

## Original Articles

## A STUDY OF VITAMIN-A DEFICIENCY IN CEYLON WITH SPECIAL REFERENCE TO THE STATISTICAL INCIDENCE OF PHRYNODERMA AND 'SORE MOUTH'

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THE principal aim in life of the poorer classes of Asia appears to be the production of a family; they multiply to an extent that is only limited by the available food supply; and the spectre of starvation is never far away. Their diets consist of some staple comestible, such as rice, and vegetables; and these may or may not be augmented by a small quantity of dried or fresh fish, and on rare occasions by curds or meat. The fat-soluble vitamins are present in quantities in the more expensive comestibles of animal origin, such as eggs, milk, butter and liver, which these indigent people cannot afford; vitamin A also occurs in green leaves and certain vegetables procurable in quantity only in season.

Therefore it might be expected that signs of the deficiencies of the fat-soluble vitamins should be rife among them, especially in those parts where the dry season spreads over many months each year, when fresh vegetables become unprocurable.

Dr. L. J. Harris (1933) states:—'Recent official reports show that no less than 80 to 90 per cent of the elementary school population of London gave evidence to having had to some degree rickets, notwithstanding the decreasing severity of the disease as now met with'.

The diet of these London school children is incomparably better than that of the majority of the children of the masses of Asia, where 10 cents (2 pence) a day is a reasonable estimate of the cost to the parents of bringing up a child. Yet over 5,000 school children in Ceylon have been inspected recently, and the bone changes of rickets were found in only one of them. Rickets occasionally occurs in Ceylonese children soon after they are weaned, and usually each case has followed some illness which has caused the child to be confined for a long time in a dark dwelling; and the common termination is not recovery, but death.

Although the fat-soluble vitamins are deficient in the diets of the poorer classes of Ceylon, fortunately for the children vitamin D, a lack of which causes rickets, can be elaborated in the body by exposure to the sun, and those of school age must obtain an ample supply in this way. But vitamin A is another matter; it must be supplied ready formed, or

as the provitamin, carotene, in the food. Hawk and Bergeim (1931) sum up the effects of vitamin-A deficiency as 'due to a generalized disturbance of the metabolism of epithelial tissue'.

When albino rats are supplied with a diet lacking vitamin A, but sufficient in other respects, the principal changes that take place in them may be summarized as:—

(a) Eyes—The outer layers of the cornea undergo necrosis.

(b) Alimentary canal—The cells of the salivary glands degenerate, the epithelium of the ducts proliferates and the lumen becomes partly occluded. The mucous-secreting cells of the intestines are atrophied and the tips of the villi are necrosed.

(c) The upper respiratory tract, particularly the nasal passages, the trachea, and bronchi, shows transformation of the lining epithelium into a stratified epithelium of flattened cells, which undergo keratinization.

Therefore the signs of vitamin-A deficiency in man should be sought by an examination of the epithelial tissues.

In a recent paper (1933) I have described a skin eruption, which is prevalent among the prisoners in the jails of Ceylon. The eruption is frequently accompanied by keratomalacia, nerve symptoms, and a decreased resistance to dysentery; and evidence was brought forward to show that it is due to vitamin-A deficiency. I proposed the name phrynoderma (toad skin) for this condition. When the prisoners were being inspected for phrynoderma many of them complained of soreness of their mouths; but at that time these complaints were ignored, and the importance of this mouth symptom was not recognized. More recently a large number of children in schools and adults in jails, asylums, a factory and hospitals have been inspected; and evidence has been forthcoming that not only phrynoderma but also 'sore mouth' is a sign of vitamin-A deficiency; and although there are other results of this deficiency, such as keratomalacia, nerve symptoms and a lowered resistance to infections, these two are the most frequent signs, and a statistical examination for them among the various sections and classes in a community will show the relative degrees of this deficiency.

It is necessary when collecting statistics of the incidence of such symptoms to work to fairly definite standards, so that one observer should obtain results that are comparable to those obtained by another observer.

## STANDARDS OF EXAMINATION

*Phrynoderma*.—This is a papular skin eruption, due to the blocking of the ducts and enlargement of the sebaceous glands. (It is comparable with the changes which take place in the salivary glands of rats which have been fed on a diet lacking vitamin A). This eruption is sometimes accompanied by a dryness and scaldiness of the skin.

The eruption occurs most commonly on the extensor surfaces of the arms and legs (*vide* plate III, figs. 1, 2, 3, 4 and 5); it may occur on any part of the body, but it is not common on the face, neck, hands and feet.

The eruption ranges from a just-perceptible enlargement of the sebaceous glands on the extensor surfaces of the arms to marked enlargement of these glands over the greater part of the body.

The following standards have been adopted :

(1) There must be perceptible enlargement of the glands on the extensor surface of one or both arms. This situation is adopted for these reasons:

(a) The enlargement of the glands on other parts of the body without enlargement of the glands on the extensor surfaces of the arms occurs among Ceylonese in only about 2 per cent of cases, and this will not materially affect the statistics of prevalence.

(b) It is the easiest situation of the body to examine in persons wearing clothes.

(c) The examination of the legs, etc., of women and girls must be avoided.

(2) The enlarged glands must be palpable.

(3) When the glands over and for three inches below the olecranon process show slight and uniform enlargement, and there is no enlargement of the glands of the arm above and below this situation, the case is recorded as negative. But when these glands over and for three inches below the olecranon process show slight uniform enlargement, and more than two of them show marked enlargement such as is shown by the glands in figure 3 of plate III the case is recorded as positive.

'Sore mouth'.—The standard adopted has been patches of superficial erosion of the mucous membrane of the tongue or lower lip, or its later stages, when the tongue becomes red and glazed. These patches are red and are in marked contrast to the unaffected parts of the tongue which show the whitish *duvet* of the slight normal fur. Some children with sore mouths have excoriation and ulceration of the angles of the mouth, as shown in plate IV, fig. 8. But when they have this condition without signs of erosion of the mucous membrane of the tongue or lower lip they are considered negative.

These standards for phrynoderma and sore mouth may be somewhat arbitrary, but without such standards many doubtful cases would be included in the statistics.

#### THE INCIDENCE OF PHRYNODERMA AND 'SORE MOUTH'

*Schools.*—There are several hundred schools and colleges in Ceylon and these may be divided into three classes :—

(a) Vernacular schools, where free education in the vernacular language is given to the poorest classes.

(b) English schools, where small fees are charged for an education in English and the vernacular languages; the children of these schools may be considered to belong to the middle class.

(c) College schools, where the standard of education is much the same as in the best class schools in England. The children of the upper class Ceylonese attend these schools.

Table I shows the incidence of phrynoderma in schools :—

TABLE I

	Number of children examined	Number positive for phrynoderma	Percentage positive
Colombo vernacular schools.	1,164	335	28.7
Vernacular schools along south-west coast road.	2,628	768	29.2
Deaf and blind school.	307	71	23.1
English schools along south-west coast road.	219	39	17.7
Colombo English schools.	353	55	15.5
Colombo college school boarders.	136	4	2.8
Youths in industrial department of the deaf and blind school.	26	0	..
A charity boarding school for destitute children.	47	39	83.0

After the importance of 'sore mouth' had been recognized all children were inspected for phrynoderma and sore mouth.

Table II shows the incidence of sore mouth in the schools :—

TABLE II

	Number of children examined	Number positive for sore mouth	Percentage positive
Colombo vernacular schools.	831	80	9.6
Vernacular schools along south-west coast road.	2,628	204	7.7
English schools along south-west coast road.	219	12	5.5
Colombo English schools.	353	30	8.4
Colombo college school boarders	136	0	..
A charity boarding school for destitute children.	47	13	29.2

*The workmen in an engineering factory.*—The workers in the factory in question were all men. Owing to the depression they were working for three days a week only, and the

PLATE III



Fig. 1.

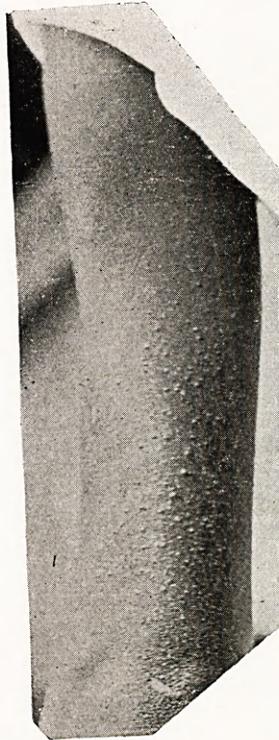


Fig. 2.



Fig. 3.

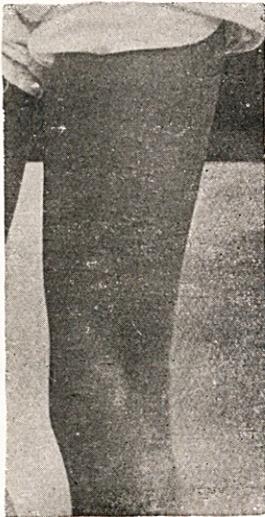


Fig. 4.



Fig. 5.

PLATE IV



Fig. 6.

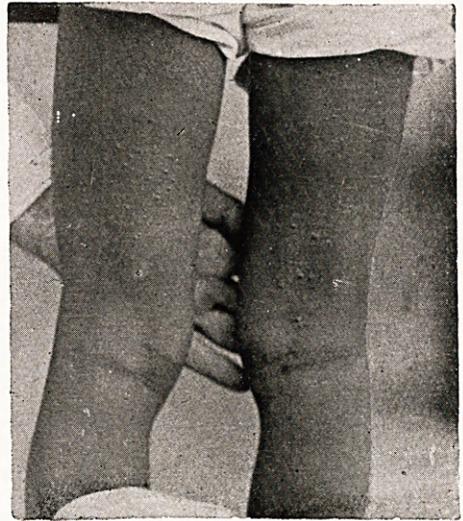


Fig. 7.

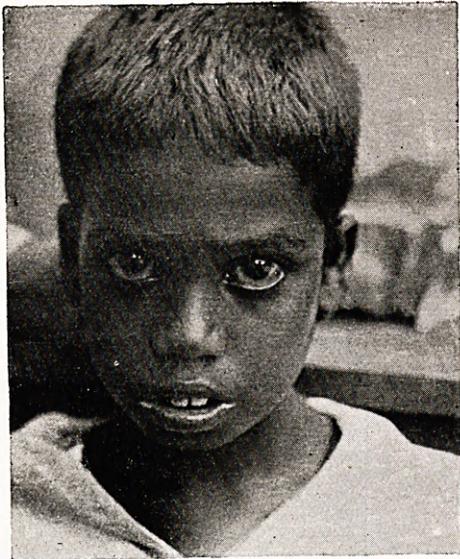


Fig. 8.

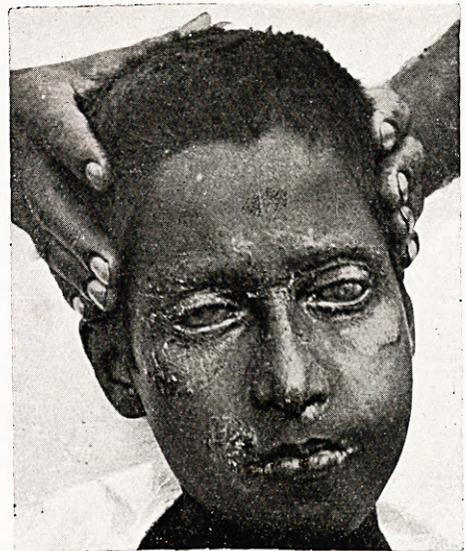


Fig. 9.

average pay of each man was Re. 1.50 a day. Table III shows the result of the inspection :—

TABLE III

	Number inspected	Number positive for phryno-derma
Men working in the foundry	23	0
Men working in the black-smith shop.	31	1 (slight)
Men working in the machine shop.	40	1 (marked) 1 (slight)
Men working in the bridge shop.	67	0
Men working in the carpenter's shop.	31	1 (slight)
Men working in the boiler house.	3	0
	195	4

This gives a sufficiently accurate normal standard for comparison with other groups of adults.

*Patients in a mental asylum.*—A very interesting state of affairs was found at a mental asylum. The medical superintendent lined up for inspection 132 Ceylonese patients on Ceylonese diet, and in the same court-yard lined up 48 Ceylonese patients on European diet so called. Then 100 women on Ceylonese diet and 33 on European diet were inspected.

Table IV shows the results :—

TABLE IV

	Number examined	Number positive for phryno-derma	Percentage
Men on Ceylonese diet.	132	58	43.8
Men on European diet.	48	1	2.0
Women on Ceylonese diet.	100	44	44.0
Women on European diet.	33	1 (a recent admission)	..

The contrast between the skins of those on these two classes of diet was very striking and a biological experiment could scarcely have been better arranged.

These diets will be discussed later in this paper.

The male section of the asylum is somewhat overcrowded but the female section is not.

*Patients in a leper asylum.*—Two hundred and thirty-four male patients were examined in a leper asylum, and only one patient was markedly positive for phryno-derma, and the appearance of it suggested that the eruption

was clearing up. He had nerve leprosy, and his history was that he had been in the leper asylum for 5 months and was discharged; he returned after 1½ years; during this time he was poverty-stricken; he had been in for 3 weeks since readmission. Three patients who had been in for 4 months or less showed slight signs. But one patient who had been in for 4 years showed slight signs.

The leper asylum is overcrowded, there are 505 beds and 678 patients, so that 173 patients must sleep on mats where they can find room to place them. This overcrowding was very marked in a temporary building which has a *kadjan* roof and a cow-dung floor. There were 67 patients in this building but none had signs of phryno-derma. This indicates that overcrowding does not affect the incidence of this eruption.

*A tuberculosis sanatorium.*—Only five cases of phryno-derma have been discovered among over a hundred patients, who had been in various hospitals for a month or more, and were receiving presumably a diet adequate in vitamin A. Three of these patients were suffering from advanced abdominal tuberculosis.

(The fourth case was of a woman where the diagnosis was neuritis. Her history indicated that she had had advanced phryno-derma and neuritis and had nearly died. The fifth case was of a deaf, dumb and blind cripple who had been in hospital for 11 years; he was in a state of extreme infantilism, probably of the Lorain type, in which the pituitary gland has failed to develop. This is interesting because of the possible interrelation between hormones and vitamins.)

The existence of phryno-derma in the tuberculous patients suggested that the increased metabolism of the body to tuberculosis might call for a greater supply of vitamins than are necessary for a healthy person. This would make the treatment of tuberculosis patients with large doses of cod-liver oil less empirical than heretofore. Therefore a tuberculosis sanatorium was inspected, and table V shows the results :—

TABLE V

	Number examined	Number positive for phryno-derma
Men .. .. .	102	6
Women .. .. .	75	5

Five of the six men, who had phryno-derma, had been in the sanatorium for less than one month, and none of the six had received cod-liver oil.

Four of the five women, who had phryno-derma, had been admitted during the previous

fortnight and the fifth had been in for two months; none of them had received cod-liver oil.

The diet of the patients includes milk and butter, and, because phrynoderma occurs among those recently admitted and is almost absent among the older residents, it is concluded that the diet is adequate in vitamin A.

*Jails.*—In a previous paper (Nicholls, 1933) it was recorded that the prisoners, who had been imprisoned in a certain jail for one month or less, were relatively free from phrynoderma; that this skin condition was very prevalent among those who had been in for periods up to 1½ years; and that there was a small lessening of this prevalence among the residents who had been in jail for more than 1½ years. Since that paper was written many more prisoners in other jails have been inspected with very similar results. The prisoners can be divided into two categories for the purpose of a brief table in this paper:—

Category I, those who have been in prison for one month or less.

Category II, those who have been in prison for more than one month.

TABLE VI

	Number examined	Number positive for phrynoderma	Percentage positive
Category I ..	420	44	10.4
Category II ..	928	508	54.7

I have inspected for sore mouth the prisoners of only one jail—the Southern Province Jail, which has a reputation of being a healthy jail; it is exceptional in that only local prisoners that have been sentenced to six months or less are retained; and as most of them earn remissions from their sentences, only six of them had been in for more than five months.

Table VII gives the results of the inspection:—

TABLE VII

	Number examined	Number positive for phrynoderma	Per cent positive for phrynoderma	Number positive for sore mouth	Per cent positive for sore mouth
Ramnad Jail.	50	5	10	1	..
2 weeks or under.	54	6	11.1		
2 weeks to one month.	33	5	15.1		
Over one month.	58	21	36.2	12	20.6

The increase in prevalence of phrynoderma in these prisoners after they have been in for more than one month, although less, is similar to that for other jails in Ceylon. And sore mouth which is almost absent among the new arrivals becomes prevalent among the old residents. There were two cases of keratomalacia among the prisoners who had been in for more than one month.

The Quarry Jail is 80 miles distant from the Southern Province Jail, and had been inspected before the importance of 'sore mouth' was realized. I was accompanied on the day of my inspection by Dr. G. W. Bartholomeusz, the medical officer of the jail. Two hundred prisoners were examined and the incidence of phrynoderma was 38.5 per cent.

Some time after this inspection I wrote to Dr. Bartholomeusz asking him to make a survey of the prison for phrynoderma, neuritis, keratomalacia, diarrhoea or dysentery, and 'sore mouth'. I had not discussed standards with him and therefore his investigation was independent, apart from the fact that I had shown him a number of cases of phrynoderma.

He has supplied me with tabulated details of each prisoner with phrynoderma; these are summarized as follows:—

He found that 231 prisoners out of a total of 923 in the jail had phrynoderma. This is a percentage of 25.0; which is lower than the percentage in my determinations among a smaller number of these prisoners. It may be that he included only the more marked cases.

The other signs of vitamin deficiency among these prisoners he found as follows:—

TABLE VIII

	Number	Percentage
Neuritis .. ..	19	8.2
Keratomalacia .. ..	22	9.5
Diarrhoea or dysentery since imprisonment.	62	26.8
'Sore mouth' .. ..	103	44.5

Dr. Bartholomeusz states that the diagnosis of 'sore mouth' was founded on 'glazed raw red tongues in varying degrees'.

The name of each prisoner and the time he had been in jail is stated in his tables and from this the prisoners may be divided into two categories:—

Category I, those who have been in for one month and less than 6 months.

Category II, those who have been in for more than 6 months.

The results are shown in table IX:—

TABLE IX

	Number of prisoners with phrynoderma	Number of prisoners with sore mouth and phrynoderma	Percentage
* Category I ..	80	23	26.2
Category II ..	150	80	53.6

\* One prisoner is excluded as he had been in prison for a few days only.

This shows that 'sore mouth' is twice as prevalent among the prisoners that had been in jail for more than six months.

Dr. Bartholomeusz did not investigate the incidence of sore mouth among all the prisoners, but confirmed his attention to those with phrynoderma. There were 37 cases of phrynoderma and 13 cases of sore mouth in the Southern Province Jail (*vide* table VII); but three prisoners with sore mouth did not show signs of phrynoderma. Therefore 10 cases out of 37, which would fall into category I of table IX, give a percentage of 27, which is nearly the same as 26.2 of table IX. Perhaps such closely approximate results were hardly to be expected from two observers examining prisoners in jails over 80 miles apart, but the figures for the Southern Province Jail are small.

Dr. Subramaniam, the medical officer of another jail, was asked to investigate the number of prisoners with marked signs of sore mouth and to give the date of admission and the duration of the sore mouth in each case.

He has forwarded these records for 47 prisoners, and table X gives the analysis of these:—

TABLE X

Those who had sore mouth on admission	4
Those who acquired it within three months of admission.	0
Those who acquired it between 3rd and 6th month after admission.	10
Those who acquired it more than 6 months after admission.	33
	—
	47

There were 616 prisoners in the jail at the time of inspection and 126 had been in for less than 3 months.

THE RELATIVE INCIDENCES BETWEEN PHRYNODERMA AND 'SORE MOUTH'

Table I shows that the incidence of phrynoderma is greater in the schools of the poorest classes than in the schools for the better classes. Table II shows that the incidence of sore mouth is similar in this respect; but the two

conditions do not follow one another in uniform curves; for instance the incidence of phrynoderma is greater and the incidence of sore mouth is less in the Colombo English schools than in the schools along the south-west coast road.

The following tables summarize the results for all the children who have been examined for phrynoderma and 'sore mouth':—

TABLE XI

		Percentage of total
Number examined ..	4,380	..
Negative for phrynoderma ..	3,205	73.1
Positive for phrynoderma ..	1,175	26.8
Positive for phrynoderma and negative for sore mouth.	830	18.9
Positive for phrynoderma and positive for sore mouth.	345	7.7
Negative for phrynoderma and positive for sore mouth.	89	2.1

TABLE XII

	Percentage
The incidence of sore mouth among those with phrynoderma.	29.3
The incidence of phrynoderma among those with sore mouth.	79.4
The percentage absence of phrynoderma among those with sore mouth.	20.5

Table XII shows that the incidence of sore mouth among children with phrynoderma is 29.3 per cent, which is in close agreement with the percentages 27 and 26.2 found among the prisoners of two jails.

If there was no aetiological relationship between phrynoderma and sore mouth, the incidence of phrynoderma among children with sore mouth would be the same as for all the children in the schools, namely 26.8, and not 79.4 as is shown in table XII.

As previously stated there were thirteen prisoners in the Southern Province Jail who had sore mouth and ten of these had phrynoderma, giving a percentage of 81.2, which is in close agreement with the 79.4 percentage for the school children.

DIETS IN CEYLON

Condiments are much used by all classes of Ceylonese; when a preparation of condiments is liquid it is called a curry, and when it is more-or-less solid it is called a sambol.

There is a subtle acidity and pungency in the smell of these preparations, which will cause a flow of saliva and an increase in appetite even in those who seldom partake of them. The use of condiments has been developed for the purposes of dispelling among the poorest classes the anorexia which arises from a deficient food supply; or to stimulate the surfeited appetites of the gourmets among the wealthy.

The following are some of the condiments used in curry making in Ceylon:—

Coriander, anise, dill fruit, pepper, mustard, chillies, saffron, various aromatic leaves, tamarind, cinnamon, onions, garlic, vinegar, cloves, cardamoms and nutmegs. A selection of these are boiled with salt in coconut milk in making the best curries, but the poor must often be content with a watery concoction of chillies, salt, onions and lime juice. All curries and sambols contain lime juice or tamarind.

A knowledge of the diets of the poorer classes is not easily obtained, because they are apt to resent a close inquiry into their intimate affairs; and some will plead poverty, and represent their diet worse than they are, while others will exaggerate the quality of theirs.

Mr. Richard de Silva of this laboratory made an enquiry into the dietary of over 100 children in a vernacular school. They were supplied with writing material and sent home to work out with their parents the composition of every meal that they had had for the past seven days. When these papers were collected and examined it was found that the children had had the usual three meals a day and had mentioned 83 comestibles\*. The names of the comestibles may be placed into groups, for instance:— the children mentioned five varieties of hoppers, six varieties of dried fish, and numerous kinds of vegetables most of which fall into one of three groups:—

(1) Watery vegetables, such as snake gourds and cucumbers.

(2) Leaf vegetables of which the leaves only are eaten.

(3) Other vegetables such as plantains and yams.

And thus it was found that their diets consisted of rice, dried fish and small amounts of vegetables daily.

This enquiry was made in September, and had it been made at another season of the year the names of other foods would probably have preponderated in the lists, for instance if bread fruit and jak fruit had been in season, the names of these would have appeared in all the lists.

Two children had received meat at one meal only. No one had had butter or ghee, and only two had had milk. A few of them had tomatoes or sweet potatoes at one or two meals during the week.

The children partake of three meals a day. These are of the following nature:—

(1) *Early-morning meal.* This consists of either cold boiled rice or hoppers eaten with a small quantity of sambol. The commonest kind of hopper is made by kneading ground rice with coconut milk, and roasting it on a hot plate, when its shape resembles that of a thick pancake.

The commonest sambol is made by grinding chillies, salt, onions and a fragment of Maldivian fish between stones, and adding lime juice to the ground mass.

(2) *The midday meal* consists of boiled rice and a little curried dried fish or vegetables.

(3) *The evening meal* is made from what is left over from the midday meal.

The children only occasionally receive such vegetables as tomatoes, which are fairly rich in vitamin A.

Many tropical vegetables have not been biologically assayed for the vitamin-A content, but by analogy they may be placed in the same categories with other vegetables, which have been assayed.

G. S. Fraps and Ray Treichler (1933) have published lists giving the Sherman-Munsell rat units for vitamin A in each ounce of various foods.

I have adopted these units in an attempt to estimate the amount of vitamin A in the diets of children and others. When the vitamin-A content of a vegetable is unknown I have assigned to it a much higher number of units than it probably contains. For instance a snake gourd resembles a cucumber in appearance, and gives a very similar analysis (*vide* table XIII); the vitamin-A units in cucumber have been determined as 10 per ounce, but I have allowed 70, which is the same as for pumpkin. The water pumpkin of Ceylon resembles water melon of which the vitamin-A content has been determined as 28, but 70 units per ounce have been allowed. All green leaves have been assigned 410 units, making them of much the same value as spinach of which the vitamin-A content has been determined as 402; and this is the maximum for green leaves which have been assayed, with the possible exception of lettuces.

Manioc and yams are assigned the same value as sweet potatoes.

Table XIII gives the analysis of some of these vegetables and in the penultimate column is shown the vitamin-A units of those vegetables which have been assayed, and in the last column are shown the units per ounce which have been allowed in the calculations of the vitamin-A content in the diets of children, prisoners and others.

It follows that the actual amounts of vitamin A in the diets are probably much lower than the estimated amounts.

Forty-one women were supplied with vegetables and requested to separate those quantities from each of them which they considered would be ample for the daily needs of a child aged 12. These 41 quantities of each vegetable were weighed; the weights varied from 1 ounce to 2½ ounces for green leaf vegetables, and the average was 2 ounces. Similarly for other vegetables such as snake gourd and plantains the average weight was 3 ounces approximately.

These quantities have been used for estimating the number of units of vitamin A in the children's diets. The rice consumed by these children was imported polished rice, which contains little, if any, vitamin A. A small

\* Tables of the diets of the children and prisoners (*vi.*) have been deleted from this paper to economize space.

TABLE XIII

Showing relative composition and vitamin units per ounce of certain vegetables

Vegetable	Water	Protein	Oil	Carbo- hydrate	Fibre	Ash	Vitamin-A units determined	Vitamin-A units allowed
Cucumber	95.4	0.87	0.16	7.87	0.71	0.40	10	10
Snake gourd	94.6	0.63	0.13	4.25	0.13	0.28	..	70
Pumpkin	89.0	1.7	0.7	6.60	1.7	0.60	70	70
Spinach	90.6	2.5	0.5	3.8	0.9	1.7	402	410
Tampala (leaf).	81.4	4.5	0.57	8.4	2.0	3.16	..	410
Kankun (leaf).	89.7	4.25	0.04	3.64	0.7	1.67	..	410
Sweet potatoes.	71.1	1.5	0.4	24.7	1.3	1.0	85	90
Manioc	74.2	1.10	0.18	22.9	1.15	0.52	..	90
Yams	63.7	2.86	0.05	27.31	1.03	1.45	..	90

amount may be present in dried fish and condiments but not enough to affect these estimates materially.

Fraps and Treichler (1933) estimate that 1,000 units per day per person are required by man, woman or child and state:—'This may not be ample for the highest health and vigour, but should be sufficient for growth and maintenance'.

Only one of the children received 1,000 units or more, the daily average was 312 units.

*Prison diets.*—The kind and quantity of the comestibles in these diets are laid down by law and may not be varied except for prisoners in hospital. There is a penal diet and each prisoner receives boiled polished rice and 4 ounces of a vegetable daily for the first fortnight of imprisonment; during the second fortnight he receives only 2 ounces of a vegetable, but there is added to the diet 2 ounces of plantain and 2 ounces of *dâl*. Thereafter for a year he receives daily the following diet:

	Ounces
Bread	.. .. 4
Rice	.. .. 18
Lean fish	.. .. 2½
Plantain	.. .. 2
One vegetable	.. .. 2
<i>Dâl</i>	.. .. 2
Sugar	.. .. ½
Coconut	.. .. ½
Lime (juice)	.. .. ½ (a lime)
Onions	.. .. ½
Chillies, pepper and salt	.. q.s.

The records of the daily supply of vegetables throughout the year were obtained from the offices of 10 prisons.

The average number of units which have been received in the vegetables daily by the prisoners in the various jails is 162. When 120 units for 2 ounces of plantain, 140 units for 2 ounces of *dâl*, and 100 units for the bread are added, each prisoner received daily 522 units.

*The diet of the patients in the mental asylum.*

—The Ceylonese diet of the patients is somewhat better than the diets of the prisoners, but not greatly so, as can be shown by the fact that the cost of the daily diet for each patient is only 2½ cents (½ penny) more than the average for each prisoner in the various jails. The 'European' diet costs 10½ cents more than the 'Ceylonese' diet; and the difference in the two diets can be summed up as follows:—

	European diet	Ceylonese diet
Bread	.. .. 12 ozs.	8 ozs.
Rice	.. .. 6 "	16 "
Eggs	.. .. 2 "	nil.
Milk	.. .. 5 ozs.	nil.

An estimate similar to that made for the prison diets shows that the patients on Ceylonese diet should receive about 620 units of vitamin A daily.

The contents of Ceylon eggs weigh about 1½ ounces. The units in eggs have been shown by assay to be 550 per ounce at the beginning of the laying season and to fall to 170 per ounce at the end of the season. Therefore a conservative estimate of 200 per ounce may be allowed, which is 600 units for two eggs. An equally conservative estimate for milk is 40 units an ounce, which is 200 units for 5 ounces.

Therefore the patients on European diet receive at least 1,400 units daily.

If this is considered with the facts shown in table IV, it follows that the addition of 2 eggs and 5 ounces of milk to a diet is sufficient to prevent phrynoderma.

*The diets of the leper asylum and tuberculosis institute.*—The diets in these institutions are even more generous than the European diet at the mental asylum; therefore it is not surprising that the older residents are free from phrynoderma.

*Diet at the deaf and blind school.*—Table I shows that phrynoderma occurred in 23.1 per cent of the children in this school, and that it was not found among 26 youths in the industrial section. The details of the diets have not been obtained, but they have been stated shortly to be as follows:—

		Children	Youths in the industrial section
Rice .. ..	..	A sufficiency	A sufficiency
Vegetable curry .. ..	..	3 ozs.	6 ozs.
Dal, meat or fish curry .. ..	..	3 "	..
Meat curry .. ..	..	..	4 ozs.
Fish curry .. ..	..	..	4 "
Total curries .. ..	..	6 ozs. daily	14 ozs. daily

It follows that the youths probably obtain at least twice as much vitamin A as the children.

*Diets of college boarders.*—It is sufficient to state that the cost of the diet of the college boarders referred to in tables I and II is three times the cost of the diet of the children in the deaf and blind school.

*The diets of a charity boarding school for destitute children.*—There is shown in tables I and II a high incidence of phrynoderma and sore mouth in a charity school. Direct and indirect inquiries suggested that the feeding of these destitute children was very bad; but unfortunately actual details could not be obtained. It appeared possible that the children had not recovered from a destitution previous to admission, but this was not so, because there were only eight children among the 47 boarders who were more or less free from phrynoderma, and seven of these had been in the school for less than one month, and the other had been in for two months. And the degree of phrynoderma or sore mouth more or less varied with the length of time that the children had been in the school.

There were in the school 17 children who attended the classes, but lived at home. Four of these had phrynoderma, this gives much the same percentage of prevalence as occurs in other schools in the neighbourhood; but their condition was markedly better than that of the boarders.

This may be a good example of the value of the inspection of school children for phrynoderma and 'sore mouth' as a criterion of the sufficiency of their diets.

*Advanced cases of phrynoderma in children.*—Four young patients have been seen recently in whom blindness had occurred. One was a child, age 4 years, the right eye was staphylococcal and the left showed opacities from healing corneal ulceration. The child had been unable to walk and at the time of examination

was walking with difficulty, the muscles were wasted, and the feebleness and awkwardness of the arms and legs suggested neuritis. The child had extensive phrynoderma. Two other cases were very similar to this, and both had phrynoderma.

The most advanced case seen was of a boy (age 16) in hospital; his signs and symptoms were:—

(a) General emaciation, but not particularly noticeable in the face.

(b) General phrynoderma of the whole body except the hands, feet and face.

(c) A superficial dermatitis around the eyes and mouth with peeling of the skin (*vide* plate IV, fig. 9).

(d) Right eye—keratomalacia, slight sight. Left eye—commencing staphyloma, blind.

(e) Dermatitis deep seated in auditory meatus. He was very 'hard of hearing'. This deep-seated dermatitis of the ears is not very uncommon in cases of marked phrynoderma.

(f) Neuritis, unable to walk, wrist drop, and absence of knee jerks.

(g) Mental condition—extremely irritable.

(h) There was no erosion of the tongue, but marked erosion of the lower lip.

(i) The temperature had been and was normal.

Advanced cases, in which there are no signs of eye lesions, are fairly common in young indigent children after 6 months of age, that is from about the time when they are weaned; the symptoms are:—extreme emaciation, phrynoderma, sore mouth (in about 60 per cent) and diarrhoea; weakness and wasting of the muscles of the limbs may indicate neuritis. Pyrexia may or may not be present.

#### THE ÆTIOLGY OF BLINDNESS IN CEYLON

Keratomalacia is common in Ceylon; and xerophthalmia keratomalacia, corneal ulceration and staphyloma appear to be the usual sequence leading to blindness.

The lady superintendent of the deaf and blind school has made extracts of the history sheets of all those under her care, which might throw some light on the causes of the blindness (and deafness).

The statements have been placed into the following categories:—

Category I. Those who are recorded as having been blind from birth or shortly after birth.

Category II. Those who presumably have become blind as a result of keratomalacia. The earliest date of blindness after birth for those in this category is stated as three months. The following are the types of statement which have been accepted for placing children in this category:—

'Results of rickets at 3 years'.

'Blindness through malnutrition'.

'Blind through mandama' (marasmus).

'Debility when 5 years old'.

'Disease when 2 years old'.

Category III. Those who are stated to have been blinded as the result of an accident, cataract, smallpox, etc.

Category IV. The history is too indefinite for the first three categories.

Table XIV is the summary of this analysis:—

the patient may not be able to feed himself. But advanced cases are rare except in those who have chronic dysentery. On one occasion

TABLE XIV

	Boys	Per cent	Girls	Per cent	Total	Per cent
Category I .. ..	17	20.1	11	16.4	28	19.0
Category II .. ..	49	61.2	48	71.6	97	65.9
Category III .. ..	7	8.7	1	1.4	8	5.4
Category IV .. ..	7	8.7	7	10.4	14	9.5
TOTAL .. ..	80	..	67	..	147	..

Therefore it is probable that about two-thirds of the children are blind as the result of keratomalacia following vitamin-A deficiency.

The deafness is another matter. There were 170 deaf and dumb children in the school. And such statements as:—'followed boil on head', 'adenoids and tonsils', 'after pneumonia' suggest that 20 per cent of them had had middle-ear disease. The remaining 80 per cent of the children are reported to have been deaf from birth. The statement by a parent as to the time when a child became blind may be accepted as correct, but deafness is not noticeable as early as blindness.

GENERAL DISCUSSION

The damage to the epithelial structures from vitamin-A deficiency which occurs in experimental animals has its counterpart in man in the form of phrynoderma, 'sore mouth' and keratomalacia.

But the signs and symptoms which follow this deficiency are more variable than those which follow other vitamin deficiencies, such as in scurvy, pellagra or beri-beri.

In Ceylon phrynoderma is the commonest sign, and perhaps it is not astonishing that the sebaceous glands require a fat-soluble vitamin for the elaboration of the oily sebum. 'Sore mouth' is the next in frequency, yet only about 80 per cent of cases of this condition show marked phrynoderma; and patients may have advanced phrynoderma and keratomalacia without 'erosion of the tongue' as in the case of the boy aged 16 mentioned above. Phrynoderma occurs in a high percentage of cases of prisoners with keratomalacia but not in all cases.

The symptom which has been called neuritis in this and a previous paper requires further elucidation as to the nature of the lesion; it may not be a neuritis. In its earliest stages the patient complains of a burning sensation in the palms of the hands and the soles of the feet. This is followed by muscular weakness, later by wasting of the muscles and an atoxic gait, and later still by inability to walk and great weakness in the arms and hands, so that

when the prisoners in a jail hospital were inspected there were 17 patients with chronic dysentery, and all of them had marked signs and symptoms of this 'neuritis'. Morgan (1929) described a condition termed 'burning feet', which is apparently common among indigent Tamil emigrants in Malaya. He treated 19 severe cases in hospital; the diet he gave them was Indian corn, ragi, eggs and mutton. The pain was less in a week and apparently gone in a fortnight. He appears to have attributed some of the improvement to the administration of nitroglycerine. But the hospital diet is the more probable reason of the rapid improvement. Labernadie (1927), in reference to 'burning feet' said that in 1762 it was recorded from Savigliano in Piedmont and in 1806 among troops in Padua; it was called pedionalgia, or chiropodalgia if the hands were also attacked.

The absence of wide recognition of the effects of vitamin-A deficiency in man may be due to the irregularity of the signs and symptoms, and may explain anomalous observations on infections following this deficiency. For instance vitamin A has been called the 'anti-infective' vitamin, and its deficiency in diets has been supposed to increase the liability to epidemic diseases, especially of the respiratory tract. But this has not received universal acceptance.

Damage to the epithelial tissue of the respiratory tract should render a person more liable to bronchitis or pneumonia than a normal person; and it may be that the stresses of a cold climate will determine that the effects of vitamin-A deficiency shall fall first on the respiratory epithelium. Therefore respiratory diseases may follow vitamin-A deficiency under certain climatic conditions.

Similarly a generally poor diet overcharged with stimulating condiments will throw stresses upon the epithelial tissues of the alimentary tract, and there bring out the effects of vitamin-A deficiency and increase the liability to dysentery. The outbreaks of dysentery among the prisoners in the jails of Ceylon are due to infection with Flexner's bacillus following vitamin-A deficiency.

Three post-mortem examinations have been done on adult male prisoners, all of whom had had phrynoderma and dysentery, and two advanced neuritis. There were the usual dysenteric changes in the large intestine, and in two cases the last foot of the ileum was affected.

The livers weighed 30, 31, and 35 ounces, respectively, and had undergone fatty degeneration of moderate degree. The spleens weighed 3, 3½ and 4 ounces, respectively. Two of these subjects were wasted, but the loss of weight of these organs appeared to be out of proportion to the general wasting. The third subject was not wasted, he had had dysentery for one week only. The walls of the small intestine were thinner than normal, and in two cases slight superficial erosion of the epithelium of the mucosa was seen extending from the lower parts of the jejunum to where the ileum had undergone dysenteric changes. This erosion was not marked in the third subject but the villous processes were seen in microscopical sections to have undergone marked atrophy.

*The general health of Ceylon school children.*

—It is difficult during an inspection to gauge the general health of the children. A child may have considerable areas of the skin affected with phrynoderma, and yet appear to be in fair health. Even those with 'sore mouths' do not appear to be greatly affected otherwise. Some of them appear puny and lethargic. Probably those in bad health remain away from school, and this is reflected in the school attendance lists, which show that the number of absentees daily is large. If the effect of vitamin-A deficiency upon the growth of children is to be estimated it must be done by weighing and measuring them.

The high degree of vitamin-D deficiency in London school children may affect the quality of the population but it does not greatly increase the death rate; but the vitamin-A deficiency in Ceylon school children probably does increase the death rate. Table XV shows the death rates per 1,000 in 1931 for England and Ceylon for young persons up to 20 years of age :—

TABLE XV

	England	Ceylon
Under 5 years .. ..	20.0	67.1
5 to 10 years .. ..	2.1	7.8
10 to 15 years .. ..	1.5	3.7
15 to 20 years .. ..	2.5	6.8
All ages .. ..	10.2	22.1

*The dietary in dysentery.*—In *Manson's Tropical Diseases* on page 395, where recommendations are made for a diet in dysentery, there appears the statement:—'The best diet is one consisting of jellies, albumen water,

rice water, chicken conje, beef tea, Brand's essence, arrowroot, sago puddings...'. All of these are more or less deficient in vitamin A. Similar diets are recommended in all textbooks, and doubtless are appropriate for well-fed persons, who contract dysentery. But such diets are not indicated where there is vitamin-A deficiency. Many native doctors, following the systems of the East, have obtained a reputation for the treatment of dysentery; they use fresh extract of green herbs, and some of them augment these by prescribing strange meats such as the liver of the land tortoise. Success in such treatment may be due to the unconscious administration of vitamin A in a form easily assimilated. And in countries where this vitamin is markedly deficient in the diets of the poorer classes, the administration of preparations of leaves might be of value in almost any disease.

*Proprietary foods.*—Many foods reinforced with vitamin D have been placed on the market. These foods are of much value in Europe, especially in towns where the atmosphere is smoke-laden, and the children seldom enjoy sunlight during the winter months. But the food which is indicated for the tropics of the East is one which has been reinforced with vitamin A\*.

*The knowledge of vitamins.*—The acquisition of the knowledge of vitamins started clinically, by scurvy, pellagra, and beri-beri being vaguely attributed to faulty diets. Once animal experiments were initiated the knowledge became more definite. And the science of dietetics could never have been built upon sound foundations without these experiments. But there has developed too great a tendency to apply without modifications the results of deficient diets in animals to the dietary of man.

An example of this is shown in the work of Jansen and Donath (1925) in the Dutch East Indies; when reasoning from experiments on rats these authors concluded that the use of one banana a day will prevent A-avitaminosis in those living upon a rice diet.

The vitamin requirements of one species of animal are not necessarily the same as those of another. For instance albino rats cannot be used in the biological assay for vitamin C, because either this vitamin is synthesized by rats, or they require very small amounts of it.

Laboratory animals lead sedentary and protected lives free from the activities and stresses which wild animals must experience, and this will affect their vitamin requirements. The accessory food factors in a comestible may be determined by animal experiments; but the relative requirements for a caged rat and a hard-working labourer cannot be defined accurately by such experiments. The amount of a vitamin necessary to maintain health varies with the nature of the other components

\* 'and vitamin B' we should add.—EDITOR, I. M. G.

in a diet; and may be more for a diet rich in carbohydrates than for one rich in proteins.

A wide field for inquiry exists in the homes of the destitute, the prisons, the asylums, schools, slums and villages of the East by those who have had experience in the signs and symptoms of food deficiencies. Because experiments, almost equal to those of the biochemist, are occurring fortuitously.

The knowledge of human dietetics will be enhanced by such investigations; and the time will come when the number of units of vitamins necessary to maintain health on various diets will be determined as accurately as in the estimation of the caloric units of other components of a diet.

It is possible that phrynoderma is a common condition in other countries, and doubtless has been described on many occasions without its significance being recognized. Malcolm Morris (1917) appears to refer to it under the term xeroderma. Chalmers Watson (1904) describes xeroderma affecting a boy aged 6; he appears to attribute the disease to malnutrition, and mentions the changes in the sebaceous glands, the boy was cured by inunctions of myelocene and the administration of cod-liver oil.

The condition may have been referred to under such terms as keratosis pilaris, pityriasis pilaris, lichen pilaris, or keratosis suprafollicularis.

Since the work described in this paper was completed there has appeared in the *Archives of Dermatology and Syphilology* a paper by Dr. L. J. A. Loewenthal (1933) wherein he describes a similar dermatosis occurring among the prisoners of the East African jails; he attributes it to a deficiency of vitamin A in the diets. He does not give any definite name to the eruption; but mentions that Dr. A. Pillat described a somewhat similar eruption in 1929.

Therefore it appears that either Dr. Loewenthal or Dr. A. Pillat have priority in attributing this type of dermatosis to vitamin-A deficiency.

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## DYSENTERY PRODUCED BY *BACTERIUM PSEUDO-CAROLINUS*

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BACILLARY dysentery occurs quite commonly in Calcutta. A routine examination of stools in the School of Tropical Medicine, Calcutta, has shown an incidence of bacillary dysentery in 12.5 per cent of the total admission of cases during the year 1933. During the last few years, however, a large number of cases of subacute and chronic type of dysentery admitted to the Carmichael Hospital for Tropical Diseases showed neither the Flexner nor Shiga type of bacilli, but *Bacterium pseudo-carolinus* has been isolated in the stools. To Lieut.-Colonel H. W. Acton, I.M.S., belongs the credit of first observing that the infection with this bacillus produced certain symptoms and that these improved by treatment with auto-genous vaccines.

During the summer of 1933 a large number of patients admitted under the senior author in the Carmichael Hospital showed the presence of this bacillus in stools on culture. As our knowledge regarding its pathogenicity is still vague, and as doubts exist as to whether it is actually responsible for producing any definite train of symptoms, it was considered advisable to study carefully a series of cases in order to see if any definite symptoms were really produced in patients when this organism is present in the stools. Agglutination reactions of the blood in a selected number of cases and the effects of treatment of the infection with vaccines and bacteriophage were studied.

Before describing the results of these observations in a series of cases studied by us, a few words may be said about this bacillus which is not very well known to the profession in this country.

*Bacterium pseudo-carolinus* is a non-lactose-fermenting bacillus occurring in the intestines. It is a non-sporing aerobe and has been referred to by Castellani along with various other similar organisms without any special reference to its position in the standard classification and pathogenicity. From some preliminary work done at the School (Pasricha, 1931) there is evidence to suggest that this organism is a phage-modified variant form of the Flexner type of dysentery bacilli. These bacilli occur

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