence of these conditions were noted in New Guinea natives.[18] But the New Guinea natives had a high intake of ascorbic acid, and the lack of this vitamin could not be regarded as a causative factor of their condition. It is likely, therefore, that the lack of ascorbic acid has no connection with these gum lesions in the aborigines.

GENERAL PATHOLOGY

Trauma

Trauma is common amongst these people although it is seldom severe, except in cases of homicide. The commonest form of trauma, other than minor cuts,

15. Pl. 5D.
16. Pl. 5A.
17. Pl. 5B; Pl. 5C.
18. *Report, New Guinea Survey* (1947), p. 235.

TABLE 7

HOOKWORM INTENSITY BY SEX AND AGE (147 STOOLS AT YIRRKALLA)

Age	Negative		Positive—eggs per gram						Total number		Maximum value eggs per gram	
			0–299		300–999		1000+					
	M	F	M	F	M	F	M	F	M	F	M	F
0—	2	0	0	0	1	0	0	0	3	0	300	0
2—	4	8	0	1	1	1	0	0	5	10	340	790
6—	4	4	1	7	0	3	0	1	5	15	†	1,800
11—	4	5	1	7	1	0	0	0	6	12	300	†
16—	9	7	2	0	1	0	1	1	13	8	1,200	1,200
21+	16	35	4	3	3	3	0	6	23	47	900	2,700
Total	39	59	8	18	7	7	1	8	55	92		
%*	70·9	64·1	14·5	19·6	12·7	7·6	1·8	8·7				
% of grand total	66·7		17·7		9·5		6·1					

† No count made.
* Per cent of total male and female respectively.

of the year, and there is a permanent still-water lagoon close to the camp. Such conditions would provide an excellent medium for the development of hook worm ova, and this fact would appear to account for the almost universal infestation at this settlement.

(b) *Helminth ova.* Table 9 shows the incidence of helminth ova for both sexes over the age of one year at the four settlements. The threadworm (*Enterobius vermicularis*) was found in stools at Angoroko and Yirrkalla.

VITAL STATISTICS

In none of the settlements visited were there accurate records of births, deaths or resident population. Such records would be difficult to keep because the natives have not yet completely abandoned their nomadic habits. The population at each settlement varied in number from week to week, and births and deaths would therefore not all occur at the settlements.

POPULATION TRENDS

The experience in Australia in the past has been that where the aborigines come into contact with Western civilization they eventually die out, the speed of the process depending largely on the extent of the contact to which they are subjected. No figures for births in a given period are available for Arnhem Land, but Table 10 gives the proportion of children and adults at the four settlements. The figures for Umbakumba and Oenpelli refer to the number of aborigines who were resident at these stations at the time of our visit. For Angoroko and Yirrkalla the figures include, in addition to those resident at the stations, natives who had tem-

TABLE 8

HOOKWORM INTENSITY BY SEX AND AGE (89 STOOLS AT OENPELLI)

Age	Negative		Positive—eggs per gram												Total number		Median of positives		Mean of positives		Maximum value	
			0–999		1,000–2,999		3,000–4,999		5,000–7,499		7,500–9,999		10,000+									
	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F
0—	1	0	0	0	0	1	0	0	0	0	0	0	0	0	1	1	—	—	—	—	0	2,700
2—	1	0	0	0	0	1	3	2	1	0	0	2	1	1	6	6	4,800	6,450	20,740	6,425	85,725	10,125
6—	0	1	2	1	0	1	2	3	0	1	0	0	0	0	4	7	2,025	3,675	2,080	3,350	3,600	5,400
11—	0	0	0	0	3	1	1	0	0	1	0	0	0	0	4	2	1,835	3,975	2,160	3,975	3,825	6,750
16—	1	0	0	0	0	1	0	1	1	2	0	1	2	4	4	9	14,400	9,000	11,650	8,695	15,150	14,400
21+	0	1	3	2	6	3	1	0	8	3	0	4	8	6	26	19	5,850	8,325	8,050	9,540	30,600	49,800
Total	3	2	5	3	9	8	7	6	10	7	0	7	11	11	45	44						
%*	6·7	4·5	11·1	6·8	20·0	18·2	15·6	13·6	22·2	15·9	0	15·9	24·4	25·0								
% of grand total	5·6		9·0		19·1		14·6		20·2		7·9		23·6									

* Per cent of total male and female respectively.

TABLE 9

INCIDENCE OF HELMINTH OVA FOR BOTH SEXES OVER AGE OF 1 YEAR
(Positive results)

	Umbakumba		Angoroko		Yirrkalla		Oenpelli	
	Number	%	Number	%	Number	%	Number	%
Hookworm ova	0	0	0	0	49	33·3	85	94·4
Hymenolepis nana	1	2·0	5	4·9	7	4·8	4	4·4
Ascaris lumbricoides	3	6·1	0	0	0	0	0	0
Number of stools examined	49		103		147		90	

porarily gone to live as nomads but who spend most of their time at the respective settlements. When adults leave the stations to live in the bush they sometimes take only the younger children with them, leaving children of nine or ten years and older in the mission dormitories. However, the number of children who were living at Umbakumba and Oenpelli without their parents was only two or three in each case and does not materially affect the figures.

TABLE 10

PROPORTION OF CHILDREN TO ADULTS AT THE FOUR SETTLEMENTS

	Number under 16 years			Number over 16 years		
	Male	Female	Total	Male	Female	Total
Umbakumba	47	38	85 (52%)	38	40	78 (48%)
Angoroko	73	68	141 (51%)	65	72	137 (49%)
Yirrkalla			162 (57%)	46	75	121 (43%)
Oenpelli	31	23	54 (36%)	45	51	96 (64%)

Table 11 shows the average number of live births per woman: Angoroko, 3·5; Yirrkalla, 3·8; and Oenpelli, 2·3. In view of what has happened in the past, the figures for Oenpelli, where there has been white settlement for over fifty years, raise the question of whether depopulation may not take place within the reserve with the passage of time. But the significance of, and the reasons for, the difference between Oenpelli and the other three settlements would require detailed sociological research in culture contact; we wish merely to show that some evidence suggestive of depopulation within the reserve already exists.

Infant mortality. The records at the settlements are quite inadequate to provide information on infant mortality rates. In order to make some assessment, two native women were selected at each of the three stations, Angoroko, Yirrkalla and Oenpelli. They were all women who had had considerable contact with the members of the nutrition unit, and they were questioned separately about the number of children born to all the women at the settlement. Where there was a difference of opinion between the two women being questioned no record was made about the woman under investigation. The results are given in Table 11. In compiling Table 11 infancy was defined as the period up to the age that a child begins to

walk; a boy and girl who were aged approximately sixteen years were indicated to the women being questioned as examples of the upper limit of childhood.

Infant mortality is normally expressed as the number of deaths per 1,000 live births per annum. It is not known exactly to what period the figures here quoted apply. Generally speaking, it would be approximately twenty years, but no widespread change in infant care has occurred over this period. The infant mortality

TABLE 11

INFORMATION RELATING TO BIRTH-RATE AND INFANT MORTALITY RATE AT THREE SETTLEMENTS

	Angoroko	Yirrkalla	Oenpelli
Number of mothers	67	74	61
Number of miscarriages (spontaneous)	16	20	13
Number of miscarriages (induced)	—	—	14
Number of still births	7	8	9
Number of live births	234	280	139
Number of children died infancy	25	43	15
Cases of infanticide	—	1	—
Number of children died childhood	6	16	5
Number died later than childhood	3	11	5
Number still alive	193	205	104
Number not accounted for	7	4	10
Infant mortality rate/1,000 live births*	106·8	157·2	108·0

* See reference in text.

rate for these three stations considered jointly is 127·1 per 1,000 live births, which is very high. The causes of this high death-rate in infants could not be ascertained. Until a few years ago most of the women left the settlements a short time before the birth of the child and stayed away for weeks or even months. At the present time they remain at the settlements and have their babies somewhere in the close vicinity. The two nursing sisters at Angoroko and Oenpelli are anxious for the women to have their babies in the hospitals and increasing numbers are being persuaded to do so.

Maternal mortality. The women from the three settlements who were questioned could remember having heard of only two mothers who had died, and both of these had died some hours after delivery.

Still births. The figures in Table 11 show 36·8 still births per 1,000 live births.

Miscarriages. Miscarriage is apparently not uncommon amongst the aborigines. All of the women who were questioned gave details of methods for inducing miscarriage but, although the practice was admitted, it was only at Oenpelli that mention was made of specific instances in the case of any of the women whose child-birth history was investigated. No instance was known in which miscarriage had caused the death of a woman. Vaginal methods of emptying the uterus are unknown and the reason for inducing abortion which was given without hesitation by both informants at Oenpelli, was 'she no want-im children, she want-im play-about'. The figure for the three settlements is 98 miscarriages per 1,000 live births; for Oenpelli the figure is 194·2 miscarriages per 1,000 live births.

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PUBLIC HEALTH

Sanitation. Under the former nomadic way of life, disposal of excreta was not a difficult problem, but the habits practised in that period have not changed and they need modification under the conditions of settled existence. All settlements have provided latrines but there is no attempt made in most cases to see that they are used, or that the receptacles are kept covered. The result is that defecation most commonly takes place within a few minutes' walking distance of the camp. When, as is often the case, the excreta are not adequately buried, the menace of flies should need no emphasis. To prevent the spread of hookworm, adequate disposal of excreta is important and needs immediate attention.

Flies (Musca domestica). Flies abound at all settlements and in some areas it is a common sight to see them clinging to the eyes and mouths of children and adults alike. They breed in the decaying vegetable matter and excreta of human and animal origin close to and within the unsupervised native camps. No methods of fly eradication or prevention are employed. In view of the complete absence of sanitation, the fact that they have not yet been a serious menace to health in these isolated communities can probably be attributed to the absence of a virulent pathogen, and cannot be attributed to the present conditions. The spread of eye infections and possibly also some diseases leading to the high infant mortality may be due to flies. Precautions in dealing with flies are therefore necessary.

Mosquitoes. Mosquitoes abound at each settlement at night-time. No methods of control are employed. Identification of mosquitoes was not carried out in this survey.

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