ENDEMIC GOITRE IN SARAWAK, MALAYSIA : I. SOMATIC GROWTH AND AETIOLOGY

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INTRODUCTION

Endemic goitre constitutes one of the world's most serious public health problems. The magnitude of the problem is reflected by the estimate of Kelly and Snedden (1960) that as many as 200 million people were afflicted with the disease. Goitre has been reported to be endemic in large areas of Southeast Asia including Sarawak, Borneo (Polunin, 1951, 1971; Kelly and Snedden, 1960; Ogihara *et al.*, 1972a, b). Much has been written about iodine metabolism and thyroid function in subjects with endemic goitre (Clements *et al.*, 1960; Visscher *et al.*, 1961; Koutras *et al.*, 1970; Thilly *et al.*, 1973; Kochupillai *et al.*, 1973; Delange, 1974). Nevertheless, apart from cretinism and the obvious deformity of an enlarged thyroid gland, little attention has been given the definition of other physical consequences. Overt hypothyroidism commencing during childhood or adolescence invariably results in retardation of growth, resulting in characteristic shortness of stature with disproportionate shortness of the legs (Woeber, 1968). Limited investigations (Green, 1972; Koutras *et al.*, 1973) of body proportions and somatic growth in populations with endemic goitre have revealed the presence of the abnormalities seen in the overt hypothyroid, though with milder manifestations. The investigators admit, however, to differences in nutritional, health or genetic origins among the local goitrous, non-goitrous and overseas control populations.

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The present work involved a comparative health, epidemiological and anthropometric survey among Ibans, the largest indigenous ethnic group of Sarawak and exhibiting a considerable difference in endemicity of goitre between 3 regions. This survey aimed to assess the incidences of alterations in somatic growth and body proportions, as well as possible aetiological factors among the endemic goitrous and non-endemic populations of Ibans.

Areas Investigated

The investigation was pursued in three areas in the second division of Sarawak (Fig. 1).

The Ai River Region : In the inland, hilly jungle forests of the Lubok Antu district, an Iban population lives in longhouse communities beside the fast, clear waters of the Ai River. The longhouses, traditional in design, resemble those described by McKay and Wade (1970). Every meal consists of boiled hulled rice, with side dishes of garden or jungle produce. Food crops of cassava, maize, long-beans, local greens, pepper, pineapples and bananas are cultivated. Wild jungle produce consists mostly of ferns, sprouts, greens, roots, bamboo shoots and fruits. Eggs, chicken, beef and pigs are rarely eaten except during festivals, while fish are scarce in the river. Lightly boiled cassava leaves form a favourite dish, the root being substituted for rice when the latter is in short supply. Water, taken from the river for drinking, is rarely boiled.

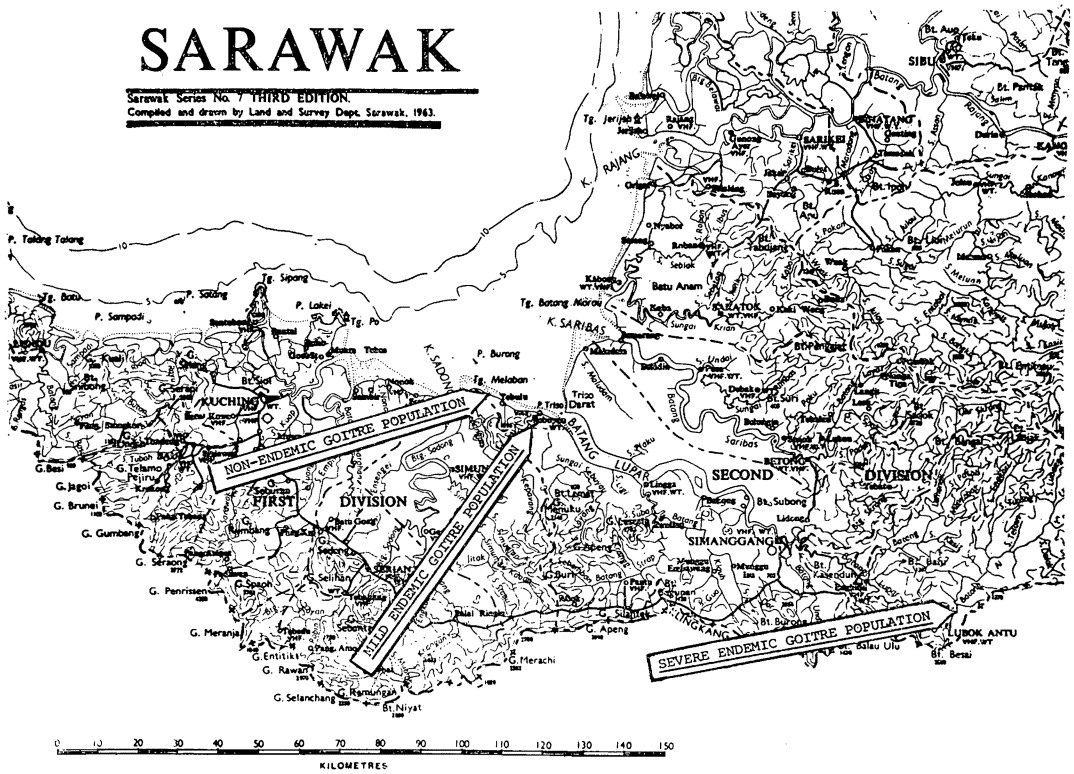

Fig. 1—Map of Sarawak showing the three populations surveyed: The Ai River region as the severe endemic goitre population, the Ruba region as the mild endemic goitre population and the Bajong region as the non-endemic goitre population.

The Rubu Region : An Iban village, Rubu, 3 miles from the coastal Sebuyau township, stands beside the tidal Sebuyau river which loops through the swampy mud flats along the coast. Most of the people live in separate houses amongst coconut, rice, maize, vegetable and cassava farms. Rice, the main food, is often in short supply. The people then depend on cassava, both leaves and roots, as their staple food. Fish caught in the salt water river or bought at the township are eaten frequently by some, but rarely by others. Drinking and cooking water is rain water caught from the roof or occasionally carried from a local fresh spring.

The Bajong Region : Bajong, and Iban village, lies on an isolated section of coast 10 miles south of Sebuyau. The houses on marshy, black soil are scattered among coconut plantations and farms. Continual flooding is prevented by a webbed network of canals dug to allow the passage of the large ebb and flow of the tide. Copra produced on a commercial scale provides a substantial cash crop. Rice and other commodities are bought to supplement rice, maize, cucumber, longbeans, greens and small amounts of cassava grown on the farms. Sea foods such as prawns, crabs and fish are often caught or bought from the local Malay or Chinese fishermen. Fresh water is in short supply, being entirely caught from rain on the roofs and collected in open tanks.

MATERIALS AND METHODS

The only suitable means of travel into the selected areas was by navigating the unpredictable waterways with an outboard driven longboat. Each survey conducted over several days involved travelling 3 to 6 hours from the nearest link with regular transport.

Both males and females aged 11 to 89 years were studied, the number examined in the Ai river region being 167; in the Rubu region, 39; and the Bajong region, 122. A short medical history and thorough clinical examination were undertaken for each subject to assess major diseases in and among the three test populations. Clinical thyroid function was assessed and goitres graded according to the criteria of Perez *et al.*, (1960). The definition of endemic cretinism proposed by the Pan American Health Organisation (Delange, 1974) was adopted.

In the field, haemoglobin levels were estimated by grey wedge photometry on 45 selected subjects in the Ai river region and 39 in the Bajong region. Sera collected from 20 subjects in the Ai river region and 20 in the Bajong region were frozen and later evaluated at St. Vincent's Hospital, Sydney, with an SMA 12/60 autoanalyser for estimation of total protein and albumin concentration.

Anthropometric measurements — viz, weight, height, sitting height, head and left mid-arm circumference, skinfold thickness over the triceps, scapular and waist were performed according to procedures set out in the International Biological Programme Handbook (Weiner and Lourie, 1972) with the exception that weight was measured on portable spring scales, instead of a balance type. Checked with standard weights, the accuracy of the portable scales showed a maximum variation of 1.5 kg during the survey.

RESULTS

Medical Observations : In all 3 regions, most of the adults complained of upper abdominal discomfort. In many subjects, the symptoms were non-specific, but in some subjects the history was consistent with peptic ulceration. A few cases of vomiting and diarrhoea could be attributed to drinking contaminated water. High prevalence of intestinal helminths were the rule in all three populations.

The living conditions—viz, close human contact in a warm, humid environment, meant that spray and droplet viral, bacterial and fungal infections were common. Chronic respiratory diseases were particularly common in the older men, of whom many displayed emphysematous chests and complained of cough with yellow or blood-stained sputum. In all age groups, cardiac murmurs consistent with valvular disease were frequent. Symptoms of acute urinary tract infections were common in pregnant women and recurrent urinary tract infections in the older women. Skin infections due to fungi, impetigo or scabies were frequent, particularly among young adolescents. The population exhibited a high incidence of malarial symptoms of chills, sweating and headaches, mostly at night, associated with tender hepatosplenomegaly and with enlarged tender parotids and generalised lymphadenopathy, particularly in children. No evidence was detected of protein, caloric or vitamin malnutrition. All subjects from the 3 regions were judged clinically euthyroid. Except for endemic goitre, there was no apparent variation in the major disease patterns among the 3 test populations.

Prevalence of Goitre : In the Ai river region, the prevalence of goitre was 99.5%, 35% being grade 3 goitres; 55% grade 2; and 9.5% grade 1. Of the subjects at Rubu, 74% had goitres but only 3% had grade 3 goitres; 16% grade 2; and 55% grade 1.

In the Bajong region, a few people had goitres but most had migrated from other endemic goitre areas; the majority had noticed a regression in size of goitre since arrival at Bajong. They were not included in the survey. The rest of the test subjects were free of goitre.

Prevalence of Cretinism : The prevalence of cretinism was estimated at 3.6% in the severely goitrous Ai river population, all being of the neurological type, without signs or symptoms of hypothyroidism. No cretins were detected in the Rubu population.

Anthropometric and Health Data : Table 1 summarizes the main growth dependent anthropometric data for the adults (> 20 years) and Table 2 summarizes less age-dependent anthropometric and nutritional data, as well as scapular skinfold thicknesses, cranial circumferences and left mid-arm muscle circumference (Jeliffe, 1966) for the three populations. Table 3 lists levels of haemoglobin, serum total protein and serum albumin for 20 subjects in the Ai river and 20 in the Bajong regions, No statistically significant differences were detected among the 3 populations. Tables 1, 2 and 3 ($p > 0.05$).

In summary, among the 3 populations of the same ethnic indigenous tribe, severely affected, less affected and unaffected respectively by endemic goitre, there were similar levels of health and nutrition and no significant differences in somatic growth or body proportions.

DISCUSSION

Although endemic goitre in Sarawak has been reported by several authors it has, nevertheless, not been studied so extensively as in other countries. In the present study, the Ai river population exhibited a 99.5% incidence of goitre. To our knowledge, this prevalence represents the world's highest in recent reports. The next highest prevalence of 98% was reported for certain villages in the Himalayan region (Kochupillai *et al.*, 1973).

As in other populations (Green, 1972; Koutras *et al.*, 1973) our observations indicate that body proportions and somatic

Table 1

Mean anthropometric data for three adult populations (> 20 years of age) in Sarawak.

Locality	Sex	No. of Persons	Weight (kg)	Height (cm)	Weight : Height	Height Sitting Ht.
Ai River	M	52	49.2	157.0	1.460	1.933
Severely endemic goitrous	F	57	43.7	150.3	1.580	1.921
Rubu	M	9	48.7	158.7	1.487	1.934
Less severely endemic goitrous	F	10	47.2	147.9	1.476	1.924
Bajong	M	33	51.1	158.7	1.434	1.952
Non-endemic goitrous	F	45	45.7	148.2	1.510	1.938
Estimated overall S.D.			18.7	7.3	0.276	0.585

No statistically significant differences were detected among the 3 populations ($p > 0.05$).

Table 2

Various mean physical data for the Ai River, Rubu and Bajong populations.

Locality	No. of persons	Head circumference (cm)	Scapular skinfold thickness (cm)	Left mid-arm muscle circumference (cm)
Ai River (Severely endemic goitrous)	167	53.26	1.122	21.8
Rubu (Less severely endemic goitrous)	39	52.44	0.912	20.0
Bajong (Non-endemic goitrous)	122	52.99	1.084	21.5
Estimated overall S.D.		1.97	0.515	3.6

No statistically significant differences were detected among the 3 populations ($p > 0.05$).

Table 3

Mean ± S.E.M. of haemoglobin, serum total protein and albumin levels in the Ai River and Bajong regions.

Locality	Sex	No. of persons	Haemoglobin (gm/100 ml)	No. of persons	Serum total protein (gm/l)	Serum albumin (gm/l)
Ai River (Severely endemic goitrous)	M	18	12.9±0.9	20	82.9±2.2	48.4±1.7
	F	27	11.9±0.8			
Bajong (Non-endemic goitrous)	M	15	12.8±1.0	20	80.1±1.2	46.6±1.2
	F	24	11.6±0.9			
Normal Australian Range	M		12.5–15.5		66–82	42–58
	F		14.5–17.5			

Data shows mean S.E.M.

No statistically significant differences were detected among the 3 populations ($p > 0.05$).

growth do not vary among populations having greatly differing endemicity of goitre. All subjects were judged euthyroid. As reported by several authors (Pharoach *et al.*, 1973; Delange, 1974), the goitrous glands are able to maintain the euthyroid state by a compensatory increase in triiodothyronine (T3) secretion, as evidenced by normal or slightly elevated serum T3 levels despite low levels of serum thyroxine (T4). Studies of circulating levels of T3 and T4 in the three populations confirmed these findings and will be the subject of a separate report. The absence of alterations in body proportions and somatic growth seems likely to result from the maintenance of this euthyroid state. An incidence of 3.6% of neurological cretinism was found, however, in the Ai river population with severe goitre. This finding is consistent with the hypothesis of Pharoah *et al.*, 1971, that neurological cretinism relates more to iodine deficiency during the first trimester of pregnancy rather than to hypofunction of the thyroid. We classified as cretins only those who were severely affected, according to the criteria of PAHO, but compared neither neurological defects nor intellectual development among the 3 populations. It seems possible, as has previously been suggested by Green, (1972), that iodine deficiency may produce a wide range of severity of these abnormalities in endemic neurological cretinism.

A single cause of endemic goitre throughout the world has not been established and research on the subject is complicated by differing regional factors and case histories. In the light of the large number of aetiological factors which are currently postulated, the unique endemicity and epidemiological findings of the present study strongly implicate certain factors as having relevance to endemic goitre in Sarawak and eliminate a number of other possible causes. Endemic goitre has long been known to be associated with inadequate iodine intake (Clements *et al.*, 1960). Sarawak has a rainfall exceeding 400 cm per annum, with a rapid run off into thousands of little streams and rivers that wind their way into the sea. Rain water is iodine free, so that over the centuries the high wash-off has leached the iodine from the soil. Areas with a hilly run off are affected worst and endemic goitre has a prevalence approaching 100% in the remote inland areas. Ogihara *et al.*, (1972) reported the mean iodine content of 6 rivers or streams in the inland Rajang river district of Sarawak was 0.3 μg/1, compared as a control with the mean tap water level of 3.4 μg/1 in the Honshin districts in Japan. This information does not explain the 74% prevalence of small goitres among the Iban population living along the tidal salt water rivers near the coast, where fish and sea foods are included in the diet. These factors are significant because the intake of only 100 μg/day of iodine is normally required to prevent goitre.

Since McClelland's work (McClelland, 1835) the relationship has been investigated between drinking water rich in lime, calcium, and more recently fluoride, or between water hardness (Day and Powell-Jackson, 1972) and frequency of goitre. However, the coastal Ibans in the Rubu endemic goitre region depend on rain water for drinking and cooking, so that these factors seem not to predominate in the aetiology of goitre in Sarawak.

The work of McCarrison (1906) on endemic goitre in Himalayan villages drew attention to the importance of water pollution. Vought *et al.*, (1974) recently reported on antithyroid compounds produced by *Escherichia coli* and other microbes. Similar bacterial pollution might be relevant to the inland tribes taking their water from rivers and streams which have passed through upstream villages but would not account for goitre in the coastal zone where drinking water is obtained from rain caught on the roof.

Cassava, both root and leaf, is often the staple food next to rice and is consumed in varying quantities by all the Iban communities which were surveyed. Delange *et al.*, (1974) recently reported on the antithyroid activity of linamarin, a cyanogenic glucoside present in cassava, the degradation of which leads mainly to the production of thiocyanate. Iodine depletion seems to be created by an increased loss of iodine in the urine, being related to a blockage of the tubular re-absorption of this ion by an excess of SCN. The Iban coastal population in the Rubu and inland endemic goitre regions admitted that they ate large quantities of cassava to supplement their limited supplies of rice. On the other hand, the non-goitrous population at Bajong, existing on a more cash orientated economy, ate little cassava and consumed relatively large quantities of sea food. Endemic goitre has also been associated with poor protein calorie nutrition (Ingenblook and Brookers, 1973). The present study in Sarawak revealed no difference in nutrition between the goitrous and non-goitrous populations.

Clustering of goitres within Iban families in Sarawak was reported by Ogihara *et al.*, (1972) who suggested a genetic aetiology. This trend, however, is more likely to be associated with environmental factors (i.e. diet). Children born at Bajong were goitre-free, whilst many of their parents who had moved in from endemic areas still retained their thyroid enlargement.

In summary, although all the above factors might contribute to goitre, the major cause in Sarawak appears to be deficiency of iodine. This deficiency can be attributed to the leaching of iodine from the soil, and to the consumption of large quantities of cassava, a known goitrogen. When these two factors are combined, large goitres are prevalent and the incidence of endemic goitre is almost 100%.

SUMMARY

A comparative epidemiological and anthropometric survey was conducted among Ibans, the largest indigenous ethnic group in Sarawak, in three regions where the endemicity of goitre exhibited marked differences, to assess the effect of endemic goitre on somatic growth.

In the Ai river region the prevalence of goitre was 99.5%; 35% having grade 3 goitres, 55% grade 2 goitres and 9.5% grade 1 goitres. At Rubu the prevalence of endemic goitre was 74%; 3% having grade 3 goitre, 16% grade 2 goitre and 55% grade 1 goitre. In the Bajong region relatively few people were detected with goitre and most of these had migrated from other regions. Neurological cretinism was estimated at 3.6% in the severely goitrous Ai river population but was not detected in the other regions. Anthropometric data obtained from the three adult populations did not reveal any statistically significant differences in the following parameters : weight, height, weight/height ratio, height/sitting height ratios, head circumference, scapular skinfold thickness and left mid arm muscle circumference. The haemoglobin, serum total protein and serum albumin concentrations were similar in the three populations.

It is concluded that endemic goitre occurs with a frequency of close to 100% in certain Iban populations which represents one of the highest incidences of endemic goitre in the world. Neurological cretinism is common in this population. Our observations suggest that body proportions and somatic growth do not vary among similar ethnic populations exhibiting greatly different endemicity of goitre. Although no iodine balance studies were performed, assessment of diets suggested that iodine deficiency is a significant contributory factor in the development of endemic goitre in Sarawak. Urgent attention to iodine supplementation is indicated to prevent

the development of endemic goitre and neurological cretinism.

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