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**DIET, DENTAL CARIES AND PERIODONTAL DISEASE**

with reference to

**INDIGENOUS PEOPLE**

of the

**TERRITORY OF PAPUA AND NEW GUINEA**

by

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## CHAPTER 1.

### INTRODUCTION.

The Territory of Papua and New Guinea consists of two parts:

- a. The Territory of Papua, comprising the area which was called British New Guinea up to 1905.
- b. The Territory of New Guinea, made into a Trust Territory of Australia by the League of Nations in 1920.

In 1949 these two parts were amalgamated and since then the whole area has been regarded as a single territory, divided into four regions for administrative purposes only.

It comprises a huge mainland mass and large island groups with a total area of approximately 183,000 square miles, extending from just south of the equator to  $11^{\circ}40'$  south latitude and from the border with West-Irian at  $141^{\circ}$  to  $160^{\circ}$  east longitude. The Mainland has a huge mountain system running chiefly through the centre in an East-West direction with peaks up to 14,500 feet. It is a rugged country with thick jungles, some large rivers and swamps, in which communications are still very limited; largely dependant on air travel, as good roads are few and most of the rivers are only navigable for short distances.

In a population of under 2.5 million, consisting mainly of Melanesians with some Micronesians, Polynesians, Chinese and Europeans, up to 700 languages are in use.

The climate is typical monsonal; hot and humid with the notable exception of the Highlands.

Outside the relatively few and small main centres, most natives live in closely knit village communities generally of 100 and 300 people only, but wide variations occur. Many villages are virtually isolated from each other. The people's livelihood depends mainly on agriculture, based on a subsistence economy of staple foods, such as sweet potato, yam, taro, banana and sago, supplemented only to some degree with fish, pigmeat and other sources of animal protein.

The indigene's diet both quantitatively and qualitatively can seldom be regarded as satisfactory. Indicative of this might be the local population's generally smaller stature, body build and lower life expectancy than that of people of Caucasian stock. Which of the factors: deficient protein - intake or heridity plays the major part here, is not known however. Muscular development and physical activity also seem to be lower.

The dental health of the peoples of the Territory is far from that state of perfection, which popular belief sometimes attributes to the more "primitive" races, leading the more "natural" life. But of course dental disease is not peculiar to any group of people, whether defined geographically or ethnically, nor is its occurrence restricted to those of a certain age, sex or economic status.

Although the indigenes of Papua and New Guinea are no exception to this rule, there are significant differences in the dental disease pattern when comparisons are made not only between the Territory peoples as a whole and the more "civilised" populations, but also between the various local communities. These differences could be, partly at least, the result of the effect primitive and modern diets have on dental health and disease.

CHAPTER 2.

NUTRITION - AND DENTAL SURVEYS CONDUCTED IN PAPUA  
AND NEW GUINEA

2.1 INTRODUCTION:

The importance of nutrition - and dental surveys, conducted in underdeveloped areas such as Papua and New Guinea, is considerable. Due to the isolation in which most of these people are living, caused by the multitude of languages and the terrain, outside influences are minimised. And whilst primitive people remain living in their own natural surroundings with unchanged dietary patterns there will be the opportunity to study human beings, whose environment is more or less free from those factors regarded as controlling the onset and incidence of dental caries and periodontal disease.

Valuable data could be provided by these surveys and they might, when investigated intelligently, contribute to the welfare of these people as well as the "civilised communities".

## 2.2 1935-1937 FIELD OBSERVATIONS IN MANUS -

R. M. KIRKPATRICK<sup>(23), (24)</sup>

Kirkpatrick<sup>(23)</sup> did epidemiological surveys of 1,976 Manus\* Island villagers in 1935 and 1937. As nearly as possible such villages as offered average conditions of living and an equal number of taro and sago eating natives were visited.

Accordingly some villages on the north and south coasts and the inland were inspected. It was therefore thought that the natives who were examined were a good sample of the total population. Particular care was taken to examine every native who lived in each village visited, so that a selected grouping would not enter into the problem.

The aim of the survey was the investigation of gingival diseases in relation to diet, but during this survey Kirkpatrick<sup>(23)</sup> also gathered data on dental caries and odontoclasia.

It was reported that those natives living principally on taro had better developed dental arches and showed a smaller incidence of acute or subacute Vincent's infection than the indigenes living mainly on sago. Mention was also made that the inhabitants of

Manus were relatively immune to caries, for both the sago and taro staple groups. Odontoclasia - incidence was reported to be higher in children living inland than in the ones living on the coast. In Kirkpatrick's surveys no precise criteria for measurements used and no age distributions, except for a gross division into groups under and over 20 years of age, were given. Also he merely assumed that separate villages, within one dietary group could be validly pooled as one population. These deficiencies invalidate accurate comparisons with other studies and reduce the value of his observations. <sup>(4)</sup>

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\* The island of Manus is situated 200 miles north of the Mainland of New Guinea and has 15,000 Melanesian inhabitants.

2.3 1947 - NEW GUINEA NUTRITION SURVEY EXPEDITION<sup>(34), (39), (40)</sup>

- E. H. HIPSLEY, et al.

The 1947 New Guinea Nutrition Survey was undertaken at the request of the Administration of the Territory of Papua and New Guinea, and the Department of External Territories. The Administration considered it desirable to collect information relative to food-production and consumption of native groups living exclusively on indigenous foods, and at the same time ascertain the nutritional status and health of these groups.

In this study five villages\* were chosen for intensive investigation.

In the latter half of 1947 the Institute of Dental Research in Sydney participated in this survey with Sinclair, Cameron and Goldsworthy, (39), (40).

The study of the oral conditions of the village-groups was undertaken largely because the data to be collected on nutrition and related aspects of native life seemed likely to form a good background for the interpretation of the dental observations.

The intention was to make clinical and bacteriological studies

of dental caries. And as the periodontal conditions of primitive races living on their native diets vary greatly in different parts of the world, it was also considered of interest to examine the periodontal tissues of the New Guinea natives as fully as possible in the time available.

331 subjects in three main centres <sup>\*\*</sup> were examined for this purpose.

Apart from periodontal conditions and dental caries, a wide range of observations was included, such as anatomy, occlusion, developmental aberrations and attrition.

Periodontal conditions were classified in three broad groups:

- (i) Includes: (a) subjects with grades of the disease detectable clinically, but not severe enough to produce discernible bone-loss and  
(b) subjects with apparently normal periodontal tissues.
- (ii) Loss of bone ranging from 1 or 2 small pockets to a widespread and general loss.

Those showing very slight loss of bone at the bifurcation of the roots of 1 or 2 of the molars were the upper limit of this degree of the disease.

- (iii) Extensive general bone-loss greater than that in group (ii) sometimes associated with exfoliation of the teeth and obvious loss of bone at the bifurcation of the roots of more than two of the molars.

This classification is undoubtedly inadequate, but in 1947 indices for periodontal disease measurements were non-existent. The discussion of the results of the periodontal conditions were too general to be of much importance. (4)

The examination for dental caries was carried out in the shade under adequate light conditions. Plane mirrors and right angle explorers were used and only cavities, in which an explorer could be positively retained were recorded as carious. Five intra-oral films were exposed in each examination, three for the upper anterior teeth and two bitewings for the posterior teeth.

Bodecker's (7) modified dental caries index was used. Slight modifications were made in the recording of deciduous teeth. Caries incidence in each village was recorded on survey charts after the field examinations were completed on the basis of:

- (1) persons: (ia) caries free  
(ib) caries other than retained roots

(ic) with caries

- (2) Standing teeth
- (3) Surfaces of standing teeth

In this survey the number of carious surfaces observed were expressed as a percentage of the total number of tooth-surfaces in each age-group.

- (4) Teeth, including missing teeth.

Also were collected and examined samples of saliva for bacteriological purposes and other relevant data (e. g. dietary). Because accurate ages were not available physiological age-grouping was used. This was based on the number of teeth erupted and general physical appearance.

The six groups used, were 1 to 5, 6 to 10, 11 to 15, 16 to 29, 30 to 44 and 45 and over.

Langley <sup>(34)</sup> collected data on the food consumption and dietary patterns of a number of households in 4 of the 5 villages mentioned. The villages were selected each to represent a particular economy. An attempt was made to ascertain the quantities of all foodstuffs consumed by the members of the households investigated and information on the food pattern of the four villages

was also obtained. It was found that the staples in each village contributed a very high percentage of the total food both in weight of foodstuffs and calories. Supplementary foodstuffs such as green leaves, berries and fruits contributed a not insignificant quantity of food and made very valuable contributions to the intake of nutrients, particularly minerals and vitamins. The villages were originally chosen as representative of stable economies using the main vegetable food staples common to the Territory. It was hoped that each village would have one principal staple, but in two instances 2 staples were eaten in practically equal amounts:

<u>VILLAGE</u>	<u>STAPLE</u>
BUSAMA	: Taro with sago as supplement.
KAIAPIT	: Banana 55%, sweet potato 45%.
PATEP 2	: Sweet potato 47%, Taro 53%.
KAVATARIA	: Yam, supplemented by sweet potato and taro plus sea foods.

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\* (1) Busama : A coastal village a few miles from Lae.

(2) Kaiapit : A village situated in the Upper Markham Valley about 100 feet above sea level.

- (3) Patep 2 : A village 50 miles from Lae in mountainous country at an altitude of 3,550 feet.
- (4) Kavitaria : A coastal village on the island of Kiriwina, one of the Trobiand Islands, with a population of about 300.
- (5) Korovagi : A village near the Purari Delta at the Papuan Gulf - about 60 miles east of Kikori.

\*\* Only the last 3 villages were included in the dental part of the survey.

2.4 1958 - FIELD STUDIES IN THE MAIN CENTRES OF

T. P. N. G. - J. F. WILLIAMS<sup>(46)</sup>.

This survey was undertaken at the request of the Director of Public Health, Port Moresby, who wished to develop a dental hygiene service in the Territory with a dental nursing service (New Zealand style) as its basis. Its aim was to assess the position of the Dental Services in the Territory and the particular dental health problems in such areas where caries had been found by patrols to be a major problem.

Williams<sup>(46)</sup> restricted this survey, because of limited time available, to the more readily accessible parts of the Territory and studied 1,427 schoolchildren, of which 1,069 were indigenous, in the 6 main centres only.

Indigenous children were compared on the basis of urban, highland and coastal divisions.

As it was impossible to obtain accurate information regarding the ages of the indigenous subjects it was decided to classify them in 3 dentition groups:

deciduous (dmf)

mixed (dmf, DMF)

and permanent (DMF)

The examinations were carried out under good natural lighting with plane mirrors and double ended explorers. No prophylaxes were done beforehand and no X-rays taken. All groups contained caries susceptible subjects. In some the disease could be said to be relatively rare, whilst in others all, or nearly all the subjects examined, were affected.

The caries prevalence was lowest for the deciduous dentitions and except for the coastal people, highest in the mixed dentition groups.

This does not necessarily indicate an improvement in prevalence of dental caries for the permanent dentition compared with the mixed dentition as dmf units formerly contributing to the whole values for the mixed dentition, are lost by natural shedding and, furthermore, that the permanent teeth present have not been at risk for any appreciable length of time.

High prevalence of gingivitis and a low prevalence of malocclusion were also recorded.

2.5 1956-1962 INVESTIGATIONS IN ALL FOUR REGIONS OFT. P. N. G. - D. E. BARMES (3)

This survey started in 1956 and was primarily concerned with a comparative study of dental caries prevalence, as found in the various dietary groups that exist in T. P. N. G., but includes also investigations into periodontal disease, attrition, vertical dimension, abnormalities and malocclusion. Its main aim was to prove or disprove the hypothesis that a distinct dental disease pattern existed for each dietary type. 2,077 subjects out of a population of 4,099 were examined from 15 village groups, each with virtually unaltered traditional diets, representing 6 different dietary groups\* and taken from areas widespread throughout the Territory.

All examinations were carried out in conditions of good natural light and the instruments employed were sharp sickle explorers and mouth mirrors.

As in the New Guinea Nutrition Survey Expedition of 1947 physiological age-grouping: 0-1, 1-5, 6-10, 11-15, 16-29, 30-44, and 45 + and the Bodecker (7) Chart of 180 surfaces for the

permanent dentition and a modified chart of 108 surfaces for the deciduous dentition were used.

The deciduous and permanent dentition were considered separately in the comparison of dental caries prevalence. Roentgenographic aids were not available. Periodontal disease prevalence in the permanent dentition was classified on the basis of four grades.

(As Russell's index <sup>(35)</sup> was not yet widely acclaimed at the commencement of this survey, no use was made of it.)

The six dietary groups were classified as follows:-

<p>Dietary Group 1. (5 villages, 491 males and 516 females)</p>	<p>Taro, Yam or Banana Staple, supplemented with fruits, nuts, leaf foods, small mammals and fish. This dietary range is typical for the coastal dwellers and therefore represents a very large group. Despite the variety there is always a definite staple in this group. Besides coastal areas it is common in all low lands, but is superseded by sago diets in swamps, river and plain regions.</p>
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Dietary Group 2.  
 (3 villages: 181  
 males and 194  
 females)

Mixed diets, which may be Taro, Yam or Sweet potato staple, supplemented with banana, and most of the subsidiary foods of group 1, except for fish, which is either absent or scarce. This dietary complex represents the transition from lowland to highland diets and exhibits in its most typical form only a slight dominance of either sweet potato on one hand or taro, yam on the other. It is common to inland village groups living at about 2,000 ft. to 3000 ft. above sea level.

Dietary Group 3.  
 (4 villages: 180  
 males and 189  
 females)

Sweet potato staple. This food is eaten in "boiled" form and supplemented with some pigmeat and to an even smaller extent also with the subsidiary foods of group 2.

This is the most unvaried diet and is exclusively found in the true highland regions; that is 3,000 ft. or above sea level.

Dietary Group 4,  
 (1 village: 29  
 males and 42  
 females)

Sweet potato staple - eaten in the "baked" form and supplemented by the same subsidiary foods as group 3.

Apart from the cooking method this group is identical to group 3 and can be best regarded as a subgroup of 3.

Dietary Group 5.  
 (1 village: 110  
 males and 62  
 females)

Unvaried sago staple. Other lowland foods are very restricted because of seasonal flooding and lack of suitable land for cultivation. This diet is common to villages totally surrounded by swamps.

Group 5 can be regarded as a subgroup of 6.

Dietary Group 6.  
 (1 village: 46  
 males and 37  
 females)

Varied sago staple. This diet is common to villages situated on rivers and plains. Most other crops are also cultivated and there is an abundance of fish, small mammals, crocodiles, etc.

This group has a higher protein intake than all others. Their diet seems to be the most versatile and perhaps the best in the

## Territory in terms of nutrition.

Caries measurements are given in table 1.

TABLE 1.

Means of caries measurements in dietary groups

Dietary Group	dmf teeth per 100 teeth	DMF teeth per 100 teeth	dmf/DMF per subject <sup>*</sup>
1	10.3	1.9	1.0
2	13.8	5.3	1.8
3	25.7	24.8	6.9
4	9.8	8.4	2.7
5	16.2	26.3	6.8
6	0.0	0.1	0.0

\* The mean dmf/DMF per subject for the whole survey was 3.4

With regard to DMF, dmf and def indices. Barmes<sup>(5)</sup> made the following remarks:

- (a) F (or f) is non existent.
- (b) Extreme difficulty is experienced in determining the reason for tooth loss. Actually M (or e or m) is virtually nil except for age groups over 29 and then it is inaccurate because of the high tooth mortality effect of periodontal disease.

(c) The DMF index is really only D for the young and either DM or D for those of advancing years.

(d) In the dmf and def index m (or e) and f are non existent.

A high prevalence of periodontal disease and a low prevalence of malocclusion was reported.

Also encountered were cases of odontoclasia.

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\* Two of these dietary groups could be considered subgroups.

## 2.6 1962-1966 SURVEY IN THREE REGIONS OF T. P. N. G.

- A. P. VINES <sup>(45)</sup> et al.

Vines\* examined between 1962 and 1966, 4,000 subjects in 52 villages distributed over 3 Regions: Highlands, Mainland and Islands.

The dental survey was part of a morbidity survey and aimed to consolidate the results of Barmes' 1962 survey <sup>(3)</sup>. Dietary groups and disease patterns, which may have been missed by previous surveys might be discovered.

Conditions described in the 1962 Survey <sup>(3)</sup>, but not fully measured, have been examined in detail; while more modern indices and refined criteria have been used.

Minimisation of observer differences had been a major consideration in developing the methodology for this survey and yet difficulties have arisen, particularly with Russell's Periodontal Index <sup>(35)</sup>. This being a combined medical-dental survey had the advantage that resources were available normally not readily at the disposal of the dental worker.

Not having publicized any of the survey results yet, Vines <sup>(45)</sup>

could only make a few data available, covering three census units, one each from the Highlands, Mainland and Islands.

MIAMPO in Census Unit 9 (Highlands - Mount Hagen Subdistrict) includes 20 subjects, while in AWAR in Census Unit 12 (Mainland-Bogia Subdistrict) 39 subjects were examined and in TALAKUA in Census Unit 4 (Islands - Rabaul Subdistrict) 85 subjects. The use of betelnut was also studied in this survey and an attempt was made to establish a relationship between betelchewing and hyperkeratosis, which was defined as a popular eruption on, and a thickening of the oral mucosa.

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\* An epidemiological sample survey of the Highlands, Mainland and Islands Regions of the Territory of Papua and New Guinea by A. P. Vines<sup>(45)</sup> - a not yet published thesis submitted for the degree of M. D. at the University of Sydney.

## 2.7 SUMMARY

1. These nutrition - and dental surveys of primitive people with largely unchanged dietary patterns, mainly conducted because of the need for comparison of primitive and modern diets and their effect on dental health and disease, have not all recorded caries - and periodontal disease prevalence as well as nutritional status and dietary patterns.

2. Kirkpatrick examined 1,976 Manus Islanders mainly for gingival diseases in relation to diet, but some data on dental caries were also gathered.

His approach to this survey was too simplified. He failed to specify precise criteria and disregarded proper age-distributions. Comparisons of his results with other studies are hardly valid.

3. The 1947 N. G. Nutrition Survey expedition investigated 5 villages and collected valuable information relative to food production and consumption.

Sinclair et al. examined a total of 331 subjects in 3 villages for the determination of dental caries incidence and periodontal conditions, with an inadequate classification.

Physiological age-grouping was used. The results were however not age-adjusted.

Langley collected data on the dietary patterns in 4 of the 5 villages, all with basically different staples.

4. Williams prepared his report following a survey which included 1,069 indigenes between the ages of 3 and 17, divided into three groups: coastal, highland and urban. Results were sectioned for those with deciduous, mixed and permanent dentitions.
5. Barmes examined 2,077 subjects from 15 villages, representing 6 different dietary groups. His main aim was to prove or disprove the existence of a relation between dental disease patterns and distinct dietary patterns. Physiological age-grouping was utilised. The deciduous and permanent dentition were considered separately and the results age-adjusted. Periodontal disease was classified on the basis of four grades, which was rather inadequate.
6. Vines examined 4,000 subjects in 52 villages. This is the most thoroughly conducted survey in the Territory, but not enough data are available yet.

7. Due to serious shortcoming in 3 of the 5 surveys only superficial comparison of data will be possible in all but the Sinclair, Cameron and Goldsworthy study and Barmes' survey.

## CHAPTER 3.

### NUTRITION AND DIET

#### 3.1 INTRODUCTION

The first major systematic study of nutritional problems in New Guinea was the 1947 Nutrition Survey Expedition <sup>(34)</sup>. The dietary report by Doreen Langley <sup>(34)</sup> featured somewhat low calorie and very low protein intakes. Vitamin and mineral intakes appeared to be generally adequate. It was suggested that the low protein - intakes would particularly affect the growth of the children. Clinical examinations did not reveal any serious malnutrition or undernutrition, but the children appeared to be substantially lighter than Australian children of the same age and even of the same height. It has been shown that there is a general retardation of growth chiefly from 4 to 44 months, shown not only in Chimbus by Venkatachalam <sup>(44)</sup>, but also in the Western Highlands by McKay <sup>(27)</sup>, in New Ireland by Scragg <sup>(38)</sup> and in the Trobriands and elsewhere by Malcolm <sup>(25)</sup>.

The adults were found to show a progressive decline in body weight from the third decade onwards.

It is now well established that the main public health nutritional problem in the Territory is protein-calorie malnutrition in infants and toddlers<sup>(1)</sup>. Ivinskis<sup>(21)</sup> reported protein-calorie malnutrition in young children and in pregnant and lactating women in the relatively densely populated Chimbu Valley (Highlands), while Kwashiorkor (a form of protein-calorie malnutrition) was reported in 1957 by Ivinskis and Venkata Chalam<sup>(20)</sup>.

Venkatachalam<sup>(20)</sup> reported that malnutrition was responsible for 27 percent of the deaths in children under five years in the Kundiawa hospital (Chimbu-Highlands).

Infants are normally relatively well nourished up to about 4-6 months of age, but beyond this point the mother's milk supply is inadequate to meet the increasing protein needs<sup>(1)</sup>. All the available dietary data confirm the general proposition that during the second year of life particularly, calorie intakes usually become relatively adequate, but protein intakes remain outstandingly low.

The overall incidence of malnutrition was found to be about 3% in the 0-5 years age group in Chimbus<sup>(2)</sup>, while in the same age group it was found to be 2.7% in South India<sup>(42)</sup>, 6% in

Malaya <sup>(13)</sup> and 1% in the Lugbara tribes of Uganda <sup>(22)</sup>. These figures are of course not strictly comparable because the criteria and standards are not identical, but they indicate that malnutrition is as much of a problem in parts of New Guinea as it is in parts of Asia and Africa <sup>(1)</sup>.

Oomen and Malcolm <sup>(31)</sup> designated the highlanders (sweet potato staple) and the coastal villagers (sago staple) nutritionally as the two most vulnerable population groups. The highlanders, because of the excessive dependence on the sweet potato, which in itself is very low in protein and the rarity of animal protein supplements. The sago-eaters, because sago is almost pure starch and practically devoid of protein, minerals or vitamins, and supplementary foods are often hard to come by in the sago swamps, because of lack of agricultural land reasonably near at hand.

The New Guinean not only has generally a diet low in protein, but he also usually eats only when hungry, rather than eating or overeating to anticipate hunger, as is often the custom in affluent societies.

Despite what by our standards can be regarded as suboptimal or even dangerously unbalanced diets, even considering the native's

more leisurely ways of living, it is rather surprising to observe that so many New Guineans have apparently attained a satisfactory equilibrium with their physical environments.

Of the various staples, yams and taro are appreciably better in protein content than sweet potato and banana<sup>(1)</sup>. Sago is worse, being almost pure starch. The indigenous vegetables are however usually much richer in terms of food values than the familiar European ones<sup>(18)</sup>. They often contain 3 to 6 percent protein as against 0.2 percent and equivalently higher amounts of some vitamins and minerals.

As it is intended to investigate possible relationships between dietary and dental disease patterns, nutritional - and dietary factors, and habits in relation to the indigenous population will be considered.

### 3.2 PROTEINS AND AMINO ACIDS

The daily allowances of protein recommended for European men, women and children aged from 1 to 3 years are approximately 70g, 58g, and 32g respectively and for infants up to 1 year of age  $2.5 \pm 0.5$  g per kg body weight <sup>(10)</sup>. But Langley <sup>(34)</sup> found these figures for persons of Caucasian origin based on  $\pm 1$ g of protein for every one kg of body weight, unduly high.

Hegsted <sup>(19)</sup> considered 18g of protein daily per square meter of body surface to be sufficient for the maintenance of health in the adult.

On these grounds it has been assumed <sup>(34)</sup> that 40g of protein would provide adequate daily requirements for New Guinea adult natives; both men and women.

Actually the protein requirements <sup>(47)</sup> are for amino-acids rather than for protein as such. This accounts for the higher biological value of animal proteins as compared to vegetable proteins; the latter being incomplete in amino-acid composition for animal tissue synthesis. In the native's diet however, almost the whole of the protein is of vegetable origin and the dietary intake is generally well below the computed requirements of 40g of protein

per day for an adult. Langley <sup>(34)</sup> gave a 1947 per capita daily protein intake range of from 19 to 41 g. Although the protein requirement is increased during pregnancy and lactation <sup>(47)</sup>, Oomen <sup>(32)</sup> reported protein intakes of pregnant and lactating women in New Guinea to be as low as from 9 to 29g per day depending on the quality of the sweet potato eaten in areas where this tuber is the staple.

Little is still known of the biological value of protein from green leaves and root vegetables, which are the main sources of vegetable protein for the New Guinea native, as most of the work on the biological value of vegetables has been concentrated on cereals. <sup>(34)</sup>

Because vegetable protein forms such a low percentage of the foodstuffs, huge quantities of food have to be eaten to provide anything like a reasonable amount of protein. This is a physical impossibility in the case of young children. It is therefore probably in this age group that the protein deficiency is most marked <sup>(34)</sup>.

Malcolm <sup>(25)</sup> reported in 1950 that children between the age of 6 and 24 months around Rabaul and in Kiriwina consumed as an

average only between 50 and 60 percent of what is generally regarded as being the need in this age group (2.5 to 3g of protein daily per kg body weight).

The average protein content of the main New Guinea staples according to Bailey <sup>(1)</sup> is:

Item	Protein (percent)
Sweet potato	1.1
Taro	2.4
Yam	2.5
Banana	1.1
Sago	0.1

### 3.3 CARBOHYDRATES

With the exception of refined sucrose, the consumption of which can be regarded to be inordinately high wherever it is readily available in the world, the proportion of carbohydrates in the diet appears in general to be determined by the availability of other foods <sup>(47)</sup>.

In the U. S. A. carbohydrates <sup>(47)</sup> provide only from 40 to 50 percent of the calories in the diet, but in New Guinea the intake of carbohydrates is excessive <sup>(3), (25)</sup>, due to the almost exclusive reliance of the native on his staples, which are extremely high in carbohydrate content.

These carbohydrates are however consumed in a natural or near-natural state and not refined as is so much of our food <sup>(40)</sup>.

### 3.4 FATS

Fats, once valued chiefly for their high caloric content, are now assuming much greater nutritional importance. The lack of fatty acids results in genuine nutritional deficiency; a small amount of fat is therefore essential in man's diet. At first this requirement was believed to be extremely small, small enough in fact to be negligible, but this is probably an error; however, it is not yet possible to state definitely a reasonable allowance for fat in the diet or to indicate the characteristics of a fatty acid mixture most favourable for the support of health, beyond the general recommendation that prudence would seem to dictate a diet in which at least one half of the fat calories come from unhydrogenated vegetable oils<sup>(47)</sup>.

In the New Guinean diet less than 5% of the calories are derived from fat<sup>(34)</sup>.

Malcolm<sup>(25)</sup> estimated that in 1950 children in villages around Rabaul and in the Trobriands received in general only about 60% of their needs for fat.

### 3.5 MINERALS AND ESSENTIAL TRACE ELEMENTS

Calcium, Phosphorus, Iron, Iodine and Fluoride are the minerals probably requiring most attention here.

The phosphorus allowances should be at least equal to those for calcium in the diets of children and of women during the latter part of pregnancy and lactation. For other adults, the phosphorus allowances should be approximately one and one half times those for calcium. Generally, if the calcium and protein needs are met through common diet foods, the phosphorus requirements also will be met <sup>(47)</sup>. The U.S.A. National Research Council recommendations in 1963 for calcium were 800 mg per day for adults and children, while the requirements for infants and pregnant and lactating women were respectively 100 mg. lower and 500 mg. higher <sup>(10)</sup>. Langley <sup>(34)</sup> stated that requirements for calcium are hard to estimate as many factors influence the absorption of calcium. The average absorption of European peoples seems to be about 50 percent of the intake, whereas it has been claimed for Singhalese that calcium absorption figures are in the vicinity of 90 percent of the intake. As no data for any Melanesian peoples are available yet, Langley <sup>(34)</sup> using the "U.S.A.

National Research Council Recommended Allowances<sup>11</sup> - figures estimated that the calcium intake of most New Guinea populations was probably below these computed requirements, but she noted that it may be well within the physiological requirements of the natives.

A high percentage of their calcium intake is derived from green leaves. Unfortunately some of these leafy products are also rich in oxalic acid, which can immobilise up to 50 percent of the calcium. The fact that in New Guinea calcium is supplied by bulk foodstuffs makes it almost certain that the intake by young children is very much below that considered desirable<sup>(34)</sup>; but according to Malcolm<sup>(25)</sup> this calcium deficiency for infants is less marked during the first year, because of the consumption of maternal milk, than during the second year when the children receive little or no milk or milk products.

Kirkpatrick<sup>(23)</sup> reported a low calcium and phosphorus intake in mothers during gestation on Manus Island in 1935 and he linked the lack of these minerals with the incidence of odontoclasia - a peculiar type of hypoplasia, mainly occurring in the temporary teeth - which was found in 6% for the total population of Manus, but for the children under 6 years of age in 22.4%.

Sobel<sup>(41)</sup> reported that animals raised on a diet with a high calcium-phosphorus ratio were more susceptible to tooth decay. It is however still unknown what relation these studies may have to human beings<sup>(47)</sup>.

In the absence of growth, pregnancy or blood loss the iron requirement is readily met by an European type of mixed diet. However during the period of active growth and during the active sexual period of the female, special attention must be given to the iron content of the diet and supplementary iron may be indicated.

The requirement for iodine is small, probably about 0.001 mg per day per kg of body weight or a total of 0.07 mg daily for a 70 kg adult.

To ensure a margin of safety for adults, the U. S. A. National Research Council recommends a daily intake of 0.10 to 0.15 mg<sup>(47)</sup>. Even if the intake of iron and iodine would not always be adequate in the New Guinean diet both Malcolm<sup>(25)</sup> and Sinclair<sup>(40)</sup> reported to have observed no clinical evidence of a deficiency in any of these two minerals.

The adult requirement for magnesium has been estimated at 200 to 300 mg daily and for copper at about 2 mg (USA N. R. C.)

Relatively little is known about the quantitative levels for most of the trace elements such as manganese, molybdenum, zinc, etc., necessary for essential physiological function<sup>(47)</sup>, although there is some suggestion of a correlation between one or more of these and caries prevalence in some parts of the Sepik area of New Guinea<sup>(6)</sup>.

Fluorides are ubiquitous materials, which occur in minute amounts in all foodstuffs and watersupplies. Data obtained from epidemiologic surveys in human populations suggest a close relation between the amount of fluoride ingested during tooth development and the amount of tooth decay that occurs in the teeth after development is completed. So far only low concentrations of fluoride have been detected in the watersupplies in New Guinea.

Vines<sup>(45)</sup> reported that the concentrations of fluorine in samples of drinking water from 45 of the 50 sample points visited by his survey team were all low and ranged from 0.05 to 0.45 parts per million. In 7 of his 15 samples, where the fluorine content in the watersupplies has been tested, Barmes<sup>(3)</sup> found it to be between 0.10 and 0.20 parts per million, while the fluorine contents of the drinking water in the three villages visited

by Sinclair <sup>(40)</sup> and her team ranged from 0.20 to 0.45 parts per million, with no suggestion of a correlation with caries prevalence.

Barnes <sup>(5)</sup> reported recently (August, 1968) to have found one high level of fluorine in the drinking water at Yalaku (2.0 p.p.m.).

### 3.6 VITAMINS

Vitamins are organic substances required in minute amounts for the metabolism of foodstuffs and the discharge of important body functions. They are useless without substrata upon which to act, or media in which to operate, without carbohydrates, protein, fat, water, oxygen and certain minerals.

The vitamins are essential for the efficient and optimum utilization of ingested foodstuffs by the body.

Recommended dietary allowances for vitamins are designed for maintenance of good nutrition of most healthy persons. But many healthy individuals require less than the recommended allowances and some apparently healthy persons require more.

Vitamins known to be dietary essentials for man include:-

#### Vitamin A and its precursor - the pigment: Beta-carotene

The National Research Council of America (N. R. C.) recommended in 1963, 5,000 I. U. Vitamin A Value for adults per day<sup>(10)</sup>. Vitamin A deficiency influences the integrity of epithelial tissues including the ameloblasts.

Although it has been demonstrated in animal experiments that enamel hypoplasia is a prominent manifestation of severe

and prolonged vitamin A deficiency there is no evidence that enamel hypoplasia in human beings is attributable to vitamin A deficiency during tooth development. It has also not been determined whether or not vitamin A deficiency during tooth development is in any way related to caries-susceptibility of these teeth post developmentally.

Since vitamin A deficiency causes such a profound influence on bone development, some of the inadequate growth patterns, which result in orthodontic problems may have had their origin in prolonged periods of subclinical vitamin A deficiency during the developmental period of the child <sup>(47)</sup>.

Kirkpatrick <sup>(24)</sup> reported the vitamin A intake of Taro-eaters to be higher than that of the Sago-eating groups of 1976 Manus Islanders. But no clinical evidence of avitaminosis - A has yet been detected in New Guineans <sup>(40), (25)</sup>.

Vitamin D is obtained by higher animals in two ways: by the action of ultraviolet light on the skin and by the ingestion of animal fats containing the vitamin. Because of these two diverse sources it is impossible to define dietary requirements in any precise terms. There is no evidence that adults need any dietary supply of the

vitamin, although a supplementary source is usually recommended during pregnancy for the benefit of the infant <sup>(11)</sup>.

The first experimental production of rickets to demonstrate an influence upon tooth development in dogs was reported by Lady May Mellanby <sup>(28)</sup> in 1918. Enamel hypoplasia does not occur except in the more severe cases of rickets in the dog.

In human beings there is likely to be more than one cause of enamel hypoplasia. In a thorough survey of the case histories of individuals with enamel hypoplasia, Sarnat <sup>(36)</sup> reported that only a small number of the cases had any evidence of a rachitic process during tooth development.

Data collected in clinical surveys have added supporting evidence that inadequate vitamin D intake during tooth development results in a high caries incidence <sup>(29)</sup>.

Sinclair <sup>(39)</sup> reported that in 1947 in New Guinea clinical and radiographical evidence revealed only a negligible incidence of rickets, so that despite low calcium intake no permanent damage to bone structures was suffered. She concluded therefore that there is no deficiency of vitamin D in the native diet.

### Ascorbic Acid - Vitamin C.

The N. R. C. of America recommends 70 mg Ascorbic Acid daily for adults. This seems to be excessive, when compared with the National Health and Medical Research Council of Australia - figure of 30 mg. <sup>(10)</sup>

Though changes in the odontoblasts occur readily in the developing teeth of experimental animals as a result of scurvy, evidence has not been presented yet to indicate a similar occurrence in human teeth. There has never been a clear-cut demonstration of a relationship between scurvy and dental caries, although the relationship of vitamin C deficiency to gingival changes and to bone pathology has been often shown <sup>(47)</sup>.

Evidence that lack of vitamin C may predispose to gingivitis and periodontal disease has also come from other sources <sup>(9), (15)</sup>.

It was reported by Malcolm <sup>(25)</sup> that there was generally an ample supply of vitamin C in the native's diet.

Langley <sup>(34)</sup> reported a very high ascorbic acid intake with a mean daily value of 185 mg per adult, due to the fact that practically all foodstuffs eaten by the locals contain some ascorbic acid and a few are very rich in this vitamin. Further, cooking

methods are such that losses due to cooking probably would not exceed 35 percent.

Pepperleaves, eaten with betelnut, might also provide an important source of vitamin C for the native<sup>(4)</sup>.

#### Some Vitamins of the B Group:

The recommended daily allowances (N. R. C. ) per adult male and female are for Thiamine 1.2 mg and 0.8 mg respectively, while the figures for Riboflavin are 1.7 mg and 1.3 mg, and for Niacin equivalent 19 mg and 14 mg<sup>(10)</sup>.

The mean daily value of Thiamine intake per adult, as reported by the New Guinea Nutrition Survey Expedition 1947, was 0.71 mg with a range from 0.57 to 0.89 mg, which is probably adequate as no signs of beri-beri were observed<sup>(34)</sup>.

Malcolm<sup>(25)</sup> noted that for infants in villages around Rabaul and in the Trobriands in 1950 the Thiamine intake may have been a bit low but he remarked that the carbohydrate foods are eaten in the natural state and with little processing, which might have helped to maintain a proper balance. Bearing in mind the overall insufficiency of the diet, it can be assumed that the supplies were enough to ensure a fairly satisfactory metabolism. In addition he

saw no sign of avitaminosis among these children. Reports <sup>(39)</sup> show that endemic pellagra is associated with a high incidence of certain types of periodontitis and stomatitis, but no clinical evidence of deficiencies, both in riboflavin and niacin, were detected in the native diets <sup>(40)</sup>.

### 3.7 CALORIES

The N. R. C. of America's recommended daily allowances for calories are 2,900 for a man aged 18 to 35 and 2,100 for a woman in that age group.

Calories are required for all body processes and all of the individual's activities. The need equals the total sum of the basal metabolism plus the energy liberated in exercise plus the increment of energy due to the specific dynamic action of food; although the last factor is of slight importance only.

The person's requirement for calories depends on age, sex, weight and physical activity and on the climatic conditions of his surroundings.

Adjustments in calorie allowances are also necessary for pregnancy, lactation, growth and metabolic aberrations. It is impossible to provide a formula by which these adjustments could be calculated with any degree of accuracy. In the last analysis, calorie-allowances must be adjusted to meet specific needs. The proper allowance for an individual is that which over an extended period will maintain body weight or rate of growth at the level most conducive to well-being<sup>(47)</sup>.

Accepting the N. R. C. recommendations for calorie-allowances, it is obvious that in New Guinea few natives attain an adequate intake. Langley<sup>(34)</sup> estimated the per capita daily intake to be in the vicinity of 1,600 which is only about 80 percent of the computer requirements and Malcolm<sup>(25)</sup> stated that the calorie intake of native children in 1950 in villages around Rabaul and in the Trobriands reached only about 70 percent of the allowances.

### 3.8. FOOD PATTERNS

#### 3.8.1 Introduction

In general the native's food is the produce of his garden, supplemented in various degrees - according to climate and terrain conditions - by the collection of "wild" foodstuffs such as berries, nuts and greenstuffs and by such scanty game as the land and sea will yield.

Livestock contributes little, if anything, to his diet.

The methods of cultivation are simple but not unsystematic. The most important point in the system is the production of a staple food, invariably a starchy vegetable.

Land may be communal, but it is always cultivated in small parcels by individuals, whose personal rights to its use are fully recognised.

The long-fallow system prevails and practically no fertilisers are used. In the rain forests and swampy lowland areas, collection of "wild" foodstuffs tends to replace or limit cultivation, which is at its most intensive development in the highland plateaux.

Climate and geographic features make agriculture often so difficult

that any production of food could be regarded as an achievement. In general, decreasing fertility of the land is to be expected at least for the near future because improvements in agriculture are often hard to introduce due to the still rather conservative socioreligious basis for so many of the practices associated with the present system of cultivation.

### 3. 8. 2 Staple - and other foods.

Staple foods constitute by far the greatest bulk of the food consumed; but though the average consumption of green leaves and other supplements is small compared to the intake of staples, they do contribute to the diet. The main staple foods, on which the various dietary patterns in the Territory are based are:<sup>(31)</sup>

1. SAGO (*Metroxylon sago*, "saksak"). This is the staple in all swampy coastal regions and low-lying river plains. Sago is obtained from the pulp of the sago-palm stem. The young suckers are also eaten.
2. SWEET POTATO (*Ipomoea* spp., "kaukau"). Many varieties are common. A better food than sago, it is the staple of the highlands. Its leaves and young shoots are also consumed.

3. BANANA (*Musa* spp.) In some regions bananas are the sole staple, but in almost all areas they are at least a supplementary food source.
4. TARO (*Colocasia* and *Alocasia* spp.) This is the traditional staple of the lowlands. Taro is the bulb of a lily-like plant of the Cassava family and is probably the best of the tubers for nutritional qualities. Young tender shoots and leaves are a good vegetable.
5. YAM (*Dioscorea* spp.) This is found in all but the swampy regions.

Besides these staple foods many supplementary foods have found a place in the native diet, though mostly only on a minor scale. The most important are:<sup>(31)</sup>

6. TAPIOCA (*Manihot utilissima*) Because of the low protein content it is the least desirable of the starch tubers and is hardly better than sago. The leaves are also edible.
7. BREADFRUIT (*Artocarpus nobilus*) This is common in all lowland areas, but often only the seeds are consumed; the meat is usually tough or stringy.
8. CORN (*Zea mais*) Grown in many places. It is a fairly

popular supplementary food, with a slightly higher protein content than most of the tubers<sup>(17)</sup>.

9. PANDANUS. Grows only at fairly high altitudes. As these fruits, which have a relatively high content of both protein (10 to 20 percent) and fat, are seasonal, they supply only an irregular addition to the diet of the people in the highlands.
10. COCONUT (*Cocos nucifera*) It plays an important role both in the economic life - the preparation of copra - and in the diet. The nuts are eaten at different stages of their development and on a large scale. The palm grows well in all coastal regions up to an altitude of about 1,500 ft., but is not found everywhere. The coconut is the principal source of dietary fats and also contributes largely to the total caloric intake. Its dietary value is not yet known, particularly in so far as proteins are concerned<sup>(25)</sup>. The young shoot which emerges from the germinating nut is also eaten, particularly by children.
- 11 PEANUTS (*Arachis hypogaea*) Are not native to New Guinea but grow well and the indigenes are fond of them. Some varieties have a high oil content while a low oil content is

found in others. The protein content is however high in all varieties.

12. **LEAFY GREENS.** The ones commonly eaten in New Guinea Bush Spinach (*Hibiscus* spp., "aibika") *Amaranthus* (*Amaranthus* spp.) and *Rungia* species - often contain about 3 percent protein or more<sup>(1)</sup>.
13. **BEANS.** The most widespread native bean species are the winged beans (*Psophocarpus tetragonolobus*), the lima beans (*Phaseolus lunatus*) and the field beans (*Dolichos lablab*). These are relatively good sources of protein. Usually the fibrous pods are discarded and the protein-rich seeds, steamed under pressure with hot stones in a "mumu" along with other foods are eaten. Introduced legumes such as peas, kidney beans and soya beans have become quite popular too. Generally the nutritive value of soya beans is even higher than that of the peanuts<sup>(1)</sup>.
14. **FRUITS.** Pawpaws (*Carica papaya*) and pineapples (*Ananas sativus*) grow well throughout the Territory. Successive plantings allow fruits to be obtained all seasons. There are several varieties of citrus fruits: lemon (*Citrus aurantiifolia*), orange (*Citrus sinensis*), lime (*Citrus medica*)

and *Citrus nobilis*, which grow well in most of the villages and are widely used, although somewhat unequally distributed. Watermelons (*Citrulus vulgaris*) are grown in some gardens and Mangos (*Mangifera indica*) are abundant in certain areas. Pumpkin (*Cucurbita maxima*) is also quite popular. Of lesser importance are the Cucumber, with a nutritional value of probably close to nil, guava, malay apple (*Eugenia malaccensis*) and passionfruit, which is only grown in the Highlands.

Many varieties of wild fruits are gathered in season and bring some variety to the diets<sup>(25)</sup>.

15. SUGAR CANE (*Saccharum officinarum*) and "pitpit" (*Saccharum edule*), a stunted sugarcane, with a nutritional value comparable with that of asparagus<sup>(31)</sup>.

16. ANIMAL FOODS

- (a) Domesticated animals: The pig is quite a feature in many villages, especially in the highlands. It does however suggest feasts and subjective wealth rather than dietary intake.

Similarly, poultry and eggs cannot be regarded as a regular feature.

There are a few small herds of goats introduced by the Administration and some missions, but they are of such slight importance that neither the meat nor the milk obtained can be regarded as playing any real part in the native's diet. This is also true for the few herds of cattle that have been introduced lately in the Territory.

- (b) **Wild Animals:** Such as the pig, the wallaby, the cassowary, the opossum ("kuskus"), the flying fox, the fieldrat, the crocodile, the lizard and the turtle. It is doubtful if hunting in general provides a promising source of protein.
- (c) **Sea foods:** Although fish and other seafoods should play a valuable part in supplementing the diets, especially of the sago-eaters, fishing is still in general of minor importance. Much time is needed to obtain any quantity of fish. Not many attempts are made to preserve fish by salting, sun-drying or smoking<sup>(31)</sup>.

17 IMPORTED FOODS. Outside the towns the consumption of imported foods is still of little consequence in the feeding and nutrition of the indigenous population, because only few who live in the villages possess enough purchasing power to spend a significant part of it on the acquirement of these foods.

The distribution of the staple foods in New Guinea follows a certain pattern:

The usual staple of the smaller islands is the yam, supplemented with other staples to a varying degree. The swampy coastal villages subsist chiefly on sago and in the sub-coastal villages of New Guinea the diet is usually more mixed, often with yams predominating when in season and sago to fall back on when tubers and bananas are not available.

The sweet potato appears to be increasing in importance nearly everywhere in the Territory, but in the highlands, which have almost one-half of the Territory's population, it is quantitatively speaking almost the only food which counts. It supplies about 90% of the calories and 50% of the protein consumed.

Adults usually eat 4 lb. of sweet potatoes and toddlers 1-2 lb.

daily<sup>(1)</sup>.

A considerable variation in the composition of the different varieties of New Guinea staple foods have been reported. These variations are tabulated in table 2.

The composition of some New Guinea foods is shown in table 3.

TABLE 2. <sup>(1)</sup>

Variation in composition of varieties of New Guinea staple foods.\*

	Moisture percent	Protein percent	Calories Cal./100g
<b>A. SWEET POTATO</b>			
Chimbu (a)	67-76	0.75-1.54	100-148
1947 Report (b)	67.3	0.9	150
Peters (c)	68.0	0.62-0.81	-----
<b>B. YAM</b>			
Maprik (Lea) (a)	75	1.6-3.9	-----
1947 Report (b)	70.7	1.9	107
Peters (c)	54.5-68.0	1.69-2.15	-----
<b>C. TARO</b>			
Chimbu (a)	69.6	1.98	117
1947 Report (b)	63.9	1.4	145
Peters (c)	53.5-59.0	0.75-1.44	-----
<b>D. BANANA</b>			
Chimbu (a)	73.1	1.08	92
1947 Report (b)	61.7-75.0	1.1-1.3	93.7-142
Peters (c)	70.5	1.13	-----

\* Quoted as composition of raw edible portion of fresh foodstuff.

- (a) Analysed by D. A. S. F. Laboratories (Port Moresby),  
D. Lea, Geography Department School of Pacific Studies,  
A. N. U. Canberra.
- (b) E. H. Hipsley and F. W. Clements (Ed. ) Report of the  
New Guinea Nutrition Survey Expedition, Department of  
External Territories, Canberra, 1947.
- (c) F. E. Peters, S.P.C. Techn. Paper No. 115, Noumea (1958).

TABLE 3<sup>(31)</sup>

## Composition of some common foods in New Guinea

	Calories	Protein g	CHO g	Fat g	Water g	Fibre. g	Calcium mg	Iron mg	Carotene mg	Thiamin mg	Ascorbic Acid mg
<u>1. STAPLE FOODS:</u>											
Sweet Potato	90	0.4	22	0.1	76	0.5	20	0.6	0.035	0.08	60
Taro	105	2.0	25	0.2	68	0.7	15	1.0	Nil	0.10	6
Yam	95	1.2	23	0.1	75	0.5	15	0.5	-----	0.10	15
Sago	285	0.2	71	---	27	0.3	3.0	0.7	-----	-----	---
Banana	105	1.2	25	0.1	71	0.5	8	0.4	0.050	0.05	10
Breadfruit	55	0.3	12	0.5	80	1.2	30	0.8	0.004	0.10	25
<u>2. SEEDS</u>											
Corn	150	4.3	30	1.0	63	1.0	10	0.5	0.010	0.15	10
Coconut.	500	4.0	10	33.0	50	3.0	25	---	Nil	0.15	2
Peanut	550	25.0	23	43.00	5	3.00	75	1.5	-----	1.10	---
<u>3. LEAFY VEGETABLES</u>											
Taro leaves	50	2.6	5	2.0	86	1.5	400	---	7500	0.20	160
Sweet Potato shoots	40	2.2	8	0.5	85	1.5	70	8.0	3600	0.10	25
Cassava Leaves	75	6.2	10	1.0	79	2.5	175	2.0	0.090	0.12	300
<u>4. ANIMAL FOODS:</u>											
Large Sea-fish	120	1.6	--	5	50	--	1.5	1.5	0.055	0.11	---
Crab	80	1.6	0.5	1.5	80	1.7	0.8	0.8	-----	0.14	---

(i) The values are expressed in grams (or milligrams) per 100 grams of edible portion.

(ii) The figures in this table have been collected from various sources and have been compiled by F. E. Peters. Published in Technical Paper No. 100 in the South Pacific Commission (Noumea).

### 3. 8. 3 Food Storage

Because of the hot, humid climate, which prevails in most areas of New Guinea, food preservation and storage present special problems, particularly foods of animal origin. With the exception of yams, which may be stored in special yam houses for up to 6 months, and sago, which is often packed into sago leaf-cylinders of about 15 inches in diameter and 2 feet high, and then stored for a few months, there is little storage of harvested crops. The usual practice is to harvest the crop as needed and to keep it only for a day or two. However to overcome seasonable shortages of more desirable crops, cassava and taro are sometimes allowed to remain in the ground.

For animal foods there are few examples of storage. Partly cooked and smoked meat is sometimes kept suspended over the fireplace for several months, and in the Trobriands smoked fish is occasionally kept for several days. Further, the pig on the hoof is always a reserve of food and crabs rendered immobile by binding their claws can also be retained for some time<sup>(34)</sup>.

### 3.8.4 Food preparation and cooking

Preparation of food is generally minimal and rough. The main cooking methods are:-

1. Boiling - Either in clay pots or in metal saucepans using a small quantity of water or coconutmilk.
2. Baking - In the embers of a fire while the food is protected by the skins of the vegetables or by leaves wrapped around it. Sometimes use is made of a bamboo stick on which the food is placed.
3. Mumu - or oven in the ground. The mumu is made in a hollow in the ground, or in a drum, or a hollowed-out log. Rounded stones are heated and placed in the bottom of the hollow or drum, followed by a layer of leaves (banana and other) and then a layer of foods; followed by another layer of leaves, stones leaves and food. Several such layers are made and then the top is sealed over with a large banana leaf. Before sealing, cold water is poured in. Thus cooking is effected by steam under pressure for about 1-1½ hours

In Sepik a shell oven is often used. A large piece of shell-shaped earthenware (about 40 by 70 cm) is set at an angle (larger portion upwards, acting as a chimney and protecting the wall against burning) on a small pile of stones inside the houses. Most families have a variety of clay shells at their disposal. A small fire is lit inside the shell, and a round-bottomed plate of earthen ware set inside to act as a frying pan. This cooker fuel burns very sparingly. It is especially used for preparing dry sago pancakes<sup>(31)</sup>.

4. Roasting - Over the flames, sometimes with the use of coconut-milk as grease. Outer portions of the food become very crusty and hard in this method and when it is used for small mammals, the flesh becomes black and tough.

The boiling - and mumu methods allow the inclusion of much sand, which is a significant factor in teeth attrition<sup>(3)</sup>

The staples taro, yam, sweet potato and bananas are consumed in variable fashion, either in the natural state, or prepared with the addition of coconutmilk, grated flesh of ripe coconuts, or the young green shoots of various plants; while sago is prepared by washing

and coarse filtration of the substance gathered from the interior of the palm-trunks and then made into small balls or flat cakes.

Cooking of the staples is mostly done by boiling or in the mumu, either directly, or after the food has been wrapped in leaves.

In general, receptacles used for boiling are firmly covered by the interposition of green leaves between the pot, or whatever serves as such, and the lid<sup>(26)</sup>.

Vegetables are usually boiled, but occasionally baked in their skins.

Fish is boiled with the staple or baked wrapped in green leaves.

Shellfish and crabs are added to the pot or roasted.

Cooking is never a prolonged affair, and there is no waste; even the cooking water is not discarded, but rather used as a soup<sup>(40)</sup>

The women do the major part of the food preparation and cooking.

The young girls do generally not assist in the actual preparation of the food but might be used to fetch and carry wood and water.

The men have mostly the privilege of organising the distribution of the cooked food<sup>(34)</sup>.

Foods are seldom specially prepared for the infants, other than being reduced to a mash, either by premastication or crushing. When a child is older the food is mostly given as it is.

### 3. 8. 5 Diet and nutritive requirements

Diet patterns and food habits vary not only from one nation to another but also from individual to individual. There is no single pattern of diet which must be followed to ensure good nutrition. There is no single food that can be called essential for life or health. The human body does require calories, certain fatty acids, amino acids, vitamins, minerals and water in sufficient amounts and in proper combinations to permit optimum growth and maintenance and repair of tissues under the environmental conditions to which the particular individual is exposed.

Not only do diet patterns and food values vary but also do requirements for specific nutrients, depending on genetic and environmental factors, severity and nature of stress situations, age, sex, rate of growth, etc. Because of these differences in nutritional needs of individuals and the variation in nutritive value of foods, it is impossible to devise a general food plan just right for everyone<sup>(47)</sup>.

Recognising the difficulties in defining the nutritional requirements of the New Guinea races, Langley<sup>(34)</sup> prepared a table of dietary allowances, based on the National Research Council of America's dietary allowances-scales, but with corrections made to compensate for the differences in stature between the New Guinea people and the average North American and their mode of life and degree of activity (table 4).

For comparison the N. R. C. scales are given in table 5.

TABLE 4.

Some suggested Daily Dietary Allowances for New Guinea Natives \*

	Weight kg	Calories	Protein g	Calcium g	Thiamine mg	Ascorbic Acidmg
<u>MAN</u>						
Age 21-49	54	2,500	40	0.8	0.84	50
Age 50 plus	48.6	2,000	40	0.8	0.70	50
<u>WOMAN</u>						
Age 21-49	46	2,100	40	0.8	0.77	50
Age 50 plus	40	1,600	40	0.8	0.53	50
<u>CHILDREN</u>						
1 year	8.2	850	35	1.0	0.30	30
2-3 years	11.2	1,000	40	1.0	0.35	30
10-12 years	27.3	2,000	70	1.2	0.70	30

\* From: the Report of the New Guinea Nutrition Survey Expedition,  
1947, Department of External Territories, Canberra<sup>(34)</sup>.

TABLE 5.

Some recommended Daily Dietary Allowances for Healthy Persons  
in the U. S. A. \*\*

	Weight kg	Calories	Protein g	Calcium g	Thiamine mg	Ascorbic Acid mg.
<u>MAN</u>						
Age 18-54	70	2,600-2,900	70	0.8	1.0-1.2	70
Age 55 plus	70	2,200	70	0.8	0.9	70
<u>WOMAN</u>						
Age 18-54	58	1,900-2,100	58	0.8	0.8	70
Age 55 plus	58	1,600	58	0.8	0.8	70
<u>CHILDREN</u>						
0-1 year	8	kg x 115 <sup>±</sup> 15	kg x 2.5 <sup>±</sup> 0.5	0.7	0.4	30
1-3 years	13	1,300	32	0.8	0.5	40
9-12 years	33	2,200-2,400	55-60	1.1	0.9-1.0	70-80

\*\* From: National Research Council, Food and Nutrition Board:

Recommended Dietary Allowances, Revised 1963, N. R. C.

Publication 1146, Washington, D. C., 1946<sup>(10)</sup>.

The average adult intake of nutrients, determined by Oomen and Malcolm<sup>(31)</sup> in the two areas of New Guinea, TAMBANUM (Sepik) and JOBAKOGL (Chimbu-Highlands) in 1956 and by Langley<sup>(34)</sup> in 1947 in four villages, BUSAMA, KAIAPIT, PATEP and KAVATARIA, are tabulated in table 6.

The information collected in this table has of course no statistical value and the quantitative data are not strictly comparable because of the differences in the number of subjects and the wide variations from household to household that were normally encountered, but the figures presented are probably a sufficiently close approximation of the average adult intake in each village<sup>(34)</sup>.

When comparing table 6 with table 4 it is obvious that the caloric adequacy of the adult diet in those 6 villages was rather suspect, the protein intake definitely low and vitamin C intake very high. The calcium intake was a bit low but generally probably satisfactory, while iron-intake in the first two villages seems to be within traditional requirements, although a moderate anaemia was not uncommon among the younger children<sup>(31)</sup>. The only significant source of thiamine came from some leafy vegetables, but could be considered generally as adequate. A-avitaminosis,

if present, was probably connected with conversion of carotene into vitamin A rather than with unsatisfactory ingestion of carotene itself (31).

TABLE 6

The mean daily adult intake of nutrients in 6 villages of New Guinea\*

Village	Site	Number of Subjects	Staple food	Calories	Protein			Carbo- hydrates	Fat	Calcium	Iron	Ascor- bic Acid	Thiamin	Carot- ene
					Animal g	Vegetable g	Total g							
Tambanum	-Sepik	14	Yam, Sago, Banana	1,395	5.0	14.0	19.0	314	5	0.4	12	120	0.7	4.8
Jobakogl	-Chimbu	58	Sweet potato	1,830	0.6	25.0	25.6	410	10	0.6	12	400	2.2	13.8
Busama	-Huon Gulf	340	Taro	1,223	4.8	14.4	19.2	---	---	0.5	---	137	0.7	----
Kaiapit	-Markham Valley	137	Sweet potato Banana,	1,609	3.1	21.7	24.8	---	---	0.6	---	216	1.1	----
Patep	-Mountains near Lae	211	Taro, Sweet potato	1,904	2.1	22.3	24.4	---	---	0.3	---	244	1.7	----
Kavataria	-Tro- briand Islands	124	Yam	1,600	22.4	18.9	41.3	---	---	0.3	---	142	1.3	----

\* From: H. A. P. C. Oomen and S. H. Malcolm - Nutrition and the Papuan Child, Techn. Paper No. 118 S. P. C. (Apr.) 1958  
 Noumea<sup>(31)</sup>, and from: Report of the New Guinea Nutrition Survey Expedition 1947, Dept. of Ext. Territories,  
 Canberra<sup>(34)</sup>

### 3. 8. 6 Food habits and taboos

The general practice is for the village natives to eat only one main meal at the end of the day's gardening activities. This takes mostly place sometime between 3 p. m. and 7 p. m. For "breakfast" they eat occasionally some cold food left over from the previous evening's meal. Small snacks of cold cooked food, edible raw fruits, vegetables or nuts are also consumed at irregular intervals during the day, especially by children<sup>(34)</sup>. Except in very few cases, all the infants are breast-fed for about 12 to 18 months and this period is often extended. Supplementary feeding begins often at the age of about three months and sometimes even earlier, mostly with premasticated sweet potato, taro, yam or banana. If sago is given it is mostly in the form of a clear soup. At a much later stage the infant is introduced to coconut<sup>(40)</sup>.

Contrary to most Europeans, who are generally accustomed to consume their food cut into small pieces, the village native is used to filling up his whole mouth with large pieces of food prior to chewing. This habit, together with the tough and fibrous nature of his foodstuffs, the regular inclusion of sand in his food due to cooking habits, and the wide variety of other uses he puts his teeth

to: such as stripping sugarcane and holding a variety of articles, has no doubt a marked effect on the masticatory apparatus of the native in general, and on the attrition of his teeth in particular.

Kirkpatrick<sup>(24)</sup> reported both occlusal and approximal attrition in many subjects in New Guinea apparently due to their food habits. He quotes Miller<sup>(30)</sup> and Box<sup>(8)</sup>, who both claim that the wearing away of the buccal cusps of the lower teeth and the lingual cusps of the upper teeth necessitates the use of greater force to produce the same degree of comminution of the food, and believe that the greater force required for mastication produces alveolar resorption and traumatic occlusion, while Gottlieb and Orban<sup>(16)</sup> consider that such degrees of wear as will eliminate the cusps of the teeth are desirable and conducive to the health of the periodontal tissues.

Attrition of the teeth might also be caused by the habit of betelnut chewing<sup>(3)</sup> indulged in by many: men, women and even children. The natives consider the chewing of betelnut to produce a feeling of intoxication, similar to alcohol. In addition, it is thought to lessen the desire for food. It is a distinctly social practice, without any nutritive value. Three ingredients are required:-

- (a) the betelnut from the palm: *Areca catechu*
- (b) a leaf or bark from the pepper vine: *Piper betle*
- (c) powdered lime.

Great variations occur in the manner of preparation and application of the lime. The usual source is from shells which are heated and pounded to powder, but there are several other constituents or additives. The application is made with a stick or looped wire. The lime mixture is sometimes slaked lime, sometimes quick lime and often a mixture of the two. The initial effect on the oral tissues appears to be of an astringent nature. Badly burned mucous membranes have often given marked evidence of the presence of calcium oxide. This habit might have an effect on cancer, caries and periodontal disease prevalence.

It is, in any case when prolonged, detrimental to the health of the oral tissues and results in the deposition on the teeth of a dark red to black substance, which finally covers the whole crown of all the teeth.

Farago<sup>(14)</sup> and Chester, who did a pilot survey in 1960 on 277 adult members of a native village in Port Moresby to investigate the incidence of cancer in the mouth, reported that almost all the

subjects chewed betelnut with lime and "pepper" bark. Some also used the "pepper" bean.

Vines <sup>(45)</sup> tried to correlate betelnut chewing with oral hyperkeratosis in his 1962-1966 survey. His results are tabulated in table 7.

Naturally there is little awareness among the natives of the relative nutritive values of the different foods available. A general notion however of the supremacy of meat, perhaps even a craving for it, and likewise for fish, is not absent. Malnutrition does not seem to be recognized as such by the unsophisticated New Guinean. The infant who fails to thrive is usually considered to be a victim of malevolent spirits or sorcerers or of an inauspicious season or other unfavourable circumstances <sup>(1)</sup>.

Taboos also appear to be of superstitious origin, but they don't seem to be nutritionally of much importance.

In New Ireland and the Trobriands, according to Malcolm <sup>(25)</sup> pregnant and lactating women are not allowed to eat certain types of fish and this taboo is sometimes extended to the husbands and the parents. This prohibition seems to result from the belief that the eating of those fish may cause the death of the child or produce on it

TABLE 7 (45)

Oral Hyperkeratosis\* and Betel-nut chewing

	30-44 years			45 years plus			30 years plus		
	Pers. exam	With HK	without HK	Pers. exam.	With HK	Without HK	Pers. Exam.	With HK	Without HK
<u>Highlands</u>									
Persons examined	249	80	169	148	31	117	397	111	286
Non betel users	239	72	167	145	31	114	384	103	281
Betel chewing occas.	9	7	2	2	0	2	11	7	4
Betel chewing daily	1	1	0	1	0	1	2	1	1
Signif.	P = .0022			P = .60025			P .01		
	(Exact test after combining occas. + daily chewers)								
<u>Mainland</u>									
Persons examined	180	90	90	152	85	67	332	175	157
Non belet users	40	29	29	39	11	28	79	22	57
Betel chewing occas.	69	37	37	39	23	16	108	55	53
Betel chewing daily	71	24	24	74	51	23	145	98	47
Signif	P			P .001			P .001		
<u>Islands</u>									
Persons examined	236	165	165	111	42	69	347	113	234
Non betel users	34	26	26	26	6	20	60	14	46
Betel chewing occas.	16	9	9	12	7	5	28	14	14
Betel chewing daily	186	130	130	73	29	44	259	85	174
Signif	N. S.			P .025			P .05		

\* Hyperkeratosis was defined as a papillary eruption on, and thickening of, the oral mucosa.

certain blemishes.

Eating of fresh-water eel is also forbidden, but shark flesh is not affected by taboo. Pregnant women are also not allowed to eat certain grubs. The eating of pigmeat is thought to dry up the breast milk and during lactation the mother is not allowed to eat the flesh of the possum.

With the exception of a red sauce, "buruma" prepared from three different fruits, there are few or no taboos affecting the diets of children. Eggs are sometimes blamed for causing the appearance of boils and a series of digestive disturbances. This could quite well be true considering the state of freshness in which the eggs are often consumed.

There is a taboo on sexual relations during weaning and there is reason to believe that the use of abortives is known, these being derived from preparations of fruits, barks and plants.

But the ancestral taboos are disappearing following lasting contacts with Europeans<sup>(25)</sup>.

Bailey<sup>(1)</sup> reported that an almost infinite variety of food taboos prohibiting the use of certain foods at certain seasons or more particularly for women during pregnancy or lactation, but Langford<sup>(34)</sup>

found it impossible to confirm most of the reported taboos. Both Langford<sup>(34)</sup> and Bailey<sup>(1)</sup> agreed however that, because the foods available are generally so low in protein, taboos could any-way not often be of much nutritional significance.

Feasts seem generally also not very important from a nutritive viewpoint, despite the fact that they are often the only occasions where animal protein is consumed by the village native.

They are usually held to observe some special occasion: religious, or in relation to family events such as birth, puberty, marriage, sickness or death and are in some villages a rather regular occurrence. The larger feasts, mostly held at 1 to 3 years interval, invariably include pig as the main dish.

### 3.9. SUMMARY

1. Villagers live mainly on the produce of their own gardens and to a much lesser extent on animal bush and marine life.
2. The principal economic factors effecting native agriculture are:-
  - (a) the generally low population density.
  - (b) the low degree of technological development associated with food production.
  - (c) the limited scope for trade provided by local sociological and geographical conditions.
3. Animal breeding is practically unknown.
4. Reliance for food-intake is almost exclusively on staples, with low protein and high carbohydrate contents.
5. Protein intake, especially of animal origin, is very low, while caloric and fat intakes are considered to be generally inadequate too, especially where pre-adolescent children are concerned.
6. Intake of vitamins and minerals appears to be sufficient, but the intake of carbohydrates is generally excessive.

7. Relative few cases of malnutrition or undernutrition have been observed, especially among adults, although diets could be regarded in general as sub-optimal.
8. Food preservation, preparation, storage and cooking methods are rather crude.
9. The native's masticatory apparatus is often required to perform many functions in preparing foods for deglutition that are performed by cooking methods and cutlery in more developed communities.
10. Meals are generally restricted to a main one per day.
11. Attrition and oral hyperkeratosis can probably be related to the native foodhabits.
12. Taboos and feasts do not significantly contribute to nutritional well-being.

## CHAPTER 4.

### DENTAL CARIES AND PERIODONTAL DISEASE

#### 4.1 INTRODUCTION

Until dietary changes will occur due to Westernization, dental caries prevalence in primitive people can be regarded to be very low compared with data for Europeans<sup>(4), (33)</sup>.

Although the diets of these people are generally rough in texture and low in refined carbohydrates, the periodontal disease prevalence pattern projects however a less rosy picture<sup>(4), (33)</sup>.

The results of the five surveys under review might provide some indications about the validity of these conceptions and could confirm the claim that different primitive groups in the same race present different dental disease-patterns because of different diet-patterns.

## 4.2. SURVEY RESULTS

### 4.2.1 Kirkpatrick (23), (24)

1, 976 Islanders were examined for caries in three groupings:-

- (a) Sago and Taro
- (b) Inland and Coast
- (c) North Coast and South Coast.

In every grouping the results for subjects under 20 years of age were recorded separately (table 8):

TABLE 8

Dental Caries in diet, districts and age - groupings in Manus <sup>(23)</sup>.

Groupings	Number of Subjects	Percentage of Subjects with Carious Teeth	Number of Carious Teeth.	Number of Carious teeth per affected subject.
Sago	1020	3.2	62	1.9
Taro	956	1.7	32	2.0
Under 20 years of age: -----				
Sago	521	6.0	60	1.9
Taro	478	2.5	24	2.0
Inland	448	2.5	22	2.0
Coast	726	3.2	44	1.9
Under 20 years of age: -----				
Inland	222	2.7	12	2.0
Coast	360	5.8	42	2.0
North Coast:	468	3.9	33	1.8
South Coast:	258	1.9	11	2.2
Under 20 years of age: -----				
North Coast:	222	7.2	31	1.9
South Coast:	138	3.6	11	2.2

The findings for the total group were that approximately 2.5 percent of the subjects had caries with 2 carious teeth per affected subject. Tests on significance based on three times standard deviation indicated no significant differences in any of the caries comparisons <sup>(4)</sup>.

If chi-square tests of significance are applied to the caries results, a significant difference at the five percent level is obtained between sago and taro staple groups and at the one percent level between the same groups restricted by an upper age limit of 20<sup>(4)</sup>.

Kirkpatrick examined the same 1,976 subjects for:<sup>(24)</sup>

1.     Recession of gingival attachment,
2.     Crowding of teeth,
3.     Traumatic occlusion,
4.     Calculus formation,
5.     Chronic gingivitis,
6.     Acute or sub-acute Vincent's infection and
7.     Suppurative periodontitis.

Each condition was compared between taro and sago staple groups, again using a test based on three times standard deviation.

Significant results were obtained for 2, 3, 6 and 7.

The results for 1, 5 and 7 are tabulated in table 9:

TABLE 9 (24)

Oral conditions pertaining to the gingival.

Diet	Number of Subjects	Percent recession of gingival attachment.	Percent chronic gingivitis	Percent suppurative periodontitis
Sago	1020	28.4	21.7	27.3
Taro	956	26.7	24.7	15.2
Significant		No	No	Yes

Suggested causes for the differences were: (24)

Firstly: there appeared to be a much higher intake of vitamins A and B in the taro - than in the sago eating groups.

Secondly: masticating effort required in these two types of diet was different.

In the incisal region more effort was required in the taro diet whereas, posteriorly, the sago diet, because of added ground up coconut, required greater effort. Kirkpatrick<sup>(24)</sup> further suggested that a dietary deficiency in the sago diet might predispose that group to acute or sub-acute Vincent's infection, and that by virtue of

narrowed arches induced by intensive posterior grinding, the sago diet might predispose also to anterior crowding and general malocclusion.

He assumed that the "firm pear" consistency of taro, by optimal gingival stimulation, might lessen the prevalence of gingival disturbance. The betelnut chewing habit was considered by Kirkpatrick<sup>(24)</sup> to be a factor for traumatic occlusion as the abrasive lime additive would cause wear on the posterior teeth while anterior teeth remained comparatively unworn.

4.2.2 Nutrition Survey<sup>(34)</sup> - 1947

The non age-adjusted results of 190 subjects examined for periodontal conditions follow in table 10:

TABLE 10<sup>\*</sup>

Population of three New Guinea villages grouped according to the Periodontal Conditions.

	Approx. age in years.	Number of subjects in each group			Percentage of subjects with some bone loss.	Total
		gp1 no bone loss	gp2 moderate bone loss	gp3 extensive bone loss		
Patep 2	16 - 29	32	11	0	14	52
	30 - 44	5	13	4	21	
	45 +	1	13	1	17	
Kavataria	16 - 29	14	3	1	7	69
	30 - 44	3	12	10	40	
	45 +	0	1	11	22	
Korovagi	16 - 29	9	4	3	12	76
	30 - 44	3	14	9	42	
	45 +	1	5	7	22	

\* Results are based on radiographical evidence<sup>(34)</sup>.

Sinclair<sup>(39)</sup> claims that on the basis of the results shown in table 10 that "the incidence and severity of the condition were less in Patep 2 than in the two other villages". In the case of severity the large proportion of subjects in Kavataria and Korovagi with extensive bone loss does appear to make the claim valid irrespective of age-adjustment.

However, as far as prevalence is concerned, adjustment of Kavataria and Korovagi data to the Patep 2 age-distribution reduces the figures for some bone loss to 55 percent Kavataria and 56 percent Korovagi, compared with 52 percent for Patep 2<sup>(4)</sup>. These results present merely a questionable difference for Korovagi.

Sinclair<sup>(39)</sup> observed also that in all three New Guinea villages the clinical appearance of the gingivae of the children was almost invariably healthy and this applied also to most of the adolescents and young adults, but in the middle aged and older people she frequently observed a condition, the clinical features of which were similar to those of Gottlieb's "Schmutzpyorrhoea"<sup>(16)</sup>, a condition also described by Thoma<sup>(43)</sup>.

The high incidence of periodontal disease was suggested to be causally associated with diet and food habits<sup>(39)</sup>.

Darkly stained debris and large amounts of sub and supra-  
gingival calculus were present in almost all adults, while the  
teeth of the children were usually found to be clean.

Actual (non age-adjusted) results for caries are shown in  
tables 11, 12 and 13.

TABLE 11<sup>(40)</sup>

Dental caries in three New Guinea villages

Village	No. of subjects examined	No. of subjects caries free	No. of subjects with caries	No. of subjects with roots present; other teeth caries free	Percentage of subjects caries free
Patep 2	136	61	67	8	45
Kavataria	94	52	39	3	55
Korovagi	101	70	30	1	69

TABLE 12<sup>(40)</sup>

## Dental Caries in three New Guinea villages

Village	No. of subjects examined	Number of teeth		Percentage teeth carious
		Standing	Carious	
Patep 2	136	3607	228	6.3
Kavataria	94	2529	114	4.5
Korovagi	101	2852	77	2.7

N. B. <sup>(4)</sup> When Kavataria and Korovagi results are age-adjusted to the Patep 2 age-distribution, percentage subjects caries free was calculated as 57 Kavataria and 69 Korovagi and percentage teeth carious as 5.0 Kavataria and 2.4 Korovagi.

Also when the two dentitions were considered separately, the results for percentage teeth carious calculated and age-adjusted for Patep 2, Kavataria and Korovagi were in that order:- deciduous dentition: 3.9, 21.0 and 6.1 and permanent dentition: 6.8, 1.7 and 1.8.

Kavataria is an outstanding example that high caries prevalence in the deciduous dentition does not necessarily predispose the permanent dentition to a similar experience.

TABLE 13<sup>(40)</sup>

Dental Caries in three New Guinea villages.

Village	Subjects examined	No. of teeth surfaces		Percentage of carious surfaces per person	
		Standing	Cariou	Mean	Median
Patep 2	128	19067	330	1.73	0.60
Kavataria	91	13841	166	1.20	0.00
Korovagi	100	15829	101	0.64	0.00

N. B. Subjects with roots, but other teeth caries free were not included under the heading of "subjects examined".

Results for the mean number of D. M. teeth per person was 3.43, 1.23 and 0.83 respectively for Patep 2, Kavataria and Korovagi.

Sinclair<sup>(39)</sup> stated that:

- (a) On examination of the results of carious incidence and distribution of carious lesions, when comparison of the 3 villages, each considered as a unit, is made, it appears that irrespective of the basis (whether persons or teeth or surfaces) for assessment of the severity and extent of the carious process, the disease is most prevalent in Patep 2, less so in Kavataria and least in Korovagi (see table 14).

TABLE 14 \*(40)

Dental Caries in three New Guinea villages.

Village	Percentage people with caries	Percentage teeth carious	Mean percentage surfaces carious
Patep 2	52	6.3	1.73
Kavataria	43	4.5	1.20
Korovagi	30	2.7	0.64

\* Calculated on the basis of 128, 91 and 100 subjects in Patep 2, Kavataria and Korovagi respectively.

(b) The difference in the degree to which deciduous and permanent teeth were affected in any one village can best be shown statistically when number of persons rather than number of teeth are compared.

(1) Within each village:

The figures for the percentage of persons with caries in the permanent dentition only and in the deciduous dentition only were for Patep 2, Kavataria and Korovagi respectively 62 and 22, 25 and 63, 26 and 33.

(2) Between the villages:

More people in the permanent-teeth group suffered from caries in Patep 2 than in Kavataria or Korovagi. But in the deciduous teeth group more children in Kavataria suffered from caries than in Patep 2 and Korovagi.

Other features associated with caries were:

- (a) Frequency of attack was highest in lower molars, upper molars and upper incisors in descending order, with third molars the most frequently attacked.
- (b) Probable causes of missing teeth were very uncertain. Periodontitis as a cause was only slightly higher than caries for the three villages combined.
- (c) No relationship between caries and periodontitis could be established.
- (d) Occlusal attrition, besides removing susceptible areas, at times actually overtook the caries process in Kavataria and Korovagi, but in Patep 2 the rate of attrition was much slower. Proximal attrition was not shown by the authors<sup>(40)</sup> to be a factor which effected caries susceptibility.

- (e) No relationship could be found between diet and nutrition on the one hand and dental caries on the other.
- (f) The existence of odontoclasia was reported.

4.2.3. Williams<sup>(46)</sup>

The results for caries prevalence for 1,069 indigenous children between the ages of 3 and 17 follow in tables 15 and 16.

TABLE 15<sup>(46)</sup>

Prevalence of Dental Caries

Group	Dentition	Number of Subjects	Number of Subjects with caries	Percentage of Subjects with caries
Coastal	D	71	13	18
	M	212	89	42
	P	293	127	43
Highland	D	42	25	60
	M	132	92	70
	P	157	97	62
Urban	D	35	25	71
	M	61	54	89
	P	66	54	82
European	D	49	35	71
	M	173	165	95
	P	42	40	95

\*N. B. D, M and P stand for: deciduous, mixed and permanent respectively.

TABLE 16<sup>(46)</sup>

dmf/ DMF Teeth

Group	Dentition	Number of Subjects	Total dmf/ DMF teeth	Mean dmf/ DMF teeth per Subject.
Coastal	D	71	44	0.6
	M	212	341	1.6
	F	293	443	1.5
Highland	D	42	109	2.6
	M	132	447	3.4
	F	157	517	3.3
Urban	D	35	153	4.4
	M	61	374	6.1
	F	66	400	6.1

- (1) The overall incidence for indigenes was highest in the urban group and lowest in the coastal group, and is in the urbanized group fast approaching that of the European group, probably influenced by the change in diet-habits, from native to european foodstuffs.

That the dental caries rate is not as low at the coast as could be expected considering the low refined food intake, might be due, in part at least, to the consumption of large amounts of

glucose, in the form of coconut-water and milk, according to Davies<sup>(12)</sup>. In the highlands, where the almost sole item of diet is the boiled sweet potato, many subjects in this group presented themselves with tooth surfaces covered with thick gelatinous food plaques. Where dental caries had not as yet commenced in such cases, initial decalcification was visually evident when the plaques were removed from the teeth<sup>(46)</sup>.

- (a) The dmf/DMF index has one important drawback. it does not give any indication of the extent of the caries attack.
- (b) Except for the urban group, dental treatment previously received, was practically nil.

The results for oral hygiene and calculus formation follow in tables 17 and 18.

TABLE 17<sup>(46)</sup>

## Oral Hygiene\*

Group	Dentition	Number of Subjects	Degree of oral hygiene		
			Good %	Fair %	Bad %
Coastal	D	71	55	45	0
	M	212	21	79	0
	P	293	32	67	1
Highland	D	42	76	24	0
	M	132	23	75	2
	P	157	23	73	4
Urban	D	35	11	89	0
	M	61	10	89	1
	P	66	23	76	1

The majority of the subjects examined used no artificial means of cleaning their teeth, except for a few, who lived by the sea or on river banks and used sand.

\* Criteria used for oral hygiene:-

Good = no discernible debris

Fair = discernible debris

Bad = pronounced debris

TABLE 18<sup>(46)</sup>

## Prevalence of calculus formation\*

Group	Dentition	Number of Subjects	Degree of calculus formation			
			None %	slight %	moderate %	severe %
Coastal	D	71	100	0	0	0
	M	212	96	2	2	0
	P	293	41	15	44	0
Highland	D	42	100	0	0	0
	M	132	91	1	5	3
	P	157	48	8	43	1
Urban	D	35	100	0	0	0
	M	61	95	3	2	0
	P	66	21	28	48	3

\* Criteria used for calculus formation:-

Slight = thin deposit confined to one or more of the  
lower six anterior teeth.

Moderate = slight deposit involving more than the  
lower six anterior teeth.

Severe = heavy deposit involving more than the  
lower six anterior teeth.

None = no deposit.

Of the various local aetiological factors that contribute to the breakdown of gingival tissues in the older age-groups many investigators have shown that the strongest association exists between calculus formation and the degree of gingival pathosis<sup>(46)</sup>.

Results for the gingival conditions are presented in table 19:

TABLE 19<sup>\*(46)</sup>

Prevalence of various degrees of gingivitis

Group	Dentition	Number of Subjects.	Degree of gingival involvement				
			None	Mild	Moderate	Severe	Very severe
Coastal	D	71	87	5	8	0	0
	M	212	47	16	37	0	0
	P	293	26	20	53	1	0
Highland	D	42	81	5	14	0	0
	M	132	30	8	58	4	0
	P	157	12	13	69	6	0
Urban	D	35	46	31	23	0	0
	M	61	12	27	59	2	0
	P	66	6	21	70	3	0

\* Criteria used for the degree of gingivitis: P. M. A. - Index<sup>(37)</sup>.

It is apparent in all groups that the gingival condition tends to deteriorate with age.

An examination of tables 17 and 19 indicates that there seems to be a direct relationship between oral hygiene and gingivitis<sup>(46)</sup>.

#### 4.2.4. Barmes <sup>(3)</sup>

Caries measurements - results in the six dietary groups follow in tables 20 and 21; and intra-group variations for dietary groups 1 to 3 in tables 22 and 23:

TABLE 20<sup>(3)</sup>

Means of caries measurements of dietary groups  
Deciduous Dentition

Dietary Group	Number of Subjects	Number of Subjects with caries	Percentage Subjects with caries	dmf teeth per 100 teeth
1	326	133	41	10.3
2	118	67	57	13.8
3	98	69	70	25.7
4	17	4	24	9.8
5	46	25	55	16.2
6	25	0	0	0.0

TABLE 21<sup>(3)</sup>

Means of Caries measurements by dietary groups  
Permanent Dentition

Dietary Group	Number of Subjects	Number of Subjects	Percentage Subjects	DF teeth per 100 teeth	DMF teeth per 100 teeth
1	817	206	25	1.6	1.9
2	307	152	50	3.8	5.3
3	318	275	86	16.3	24.8
4	64	40	62	4.9	8.4
5	149	123	83	15.0	26.3
6	66	1	2	0.1	0.1

TABLE 22<sup>(3)</sup>

Means of caries measurements by village for dietary  
groups 1 to 3.      Deciduous Dentition.

Dietary Group	Village	Number of Subjects	Percentage Subjects with caries	dmf teeth per 100 teeth
1	Kranket	108	36	8.3
	Maprik	26	22	4.2
	Wari	88	40	10.7
	Awala	69	54	15.9
	Yalaku	35	44	8.3
2	Amele	60	57	12.8
	Togarau	40	48	11.7
	Tiaraka	18	74	20.3
3	Okiufa	35	75	24.1
	Kwasang	19	89	25.7
	Kundumbu	23	79	29.2
	Pari	21	35	8.3

TABLE 23<sup>(3)</sup>

Means of caries measurements by village for dietary  
groups 1 to 3. Permanent Dentition

Dietary Group	Village	Number of Subjects	Percentage Subjects with caries	DF teeth per 100 teeth	DMF teeth per 100 teeth
1	Kranket	243	22	1.7	1.8
	Maprik	77	16	0.7	0.8
	Wari	223	28	2.2	2.5
	Awala	179	33	1.6	2.1
	Yalaku	95	20	1.1	1.4
2	Amele	146	45	3.3	4.1
	Togarau	111	58	4.4	7.1
	Tiaraka	50	45	3.7	4.7
3	Okiufa	130	85	15.9	23.0
	Kwasang	48	89	21.6	32.8
	Kundumbu	72	91	14.6	21.7
	Pari	68	83	15.2	25.8

N. B. (5):

- (1) Tables 20 to 23 provide age-adjusted results, in the expectation of correcting any variation between villages due to grossly different age-distributions, but it turned out that the adjusted results were only minimally different from the untreated results.
- (2) The under-one age group has been omitted from all tables as being of no significance to the study and the 45 and over age group has been omitted, as wholesale loss of teeth due to periodontal disease at that age, results in misleading caries - prevalence levels.
- (3) The variations in caries-prevalence between the six dietary groups and within group 1, 2 and 3 could be related to:

(a) Diet.

Although variations within a N. G. village and even from one village to another, are generally not so great they still should be taken into account, especially in dietary groups 1 and 2, which have a greater variety in foodstuffs than the other groups. Most villages in these two groups are also placing a different emphasis on their main staple.

(b) Race.

Racial and language barriers keep villages in all the dietary groups separated, sometimes even when only a few miles apart. As certain levels of caries prevalence exist however across racial boundaries, it is doubtful if race is an important factor in caries prevalence.

(c) Climate.

Within all groups variations occur in climatic conditions, such as: - humidity, rainfall and temperature levels. Temperature differences are especially encountered in group 2, which has most variation within the group, with villages ranging from coastal level to 3,000 feet above sea level. But same as for racial differences there is also no evidence of a significant relationship between climatic and caries

(d) Soil composition.

Variations in soil composition, which are to an extent dependent on the climatic condition, are likely to be far more marked between the dietary groups than within each

group, with group 2 as a possible exception. A link between soil composition and caries could very well be significant.

(e) Customs and habits.

Habits, such as betel-chewing and toothcleaning methods, which rely on the use of sand, husks and sticks might have some small effect on caries, but this has been by no means proven. The big difference in habit occurrence and/or intensity between the sexes might be related to the differences in their dental disease pattern.

(f) Fluorine content.

Except for the village Yalaku, where the F-content in the water was 2.0 p.p.m., all other samples gave results not greater than 0.2 p.p.m. The variation caused by such an isolated case of high F-level is hard to assess in a population where caries is already low and the intake of fluorine from other sources is unknown.

(4) Statistical tests placed the results for percentage subjects with caries of all samples from groups 2 and 3 within acceptable limits of variation from the overall mean after the 'Parai' - results were omitted in the deciduous dentition

because of an inadmissible sample.

- (5) In group 1 the village Maprik was significantly different from the overall mean at the 5% level. The consistently lower caries - measurements in Maprik, compared with all other group 1 samples could be due to the annual dominance of sago, which has a high F'-content, in the diet. Due to this variation in diet it might be even correct to put Maprik in a separate dietary group with a lower prevalence of dental caries than group 1, but higher than group 6.
- (6) Generally a higher caries prevalence in males than in females occurred in both dentitions, an extreme example being Rongo (group 4) where 7 males produced a dmf of 16.96 per 100 teeth and 10 females a dmf of nil and 25 males produced a DF of 6.40 and 39 females of 3.63 per 100 teeth.
- (7) A very common trend was observed of a decrease in caries prevalence from the 6 - 10 to 11 - 15 to 16 - 29 age group, with the upturn at the 30 - 44 age group. Barmes<sup>(5)</sup> suggests relationships with occlusal attrition early and cemental caries-onset later.

- (8) Ratios of carious surfaces to carious teeth ranged from 1.09 to 1.38 in the low caries prevalence groups 1 and 2. In the moderate to high caries groups 3, 4, 5 the range was from 1.47 to 1.53.

Periodontal disease measurements - results for dietary group 1 to 6 were respectively: 182, 200, 180, 158, 189 and 150. These results were calculated by multiplication of the percentage in category 0 by 0, percentage in category 1 by 1, etc., while grading<sup>(3)</sup> of the categories was as follows:-

Category 0	=	no abnormal conditions discernable
" 1	=	gingivitis only
" 2	=	shallow pockets
" 3	=	deep pockets and or moderate loss of bone in molars as far as the bifurcation.
" 4	=	extensive loss of bone with looseness of teeth.

Barnes<sup>(3)</sup> admits that this classification is not ideal, but at the commencement of his survey Russell's index<sup>(35)</sup> was not in use yet to any extent, otherwise advantage would have been taken of its far more meaningful measurements.

A slightly higher periodontal prevalence was reported for males than for females in all six groups.

#### 4.2.5 Vines<sup>(45)</sup>

Caries-prevalence results in three villages, the permanent and deciduous dentitions taken as separate identities, follow in the next two tables (24 and 25):

TABLE 24<sup>(45)</sup>

Caries measurements in three villages - Permanent  
Dentition.

Village	Number of Subjects	Number of Subjects with caries	Percentage of Subjects with caries	DMF teeth per
MIAMPO (Highlands)	48	34	71	3.2
AWAR (Mainland)	39	13	34	0.5
TALAKUA (Islands)	85	13	16	0.3

TABLE 25<sup>(45)</sup>

Caries measurements in three villages - Deciduous  
Dentition.

Village	Number of Subjects.	Number of Subjects with caries	Percentage of teeth of subjects per with caries.	DMF/dmf teeth per subject	DMF/dmf teeth per subject
MIAMPO (Highlands)	28	9	32	1.5	2.7
AWAR (Mainland)	14	10	71	0.61	0.6
TALAKUA (Islands)	29	17	57	0.9	0.5

- (1) Overall caries rate was highest in the MIAMPO (highlands)
- (2) Caries rate of the permanent dentition was much higher than that of the deciduous dentition in MIAMPO but in the other two villages: AWAR (mainland) and TALAKUA (islands) the situation was reversed.
- (3) The three villages were of course not fully representative of the regions from which they were drawn.

The results, using Greene's<sup>(17)</sup> Oral Hygiene Index per subject for the permanent dentition in MIAMPO, AWAR and TALAKUA were: 4.6, 3.0 and 3.2 respectively, while for the deciduous dentition the figures were: 2.1, 2.1 and 1.9.

### 4.3 DISCUSSION

Caries data for comparison from all five studies follow in table 26.

TABLE 26

A comparison of caries data from five studies.

Area	Number of Subjects	Number of Subjects with Caries.	Percentage Subjects with Caries.
Manus	1976	49	2.5
Patep 2	128	67	52
Kavataria	91	39	43
Korovagi	100	30	30
Williams':			
Coastal	576	229	40
Highland	331	214	65
Urban	162	133	82
Barmes':			
Group 1	1143	339	30
2	425	219	51
3	416	344	83
4	81	44	54
5	195	148	76
6	91	1	1

TABLE 26 (Cont'd)

Area	Number of Subjects	Number of Subjects with Caries.	Percentage Subjects with Caries.
Miampo	76	43	57
Awar	53	23	43
Talakua	114	31	27

- (1) Only Barmes' group six and Kirkpatrick's results are exceptionally low.
- (2) Next to Williams' Urban group the highest caries prevalence is found in the Highlands. (Patep 2, Williams' Highland group, Barmes' group three and Miampo)

Table 27 gives caries data for comparison of Barmes'<sup>(3)</sup> and Vines<sup>(45)</sup> studies results.

TABLE 27

Caries data for comparison of Barmes' and Vines' studies  
Results.

Author (a)	Region (b)	Permanent DF per person (c)	Range	Deciduous df per person (d)	Range
B	Highlands	3.5	1.5-4.5	2.4	1.1-4.0
V		2.5	0.8-4.2	1.8	0.5-3.1
B	S. H. D.	1.5	N. A.	1.1	N. A.
V	only	1.1	N. A.	N. A.	N. A.
B	Mainland	0.7	0.0-4.4	1.5	0.0-4.0
V		1.1	0.1-3.1	1.8	0.5-5.1
B	Islands	0.8	0.3-1.1	1.7	1.2-3.0
V		0.8	0.2-3.5	1.7	0.5-3.9

(a) B = Barmes<sup>(3)</sup>

V = Vines<sup>(45)</sup>

(b) S. H. D. = Southern Highlands District.

(c) The 45 and over age group has been omitted.

(d) Although proper comparison is not possible as Barmes' figures should read dmf per person, the difference between dmf - and df per person is negligible.

- (1) Of interest is the lower D. F. per person rate in the Southern Highlands District in comparison with the figure for the three Highland District combined. Barmes<sup>(6)</sup> stated last year that later investigations suggest that the alkaline soil is more likely to account for the Southern Highlanders' lower caries rate than dietary - or cooking differences. The dmf/DMF rate per subject for S. H. D. was only 2.7 against 6.9 for group three (= the combined Highlands).
- (2) Barmes<sup>(6)</sup> has recently also suggested that the wide range in D. F. rates in all the dietary groups might indicate that the dietary staple is not such a significant factor in the caries pattern as has been assumed in the past.

Table 28 compares Barmes<sup>(3)</sup> caries data with other studies:

TABLE 28

Caries data for comparison between Barmes' and other  
Surveys.

Sample	dmf teeth per 100 teeth(a)	DF teeth per 100 teeth	Diet Staple
Dietary Group 1.	10.3	1.6	Taro - Yam
2.	13.8	3.8	Taro - Yam
3.	25.7	16.3	Sweet Potato
4.	9.8	4.9	Sweet Potato
5.	16.2	15.0	Sago
6.	0.0	0.1	Sago
Patep 2	3.9	6.8	Taro - Sweet Potato
Kavataria **	21.1	1.7	Yam
Korovagi ***	5.8	1.8	Sago
Samoa *	3.6	---	Taro
Puka Puka *	27.5	9.3	Coconut - Fish

\* From: Barmes<sup>(3)</sup>

\*\* Age-adjusted to Patep 2 - age distribution.

(a) Most figures represent again df teeth per 100 teeth and not dmf  
but the differences are small.

Patep 2 can possibly be regarded as a Barmes'<sup>(3)</sup> dietary group-two sample, notwithstanding its altitude of 3,550 feet above sea level. Kavataria is a dietary group-one sample, but due regard should be given to the fact that two years previous to the 1947 survey the diet had been affected for a period of three years by the presence of numerous service-men.

Korovagi's diet is a problem. It may belong to a seventh dietary group, but is probably closest related to dietary group six with a sago-varied diet. For 3 months annually however sago is replaced by sweet potato and taro<sup>(4)</sup>.

Vines' Miampo can probable best be fitted in Barmes' dietary group 3 and Awar and Talakua in dietary group 1.

If an attempt is to be made to link diet and nutrition with dental diseases, several factors associated with diet should be considered, such as:

- (a) Food patterns.
- (b) Soil - and water content
- (c) Nutritional value of the food.

ad (a) In New Guinea three factors in food patterns are in this concept of major importance:

- (1) Type and character of the foodstuff
- (2) Cooking method
- (3) Food habits.

ad (1) The lack of refined food in the native's diet and the cleansing - and detergent character of the food he eats, are probably the major factors in the overall low prevalence of caries. Variations between the villages in nutritional factors can probably be best explained on the basis of distinct food patterns, which differ widely both in staple and supplementary foods.

Barnes<sup>(3)</sup> e. g. tried to correlate an almost exclusive and unvaried sweet potato-diet with this highest caries-prevalence for village natives.

ad (2) Barnes<sup>(3)</sup> also distinguished between cooked- and baked sweet potato and connected the first form with a very high caries-incidence, while sweet potato, when baked was thought to

cause much less caries. This assumption was based on 1 sample only in the "baked sweet potato"-dietary group<sup>(4)</sup>. Later he<sup>(6)</sup> repudiated this suggestion and now accepts differences in soil content to be a more likely factor.

ad (b) It has not been shown yet that the existence of certain minerals and trace elements in the soil could in any way contribute to the dental disease pattern; Barmes<sup>(6)</sup> only suggested the possibility.

Nor could fluorine concentrations in drinking water be a very important factor in New Guinea as test-results with one exception only, ranged from 0.05 to 0.45 parts per million.

ad (c) Which bearing the native's definite low intake of proteins and possibly a few other nutrients as well, has on dental disease is as yet unsolved; although Kirkpatrick<sup>(24)</sup> suggested that lack of essential food constituents - without however specifying them - could be partly responsible for the predisposition of the gingivae of the Manus Islanders to severe fusospirochetal infections.

## CHAPTER 5.

### SUMMARY AND CONCLUSION

1. Nutrition - and dental surveys, conducted in lesser developed countries such as Papua and New Guinea have distinct advantages such as:-
  - (a) readily available material,
  - (b) several specific levels of dental disease prevalence
  - (c) comparisons between primitive villagers and those at various stages of civilisation.
  - (d) clearly defined populations, such as : villages,
  - (e) variety of conditions, some of which have not been reported in civilized communities.
2. Attempts have been made to correlate dental disease-patterns with diet-patterns, not only within village groups, but also when these groups are compared as one unit with more sophisticated communities.
3. Dental caries prevalence varied widely within the groups and indeed within the same race. It was found to be very low in some of the Sepik-areas and Manus, and high in the Urban areas and Highlands. A higher prevalence in the deciduous -

than in the permanent dentition has been reported, but caries prevalence differences by sex were less significant. Overall this prevalence in New Guinea was far lower than is usually observed in most Western societies.

4. Caries prevalence was found to be highest in the "boiled" sweet potato - and the urbanised "Western style" dietary groups, and very low in some sago eating groups.
5. Not before at least all the results of Vine's survey<sup>(45)</sup> are available, can Barmes' hypothesis:<sup>(3)</sup> that caries prevalence in New Guinea is associated with distinct dietary pattern groups, be supported or rejected, taking into account of course the possibility that in some areas the dietary habits could have changed significantly during the period between the 2 surveys, and also that other factors, such as soil composition, could prove to be more significant. Other workers have been unable to show any connection between caries and diet, other than the complete absence from the village native diet of refined ingredients.
6. Many factors, such as lack of age-distribution and separate consideration of the two dentitions, use of different indices and not always clearly defined criteria, have reduced the validity of a general comparison of the caries prevalence - results from the studies reviewed.

7. Gingivitis and periodontal disease were commonly encountered all over the Territory with a very high prevalence, especially in the Highlands, but the data were too variable for comparison. The overall prevalence is probably higher than in most Western communities.
8. It was found impossible to relate in any way periodontal disease to diet, except that Kirkpatrick<sup>(24)</sup> claimed to have found a significant difference for suppurative periodontitis between taro and sago eaters at Manus.
9. Except by Sinclair<sup>(39)</sup>, whose data were anyway drawn from too small a range, no relationship between caries and gingival - and periodontal disease could be established.
10. Betelnut chewing and its possible relation to oral hyperkeratosis has been discussed.
11. The fluorine-concentration in the drinking water was found to be low.
12. The diet of the village native was in general considered to be poorly balanced and to be deficient in proteins, especially

in those of animal origin, and in fats; probably adequate in calories, minerals and vitamins; but excessive in carbohydrates.

13. As civilisation is making its inroads on the primitive races of New Guinea, data of the type supplied by these surveys are becoming scarcer. The time available to undertake more of this type of studies is therefore becoming very limited.

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