not make up the under-development of their earlier years. Judging by the investigations of Kahn and Friedman (40) in 1959 in South Africa and by Burgess and Burgess (31) in 1964 in Uganda, children of well-to-do Bantu do nearly reach the Harvard-Standard. So we can assume that underweight and length are not due to genetic reasons, but to undernutrition. The anaemia which is found so often in East Africa occurs only rarely in the Usambara villages. This was shown by the haemoglobin and the haematocrit values. But this fact seems not to be attributable to better feeding or hygiene, but to the high altitude above 3,000 ft. and to the low incidence of malaria. As was to be expected, much lower values were found in the coastal villages. As far as the haemoglobin-haematocrit quotient showed microcytic anaemia was rare. This is in accordance with the good coverage of the iron requirement, as shown from dietary investigations. There was an insufficiency of protein, calcium, vitamin A, riboflavin and niacin. Except for protein the clinical examinations did not show so many signs of malnutrition as expected. Two of the reasons might be:

• the recommended dietary allowances have been set too high or,
• as a result of the chronic underfeeding, some sort of adaption occurs which demands a smaller supply of nutrients.

If this is pertinent, then hypovitaminosis A or B, for example, should occur if a one-sided improvement of the feeding situation occurs. This could explain why we found most signs of undernourishment in Leguruki, although our anthropometric measurements showed a better development of the children there. There is no doubt that a higher consumption of animal protein would bring about the most harmonious improvement in nutrition of the people. If this were carried out, the present short supply of calcium, vitamin A, riboflavin and niacin would be removed. Such a solution would take a long time to bring about, but could be implemented as the standard of living improved. Since this cannot be expected to take place quickly enough a higher consumption of legumes should be the first step towards improving the nutritional situation from local sources.

M. G. Atters showed in his report that the growing of beans would help to improve the soil in Usambara. Beans however cannot be stored for longer than 2 months because of noxious insects. This could be avoided by the use of insecticides like pyrethrum.

From the nutritional point of view, more consumption of beans would be advantageous for three reasons:

• Tests in the Max-Planck-Institut für Ernährungsphysiologie in Dortmund have proved that protein mixture of maize and beans (Phaseolus vulgaris) has a high biological value for adults.
• Our own investigations on feeding in the Irente and Kifungilo orphanages have shown that children over 6 months old can easily digest beans when the outer skin has been removed. Growth then develops regularly, compared with the proceeding period, if the portion of milk in the nourishment of the child is replaced by beans. As we learned from the Bukoba orphanage, and from the Nutrition Rehabilitation Unit of the Medical School in Kambala, beans have been given to children from 1 to 2 years of age as protein source for a long time. The beans are easily digested.
• Such an addition would increase not only the intake of protein, but also the intake of other deficient nutrients like riboflavin, niacin and calcium.

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III. Analysis of Some Important Foodstuffs of Usambara

by

C. SCHLAGE
Investigations into Health and Nutrition in East Africa

with 132 tables and 70 figures

By

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WELTFORUM VERLAG · MÜNCHEN
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A. INVESTIGATIONS IN NORTH EAST TANZANIA

by

M. G. Attems, W. Keller, H. Kraut, J. Kreysler,
W. Poeplau and C. Schlage
Investigations into the problems of nutrition and agriculture in developing countries were carried out with a double purpose. They were intended to indicate ways in which these countries could use their own resources to eliminate food shortages and errors in nutrition and thus raise the standard of health and improve working efficiency. Since about 80% of the population is engaged in agriculture, there should have been an increase in the cultivation and sale of suitable cash crops in order to raise the general standard of living.

Developing countries lie predominantly in the tropical and subtropical zones and differ from the countries in the temperate zones in many ways, in particular by their great contrasts in climatic conditions, namely the abruptness of the changes from rainy to dry weather, and the great range of transitions from arid to humid climate. It is characteristic of many of these countries that there are great variations in the cultivation possibilities of agricultural produce. There are also variations in the harvest, the living standards and the consumption habits, all in close proximity to one another. The advice, generally held to be good, to increase consumption of animal products, to expand cultivation of plants with high protein content, to develop agricultural export articles in order to improve the balance of foreign currency, is generally not followed or when followed, without effect. Those who have gained practical knowledge over a long period of time in a given area, recognise that the problems are many-sided and that frequently, within a distance of only a few miles, such varying conditions prevail that quite different advices must be offered. There is nothing more inimical to the success of development schemes than to apply measures in places were they are not suitable. To be able to point out that the measures were very successful in one place is far less impressive than the obvious lack of success in another.

When writing an account of scientific studies in developing countries, it is absolutely essential to state exactly in which spot, at what time, and for how long the investigations took place. It should also be noted where the conclusions drawn from such a study are applicable. Any advice which is offered should also pertain to a specific area. The change in climatic conditions from one year to another is often so great that only investigations on the spot, and spread over several years, can lead to reliable results. Finally, it should be pointed out that the complexity of human life necessitates other studies focused on complementary branches of knowledge which are performed in
the same area. This is the only way to obtain a complete picture of the situation avoiding wrong conclusions.

In accordance with recommendations of an WHO Expert Committee on Nutrition (1963) the surveys consisted of the following:

- A collection of background information concerning Tanzania in general and the survey areas in particular.
- Vital and health statistics including incidence studies of intestinal parasites and malaria.
- Questionnaire surveys which obtained more detailed background information, birth plus mortality rates, habits of child care, and nutrition.
- Food consumption surveys.
- Anthropometric measurements.
- Clinical assessments of the nutritional status.
- Biochemical assessments of the nutritional status.

None of these methods alone would have provided sufficient information. Only the combination of essential dietary, anthropometric, clinical and biochemical data plus thorough background information including studies of environmental and social factors and consideration of such vital statistics as morbidity and mortality rates, made possible full appreciation of the public health situation.

The surveys also provided a valuable opportunity for the critical testing of new biochemical and other methods recommended for the assessment of the nutritional status.

In 1961, Wolfgang Keller, M. D., from the Max-Planck-Institut für Ernährungsphysiologie in Dortmund, did the preparatory work for the establishment of an experimental station in Bumbuli. He has given us much valuable advice and cooperation in the planning of our studies. We take this opportunity to express our sincere thanks to him.

We are also most indebted to the personnel of Bumbuli Hospital and in particular to its former Director, Professor Otto Walter, M. D., for the valuable encouragement and advice given to us in our work.

In Uganda and also in Kenya and Tanzania where the research was not so detailed, investigations have already been made on the nutritional conditions of the population concentrating on young children. Some comments on food consumption have also been given. Up to now, however, there were very few studies dealing with family consumption combined with a description of the health conditions of all age-groups within the population. With the help of the Fritz Thyssen-Foundation, a research station called "Max Planck Nutrition Research Unit", was erected in Bumbuli (Usambara). Its first task (1964-1966) was to determine the state of health and nutrition of the population as a whole. This study was based on dietary observations made throughout the year on a selected number of families from Bumbuli and the neighbouring villages together with anthropometric, clinical and biochemical investigations. These results were compared with another survey carried out in N. E. Tanzania. Our aim was to find out to what extent the conclusions drawn from Bumbuli would apply to other areas. Dipl.-Ing. M. G. Arems, an agriculturist, sent out by the IFO-Institute, carried out a year's investigation into the agricultural conditions of Bumbuli and the surrounding area. Working in cooperation with him, we tried to find ways to improve the nutritional status significantly.

In 1966/67, in 8 areas between Kilimanjaro and Usambara, a study of nutrition was carried out on certain families who had already been selected by a group of the F.A.O. for a sociological study. Both investigations were done with the cooperation of the Tanzanian Government. The aim of both was to determine the living conditions of groups of the population who were under consideration for resettlement in the irrigated areas of the Pangani-project. Beyond this, there was the chance to find out whether certain shortages of foodstuffs existing were greater among the people of the plains than among the neighbouring hill-folk who were of comparable ethnic origin.

Investigations could be made over an area in which a border line existed with regard to the different food habits in East Africa. For example, the diet in Usambara is based principally on maize. The diet of the people living on the slopes of Kilimanjaro is mainly bananas. We found it necessary to study the composition of the local foodstuffs eaten, and to determine if possible, any losses which were caused by the local methods of preparation. The market in Bumbuli served as an example for our study on seasonal variations in the market demand for some important foodstuffs. The focal point of the first enquiries was the village of Bumbuli, which lies in the south-eastern part of West Usambara at an altitude of 1,200 or 1,300 metres above sea-level. It is connected with the main road between the port of Tanga and Moshi at the foot of Mount Kilimanjaro by the Bumbuli-Soni-Mombo road. Bumbuli has a population of some 300 families who belong to the Shambala tribe (Bantu group). They live in two distinct parts of the dwelling area. There is the old part (referred to later as Bumbuli A) where about 130 families live. Here more Moslems live than Christians. Then there is the new part (Bumbuli B) which is predominantly Christian, where the market place and most of the shops are located.

The villages of Funta, Mayo, Mulungui and Soni all lie within 15 miles off Bumbuli in the Usambara hills and all of them are roughly at the same altitude as Bumbuli. They are also inhabited by the Shambala and have similar living and eating habits. In Soni, enquiries were made only of vegetable growers whose produce goes via the Soni market as far as Tanga and Dar-es-Salaam. We studied the question of whether their higher incomes affected the standard of nutrition and health of the population of the area.

For a further comparison, we chose the two coastal villages of Maranzara
and Chakidhani near Tanga. These belong to the area of the Digo tribe (Bantu). The average diet here is different from that in West Usambara. Here in the coastal area, the coconut palm grows and sea-fishing is practiced.

The village of Leguruki (1,200 m above sea-level) lies between Mount Kilimanjaro and Meru. It is populated by the Meru tribe (Bantu) who are engaged in animal husbandry and agriculture. They have a satisfactory water supply. Living conditions here are worse than in the Shambala and Digo tribes. In the Pare hills west of Usambara, we studied the nutrition and the state of health of five Pare families (Bantu) in the higher income bracket. In Irente (Usambara) there is an orphanage supervised by doctors of the Bumbuli hospital. Here we were able to examine the children.

For the second nutrition study in connection with the Pangani irrigation project, places were chosen which were considered to be characteristic of the particular area. We also differentiated between the hilly country and the lowlands so that we had four pairs of survey areas.

Kilimanjaro-area: Highland: Kilema, Kirua-Vanjo, inhabited by Chagga
Lowland: Kaha, inhabited by several tribes
North-Pare-area: Highland: Usangi, Ugweno, inhabited by Pare
Lowland: Mwanga, inhabited by Pare
South-Pare-area: Highland: Mamba, Bombo, inhabited by Pare
Lowland: Makanya, Heduru, inhabited by Pare and Masai
Usambara-area: Highland: Lushoto, Gare, inhabited by Shambala
Lowland: Mkomazi, inhabited by several tribes.

The outstanding feature of the population (in relation to nourishment) in West Usambara is that from the age of 4 to 6 months, the development of most of the children falls more and more below the European and North American standards. Well-nourished Bantu children, however, sometimes fully reach western standards. The reason for this lies in the fact that once the mother’s milk fails to satisfy the child’s needs, his extra feedings are quite insufficient. On the average, children of about two years of age who live in the villages where we worked came up to the standards of height and weight of 9-months-old western babies. It was nearly always a case of general under-nourishment rather than a one-sided lack of proteins. Nevertheless, the main cause of the widespread under-nourishment of children certainly lay in the lack of protein-rich food.

The averages of height and weight remained under the normal limits right up to school age. They improved, however, during the school years, and by the time the children were 16 their weights approached western standards. This is particularly true for girls. There is a uniform lack of weight and height which is observed very frequently in the following age categories. Adults are generally about 8 cm shorter than European people. Even their weight is much less than that of Europeans of the same height. This is attuned retarded growth.

The extent to which the food requirements of the Shambala were met is shown in round figures, as follows:

| Nutrient | Requirement | Percentage
|----------|-------------|-------------
| Protein  | 60 to 90%   |             |
| Calcium  | 20 to 45%   |             |
| Vitamin A| 20 to 60%   |             |
| Vitamin B₂| 20 to 60%  |             |
| Niacin   | 60 to 80%   |             |

When the protein requirement is met by only 60%, there is a state of considerable under-nourishment. An improvement in the protein supply should, therefore, be the first aim of nutrition development. Since animal production is depending on many conditions, it would appear that the most expedient way to improve nutrition standards would be to cultivate more legumes. We found out that a small amount of beans (Phaseolus vulgaris) without skins, mixed with maize porridge could be digested without difficulty by children 6 or 9 months old. Increasing amounts of up to 60 g per day for children up to school age would really improve their protein supply. During the days of antiquity in the Mediterranean area, the grain legume (cicer arietinum) was always a regular part of the food of the less prosperous population.

The small amount of calcium consumed is noteworthy. It is, of course, well known that the body can become accustomed to a considerable degree of under-average supply. But it is still surprising that, with an intake of only one third of the recommended amount, no clinical signs of the lack of calcium were observed.

The situation is the same concerning vitamin A. The average intake is half (or even less) of the amount recommended. This holds true even when one takes into consideration the fact that during and after the rainy periods the consumption of wild vegetables and cassava leaves (both rich in carotene) is much higher than in the dry periods. In many families, there is no intake of retinol. Signs of a lack of vitamin A were not observed. But it should be pointed out that early symptoms (e.g. hemeralopia) cannot be diagnosed by means of simple clinical examinations.

In contrast to South-East Asia, the supply of B₁ is sufficient. But the supply of vitamin B₂ and niacin is critical. We have a good knowledge of the B₂ requirements because any excessive intake of it can be measured in the urine. The intake in Usambara was never found to exceed 70% of the requirements, and it was often much lower. The requirement of niacin is not known with certainty. Niacin is partly obtained from tryptophan.
To be sure, the intake in Usambara is well below the requirement. It is, therefore, quite understandable that signs of an insufficiency of these vitamins, such as atrophy of papillae of the tongue or splitting of the corners of the mouth, were often observed. In Usambara this amounted to only 2% of the cases examined, but in Mulungui, where the supply is at its lowest, such signs were observed in 14% of the people. Here again, greater consumption of legumes would bring about a marked improvement, as its niacin content is higher than in the basic foodstuffs. Only singular cases of fluorosis of the teeth were found in Usambara. This was to be expected in view of the small fluoride content of the water. Two water analyses showed 5 p.p.m. respectively 10 p.p.m.¹. On the other hand, in Leguruki, near Mount Meru, there were many cases of fluorosis due to the well known high content of fluorine in some waters of this volcanic area.

The investigations in other areas of North East Tanzania were of too short a duration to allow a firm judgement of the nutrition of the population. It is, however, certain that the composition of the diet in Leguruki, near Mount Meru, and in the coastal area, is quite different from that in Usambara. Here we found that only 13–15% of the protein intake was of animal origin (mostly in the form of meat). In Leguruki, it was 24% among the few families investigated, and of that 15% was from milk. The main food in both areas was maize and bananas. In the coastal villages of Maranzara and Chakidhani, the basic food was cassava and fish. The proportion of animal protein was considerably higher than in Usambara. In Chakidhani, on the coast, it accounted for 54% of the protein intake, and in Maranzara, 10 miles inland, it was 27%.

In Leguruki, the physical development of the infants was considerably better than in Usambara. This was probably due to the higher milk consumption. In the coastal villages the situation was somewhat worse than in Usambara because the infants got no fish. In addition, cassava, known for its very low protein content, is the staple.

Our agricultural investigations in Usambara led to the following conclusions. According to the degree of commercialisation of the small farms, three development stages can be distinguished: Subsistence holdings, partly commercialised, and half-commercialised holdings. In Mulungui subsistence economy prevails the degree of commercialisation being 4% only (figures based on the share in sales of the raw produce from the worked fields). On the average, each holding produces a yearly income of 240 E. A. shs. In Bumbuli, the gross income from a small-holding commercialised to 15% was 900 shs. on the average. The income came principally from non-agricultural work (hospital employees, shop keepers, etc.). The holdings of the vegetable growers whom we investigated near Soni, were half commercialised. The average income per holding was 2,015 E. A. shs.

Commercialisation constitutes a large step forward in agricultural development. It stimulates the interest in improving the yield in order to get a higher income from the same piece of land. The fact that agriculture has developed into a half-commercialised form of the economy in the Soni area of Usambara has certain socio-psychological aspects, but more important, it has four agro-economic causes:

- The relative seclusion and inaccessibility of the Usambara hills which prevent all but the vegetable growers in Soni from marketing their produce in the large towns.

- The increasing partition of the land due to the rapidly growing population. This has led to a reduction in size of the agricultural plots, and thus works against a planned agriculture. The maintenance of traditional agricultural methods has led to the soil being on the verge of exhaustion. Reduced yields and increasing soil erosion are the accompanying results.

- The indefinite occupation or ownership conditions. There are tribal lands and family lands upon which the temporary occupier has certain rights including inheritance. There is no desire to invest manpower or money to improve the soil. No fertilizers are used.

- The excessive number of cattle are maintained less on account of their yield than for the prestige of ownership. They are used as capital instead of money. The cows graze freely on all grassland as well as harvested fields. The farmer has no interest in preserving the pasture land because of excessive communal grazing. Preservation would only be possible if the number of stock were reduced.

One remarkable point is the unsatisfactory relation between income and nutrition. In Soni, where the income is greater, people eat a little more (better calorie intake), but the composition of the diet (with insufficient protein, vitamin and mineral content) remains for the most part unchanged. Thus, it is not possible to say that differences in the state of nutrition and health were dependent on social standing. The supposition that an increase in income automatically brings about an improvement in nutrition is inaccurate. Answers to questions put to the families as to what things they wanted and would buy if they had a higher income, showed that other improvements in living standards took preference over improvements in nutrition. If they had more money, it would first be spent on housing, then on the purchase of land, and thirdly for their children's education. School fees and school clothes are beyond the reach of poorer families. Beyond this, they wanted to raise their agricultural production by investing, as in Soni, in the purchase of seeds. Therefore, we assume that the increase of income for the vegetable growers in Soni was neither big enough nor of a long enough duration to

¹ We are indebted to TWIN CITY TESTING and ENGINEERING LABORATORY, Inc. St. Paul, Minn., USA, for the quantitative determination of fluoride in two water samples.
bring about a change in the eating habits to which they had grown so accustomed.

In many cases, this attachment to the old forms of nutrition was due to ignorance of the importance and necessity of nutrition. Over and above the recommendation of increasing the agricultural production, there should be a comprehensive program for nutrition education. There should also be particular instruction for mothers concerning proper food for babies and infants.

The second enquiry on nutrition (the Pangani Survey) showed interesting differences between the hill population and the people in the lowlands. The vitamin C content in the blood of the hill-dwellers is considerably higher than in that of the lowland inhabitants. The reason for this is that there are greater quantities of fruits and vegetables on hand all the year around in the green hill-country, but the plains remain dry for most of the year. On the other hand, the dryness of the soil in the plains decreases the propagation of worm parasites. This was demonstrated by the fact that there was a smaller degree of infection amongst the people of the plains.

It was surprising that the results of almost all studies revealed a poorer nutritional status among the inhabitants of the mountains (Kidimanjaro, Pare, Usambara) in comparison to the population groups in the plains.

The Chagga, supposedly the most highly developed tribal group in this region, were slightly better than the Pare or Shambala in many respects. Their higher nutritional standard was due to their intensive and long standing coffee cultivation as well as their good sense of social priorities.

We were able to show that population density was somewhat related to intestinal worm infection. Other investigations showed similar correlations. It seems as if the nutritional status of all these population groups developed inversely proportional to the population density.

Although the analyses of foodstuffs showed only minor differences from the data given in the food composition tables, these differences became important in calculating the nutrient intakes especially with respect to foodstuffs in common use like maize. We found that maize had a somewhat higher water content and a lower protein content. Fresh cassava roots and sweet potatoes showed a definitely higher content of Vitamin C. A study of the local preparation of maize showed the inexcusably high loss of 40% of the total weight. There was an almost complete loss of the germ which resulted in a low fat content in flour. Accordingly, there was a loss of carotene in processing yellow maize. This loss coupled with the already poor supply of vitamin A must be regarded as very serious. If only the maize were ground in a simple hammer mill instead of being stamped in a wooden mortar, all these losses could be avoided.

The market study showed that maize, cassava, pawpaw, and dried fish were sold practically all year around with very little variation in price. There were, however, considerable price variations for mangoes because its season is so short (December to January). The supply of oranges, tomatoes, onions, and green beans is also seasonally limited. Dried beans, pineapples, and lemons are always available but with considerable variation in supply and price.

Meat is not on sale in the market but in special shops. There are several kinds of preserved fish in the market. The popular smoked fish is twice as expensive as salt fish. But the protein level in salted fish is still much higher than that in vegetable protein. So from this point of view as well, the increased use of vegetable protein has to be stressed in order to fill the gap in this most important nutrient.
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1. Methods

a) Selection of the Families

With the first series of tests, it was hardly possible to get a representative
selection of families from the statistical point of view. In Bumbuli we chose
families with different levels of income derived from subsistence cultivation
and extra earnings. Our selection was also made more difficult because some
of the chosen families were not willing to undergo our tests. They had to be
replaced by others in order to obtain the required number of samples. We
intended to examine 20% of the families. This figure was almost reached in
Bumbuli A, but in Bumbuli B it was considerably less. A complete investi-
gation of the whole village of Mulungui (with the exception of two families
who refused) was carried out. Almost all the inhabitants in Punta were
measured and weighed.

In other villages (Leguruki, Maranzara, Chakichani), where we worked for a
shorter period, a classification by income was impossible. The headmen and
the teachers living in these places gave us the names of families with medium
incomes. From the names we chose those who were willing to cooperate
with us.

All the members of the selected families (cooking units) were listed
according to sex and age. Pregnancy and lactation were also noted. In most
cases, the age had to be worked out according to a calendar of locally
known events. The age of some children born in Bumbuli Hospital was
known.

b) Dietary Investigations

After it had been established that enquiries of 4 days were sufficient to
determine the menu and the amounts of food consumed, the survey team
visited on at least 4 successive mornings the homes of the selected families
and put questions to the housewives about the meals of the current day.
During these questionings, the data concerning the previous day's meals
were also checked, and alterations noted. The number of those partaking in
the meals was noted. Also noted were those family members who happened
to be absent and any guests who were temporarily present. Then the house-
wife brought the food which would be eaten at the midday and evening
meals. This was weighed. Additional ingredients were measured by using
whatever measuring instruments (teaspoon, woodenspoon etc.) which were
locally used. We then measured their capacities. It must be pointed out that
with investigations of this nature only the consumption of the whole family
(cooking unit) could be established. The presence of investigators during
the actual meal who would estimate the consumption of the individual
family members would have been an offence to the people. Any presence
of an observer would in addition have changed the pattern of the meals and even have falsified the results.

In Bumbuli all the families under investigation were visited many times in the course of the year so we could judge the seasonal alternations in food amounts. Owing, however, to the great irregularity of the harvest periods and the yields it was impossible to work out a yearly average of food consumption.

Working on the recommendations of the Food and Nutrition Board of the National Research Council of the USA (Recommended Dietary Allowances), and grouping the people according to age and sex, the nutrient requirements (from now on referred to as "requirement") of the families were calculated. Due to the smaller body measurements of the Bantu population (see page 38 and Literature 13–16) we reduced the requirements of calories and protein by 10%. A correction in the average value is also in accordance with the recommendations of the Food and Nutrition Board and the Food and Agriculture Organisation. In the case of adults, semi-heavy physical work was taken into account; pregnancy and lactation were also taken into consideration as recommended.

Table 1 shows the nutrients that were under observation and the requirements that were worked out. The daily meals consisted of a small breakfast and two hot main meals. We worked out the requirement of a family during the 4 days of enquiry and estimated the presence or absence of a person at breakfast as 1⁄3, and at each of the other meals as 1⁄5 of his daily requirement.

The figures for the nutrient content of the foodstuffs were taken from the Food Composition Tables (17 and 18), which were checked and completed by our own analyses (see Chapter on Food Analysis A III 4, p. 55 ff). In all there were about 80 different types of food consumed. 10 of these foods provided not less than 90% of the nutrient consumption. In order to compare and judge the nutrient intake of the family, this was expressed as percentage of the calculated family requirement.

After evaluating the data we found some questionable results. We found that in some cases the calorie requirements were met by over 120%. Some cases were under 50%. This discrepancy was probably due to the incorrect values for the numbers of persons partaking in the meal. Moreover, in many cases, the estimation of calorie requirement for semi-heavy work was too high, because the working capacity was very seldom fully utilized. Consequently, we decided not to take account of the supplies for the individual families. Since the enquiries were made by the same team and no definite trend was visible, we think we are justified in making some remarks on the different survey areas separately.

1 See ATTEM, page 203.

<table>
<thead>
<tr>
<th>Table 1. Nutrients Considered, and their Assumed Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Years</strong></td>
</tr>
<tr>
<td>-----------</td>
</tr>
<tr>
<td>Both Sexes</td>
</tr>
<tr>
<td>1–3</td>
</tr>
<tr>
<td>4–6</td>
</tr>
<tr>
<td>7–9</td>
</tr>
<tr>
<td>10–12</td>
</tr>
<tr>
<td>Males</td>
</tr>
<tr>
<td>13–15</td>
</tr>
<tr>
<td>16–19</td>
</tr>
<tr>
<td>20–24</td>
</tr>
<tr>
<td>25–34</td>
</tr>
<tr>
<td>55 and older</td>
</tr>
<tr>
<td>Females</td>
</tr>
<tr>
<td>13–15</td>
</tr>
<tr>
<td>16–19</td>
</tr>
<tr>
<td>20–34</td>
</tr>
<tr>
<td>35–54</td>
</tr>
<tr>
<td>55 and older</td>
</tr>
</tbody>
</table>

**During the second half of pregnancy**

**300** | **20** | 1.4 | 14 | 5,500 | 1.2 | 1.8 | 15 | 90

additional

**During the first 6 months after delivery (lactation period)**

**1,000** | **40** | 1.8 | 14 | 7,200 | 1.5 | 2.2 | 17 | 135

additional

**Infants from 7 to 12 months old**

kg × 90 kg × 2.5 0.7 6 1,350 0.5 1.7 6 27

c) Anthropometric Measurements and Clinical Investigations

The anthropometric measurements were similar to those used by W. KELLER investigating German students and recruits as well as soldiers in Tanzania, Kenya and in Guatemala (Literature 19–21). The measurements were not restricted to families, but applied to school children as well. Those who were to be examined gathered together at a pre-arranged time in an appropriate room. The weight of infants was taken by using a beam baby scale. The others were weighted with a spring balance. This was checked at regular intervals with certified weights. Children were weighed without clothes. No allowance was made for the clothes. Length was measured in infants with a length measuring board in a horizontal position. All other heights were measured with a stick fixed to the wall. In the Masai survey the rod was fixed at a tree. All persons were measured in barefeet.

Circumferences of the head, chest, upper arm and calf were taken with a
Altogether the areas that we investigated gave a much better picture than the one obtained by Rosson (36) in other parts of Tanganyika.

Results of the determination of total proteins in the plasma are shown in table 8.

### Table 8. Total Protein in the Plasma

<table>
<thead>
<tr>
<th>Area</th>
<th>No. of determ. n</th>
<th>Av. value m</th>
<th>Values under 6.0</th>
<th>Values 6.0–6.4</th>
<th>Values 6.5–6.9</th>
<th>Values 7.0 and more</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bumbuli</td>
<td>128</td>
<td>7.27 (s = 0.61)</td>
<td>3 (2%) 7 (6%)</td>
<td>24 (19%)</td>
<td>94 (73%)</td>
<td></td>
</tr>
<tr>
<td>Soni</td>
<td>52</td>
<td>7.29</td>
<td>0 1 (2%)</td>
<td>15 (29%)</td>
<td>36 (68%)</td>
<td></td>
</tr>
<tr>
<td>Irente</td>
<td>34</td>
<td>7.24</td>
<td>1 (3%) 1 (3%)</td>
<td>6 (18%)</td>
<td>26 (77%)</td>
<td></td>
</tr>
<tr>
<td>Mazumbai</td>
<td>84</td>
<td>7.25 (s = 0.63)</td>
<td>5 (6%) 9 (11%) 10 (12%)</td>
<td>41 (49%)</td>
<td>2 (3%)</td>
<td></td>
</tr>
<tr>
<td>Coast</td>
<td>37</td>
<td>6.98</td>
<td>2 (5%) 5 (14%)</td>
<td>10 (27%)</td>
<td>20 (54%)</td>
<td></td>
</tr>
<tr>
<td>Masai</td>
<td>32</td>
<td>7.67</td>
<td>0 0</td>
<td>4 (13%)</td>
<td>28 (87%)</td>
<td></td>
</tr>
</tbody>
</table>

Although the average values are all within the normal range, a distinct tendency was noted. The values in Usambara were almost uniform, but they were much worse in the coastal area, and again better amongst the Masai.

Out of the 145 determinations made in Bumbuli of Vitamin C in the blood, we found an average of 1.26 mg% of ascorbic acid (s = 0.36). The results are, therefore, completely within the normal range and in accordance with the clinical findings.

e) Dietary Investigations

These were usually done at the same time as the clinical examinations. We visited people in both Bumbuli A and Bumbuli B several times from January 1965 to April 1966. In the two coastal villages the investigations were carried out in February and May 1965; in Upare in February 1965; in Leguruk in March 1963; in Soni from September to December 1965; and in Mulungu in January 1966. Eating habits are roughly similar in all places. At breakfast a heavily sweetened tea (in a few families accompanied by biscuits) is taken, or, in poorer families, this is replaced by a thin maize soup (Uji) or breakfast is omitted altogether. Normally a cooked meal is eaten at midday, and in the evening, although the midday meal is missing when there is a food shortage or if there is urgent agricultural work to be done. The various articles of food, however, were consumed in our survey areas in varying quantities, as can be seen from table 9. It lists the amounts of the most important foodstuffs consumed.

Particular difficulties arose in dealing with the consumption of alcohol, which is frequently accompanied by meat consumption in the bars of the areas under investigations. Such extra meals were not freely admitted by the families, and especially not to Europeans. After many enquiries, we decided to

### Table 9. Amounts of the Most Important Foodstuffs in the Total Consumption of Calories and Nutrients in the Different Survey Places

<table>
<thead>
<tr>
<th>Food</th>
<th>Cal.</th>
<th>Prot.</th>
<th>Ca</th>
<th>Fe</th>
<th>Vitamins</th>
<th>A</th>
<th>B1</th>
<th>B2</th>
<th>Niacin</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maize</td>
<td>38</td>
<td>38</td>
<td>5</td>
<td>22</td>
<td>17</td>
<td>33</td>
<td>23</td>
<td>23</td>
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<td>2</td>
</tr>
<tr>
<td>Cassava flour</td>
<td>14</td>
<td>2</td>
<td>18</td>
<td>15</td>
<td>0</td>
<td>6</td>
<td>8</td>
<td>10</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Leguminosae</td>
<td>3</td>
<td>10</td>
<td>9</td>
<td>14</td>
<td>+</td>
<td>13</td>
<td>7</td>
<td>4</td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>Plantains</td>
<td>12</td>
<td>2</td>
<td>6</td>
<td>4</td>
<td>9</td>
<td>8</td>
<td>7</td>
<td>9</td>
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<tr>
<td>Wild spinach</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>8</td>
<td>42</td>
<td>3</td>
<td>11</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Meat</td>
<td>2</td>
<td>12</td>
<td>2</td>
<td>5</td>
<td>+</td>
<td>2</td>
<td>8</td>
<td>10</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Milk</td>
<td>+</td>
<td>1</td>
<td>13</td>
<td>+</td>
<td>2</td>
<td>1</td>
<td>6</td>
<td>+</td>
<td></td>
<td>+</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mulungu</td>
<td>36</td>
<td>37</td>
<td>3</td>
<td>16</td>
<td>13</td>
<td>35</td>
<td>17</td>
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<td>3</td>
<td>+</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>12</td>
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</tr>
<tr>
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<td>16</td>
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<td>7</td>
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<tr>
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<td>5</td>
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<td>+</td>
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<td>6</td>
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<tr>
<td>Fish</td>
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<td>13</td>
<td>1</td>
<td>+</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Meat</td>
<td>2</td>
<td>11</td>
<td>1</td>
<td>5</td>
<td>+</td>
<td>1</td>
<td>5</td>
<td>10</td>
<td>0</td>
<td></td>
</tr>
<tr>
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<td>44</td>
<td>4</td>
<td>21</td>
<td>17</td>
<td>31</td>
<td>20</td>
<td>21</td>
<td>+</td>
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</tr>
<tr>
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<td>6</td>
<td>30</td>
<td>31</td>
<td>0</td>
<td>11</td>
<td>16</td>
<td>23</td>
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<tr>
<td>Wild spinach</td>
<td>1</td>
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<td>19</td>
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<tr>
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<td>17</td>
<td>1</td>
<td>4</td>
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</tr>
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<td>4</td>
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<td>5</td>
<td>7</td>
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<td>15</td>
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<tr>
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<td>23</td>
<td>35</td>
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<td>40</td>
<td>23</td>
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</tr>
<tr>
<td>Wild spinach</td>
<td>+</td>
<td>+</td>
<td>4</td>
<td>4</td>
<td>55</td>
<td>+</td>
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<td>+</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fish</td>
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<td>27</td>
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<td>4</td>
<td>11</td>
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<td>14</td>
<td>12</td>
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<td></td>
<td></td>
</tr>
<tr>
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<td>5</td>
<td>26</td>
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<td>6</td>
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<td>3</td>
<td>15</td>
<td>12</td>
<td>7</td>
<td>9</td>
<td>10</td>
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<td>65</td>
<td>56</td>
<td>0</td>
<td>22</td>
<td>35</td>
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<tr>
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<td>23</td>
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</tr>
<tr>
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<td>22</td>
<td>3</td>
<td>11</td>
<td>7</td>
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<td>16</td>
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</tr>
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<td>29</td>
<td>31</td>
<td>41</td>
<td>+</td>
<td>56</td>
<td>21</td>
<td>15</td>
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</tr>
<tr>
<td>Plantains</td>
<td>7</td>
<td>3</td>
<td>3</td>
<td>5</td>
<td>9</td>
<td>6</td>
<td>8</td>
<td>7</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td>Meat</td>
<td>4</td>
<td>19</td>
<td>2</td>
<td>11</td>
<td>+</td>
<td>4</td>
<td>13</td>
<td>19</td>
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<td></td>
</tr>
<tr>
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<td>1</td>
<td>2</td>
<td>17</td>
<td>+</td>
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<td>8</td>
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</tr>
</tbody>
</table>

See remark next page.
The word "requirement" as being equivalent to the American term "recommendation". Even in the light of this fact, the low requirement coverage of vitamin A in Maranzara and Chakihani seems frightening. As our food investigations on the coast coincided with the dry period, the population had no wild spinach to eat. We found out that at other times of the year, young leaves of the cassava plant are eaten. The vitamin supply would then be better. In all the survey areas the supply of calcium, vitamin A and riboflavin was particularly bad. Niacin and protein were also poorly provided. The requirement for calcium (1 g per person per day) was covered by less than 60% in almost all families, and by less than 30% in about half the families. It is known that the metabolism of calcium is adaptable to lower consumption levels. It can go down as far as 300 mg per person per day (37). But even this low level is not reached by half of the families we investigated.

Table 10. Average Coverage of Requirement of the Various Nutrients and Calories in the Surveyed Areas (Total Intake per Total Requirement X 100)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Bumbuli</td>
<td>81</td>
<td>68</td>
<td>22</td>
<td>106</td>
<td>40</td>
<td>82</td>
<td>40</td>
<td>64</td>
<td>91</td>
</tr>
<tr>
<td>Mubungui</td>
<td>63</td>
<td>60</td>
<td>33</td>
<td>111</td>
<td>38</td>
<td>.</td>
<td>.</td>
<td>58</td>
<td>141</td>
</tr>
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<td>Soni</td>
<td>91</td>
<td>60</td>
<td>36</td>
<td>126</td>
<td>42</td>
<td>91</td>
<td>49</td>
<td>68</td>
<td>179</td>
</tr>
<tr>
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<td>77</td>
<td>30</td>
<td>140</td>
<td>6</td>
<td>90</td>
<td>42</td>
<td>64</td>
<td>125</td>
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<tr>
<td>Chakihani</td>
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<td>64</td>
<td>28</td>
<td>100</td>
<td>4</td>
<td>66</td>
<td>32</td>
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<td>76</td>
</tr>
<tr>
<td>Upare</td>
<td>64</td>
<td>87</td>
<td>27</td>
<td>139</td>
<td>58</td>
<td>93</td>
<td>47</td>
<td>67</td>
<td>126</td>
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<tr>
<td>Leguruksi</td>
<td>73</td>
<td>86</td>
<td>45</td>
<td>140</td>
<td>36</td>
<td>124</td>
<td>69</td>
<td>62</td>
<td>60</td>
</tr>
</tbody>
</table>

The strikingly low consumption of calories is accounted for by an excessive estimate of the calorie requirements (see page 204).

Note: The calculation of the B₁ and B₂ requirements has, by technical error, been omitted.

According to the anthropometric measurements and the clinical examinations which have already been described, the provision of protein is one of the most severe problems. 15 to 50% of the families consumed less than 60% of their requirements. Less than half of the families covers their protein requirement by more than 90%. Although vitamins and minerals have a wide range between the optimal intake and one that is still sufficient, no such range exists for protein. An intake of only 60% must lead in the long run to nutritional damage. The supply of calories is not much less than the requirement which is on the average covered by 95%. It is also possible to save calories by diminishing the amount of physical work. Consequently, an insufficient supply of calories is more an economic problem than a food problem. The average relation of protein to calorie requirement coverage varies characteristically from village to village. In the two coastal villages with their high
consumption of cassava, the calorie coverage is easily higher. In Bumbuli, the relation is 1, in Upare about 1, whereas only in Leguruki does the protein requirement coverage exceed that for calories. Only the supply of iron in the examined people could be called sufficient. Nevertheless a higher iron intake might be needed to counteract the loss of blood in victims infected with parasites.

3. Conclusions

We must practice care in drawing conclusions from our experiences. The material gathered is indeed too small to make generally valid assertions. The surprisingly few cases of kwashiorkor amongst small children is confirmed by statistics of patients in the Bumbuli Hospital. This may be traced back to the fact that, in contrast to other areas (e.g. Uganda), in the villages we investigated either maize was the basic food (and maize is relatively rich in protein compared to cassava and bananas), or other high-value proteins were available whereas cassava or bananas form the staple diet (fish on the coast, milk in Leguruki). The main results of under-nourishment were muscle wasting and a uniformly retarded rate of growth. Whereas muscle wasting is characterised by a considerable under-weight for the body length, we mean by "uniformly retarded growth" the uniformly delayed increase in both length and weight. Our investigations comply with numerous others that the main problem is the feeding of children aged 6 months to 5 years. The satisfactory development of the children in the first 3 months is due to the mother's breast feeding. When breast feeding becomes insufficient under-nourishment begins. Small children were more undernourished than the other members of the family, because they were dependent upon their parents who did not always know the best methods of feeding them, nor did they know the proper nutrients small children must have. When the mother's milk (usually given up to the end of the second year) was no longer sufficient, then the children received a thin gruel of maize flour. This was neither of sufficient value nor of sufficient quantity. In many cases it did not conform to a minimum standard of hygiene. If the child refused this food, then many mothers thought the child was not hungry and made no extra effort to give it more nourishment. The result was that the children have an average weight of only 9.2 kg at the age of 2 as compared with the Harvard-Standard of 12.4 kg. According to the classification of Gomez, this represents the borderline between first and second grade under-nourishment. Not until the children grew older and were in a position to be sure of their share of the family's food, did the maximal condition go over to "uniformly retarded growth". In most cases the children did

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9 For a discussion on this retarded growth (nutritional dwarfing) see (38, 39).