SOME FURTHER OBSERVATIONS ON BILHARZIASIS IN THE TRANSVAAL

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The Transvaal north of the Highveld can conveniently be divided into the Lowveld, east of the Drakensberg, and the Bushveld, west of it. The eastern slopes of this mountain range are very well watered by numerous small streams, all of which eventually drain into bigger rivers flowing east. The altitude of the Lowveld varies from about 500 to 2,500 feet above sea level, that of the Bushveld (Middleveld) round about 3,000 feet. (The true Highveld has an altitude around 5,500 feet.) Rainfall occurs in the summer in both regions and varies from 500 to 1,000 mm. per annum.

Since days gone by Natives have inhabited the mountain slopes, but nowhere have they established irrigation projects. The available waters were used as nature provided them, for all purposes—washing, bathing and drinking. They and their animals use the same water supply. Small streams are preferred to larger ones because of the fears of drowning and crocodiles.

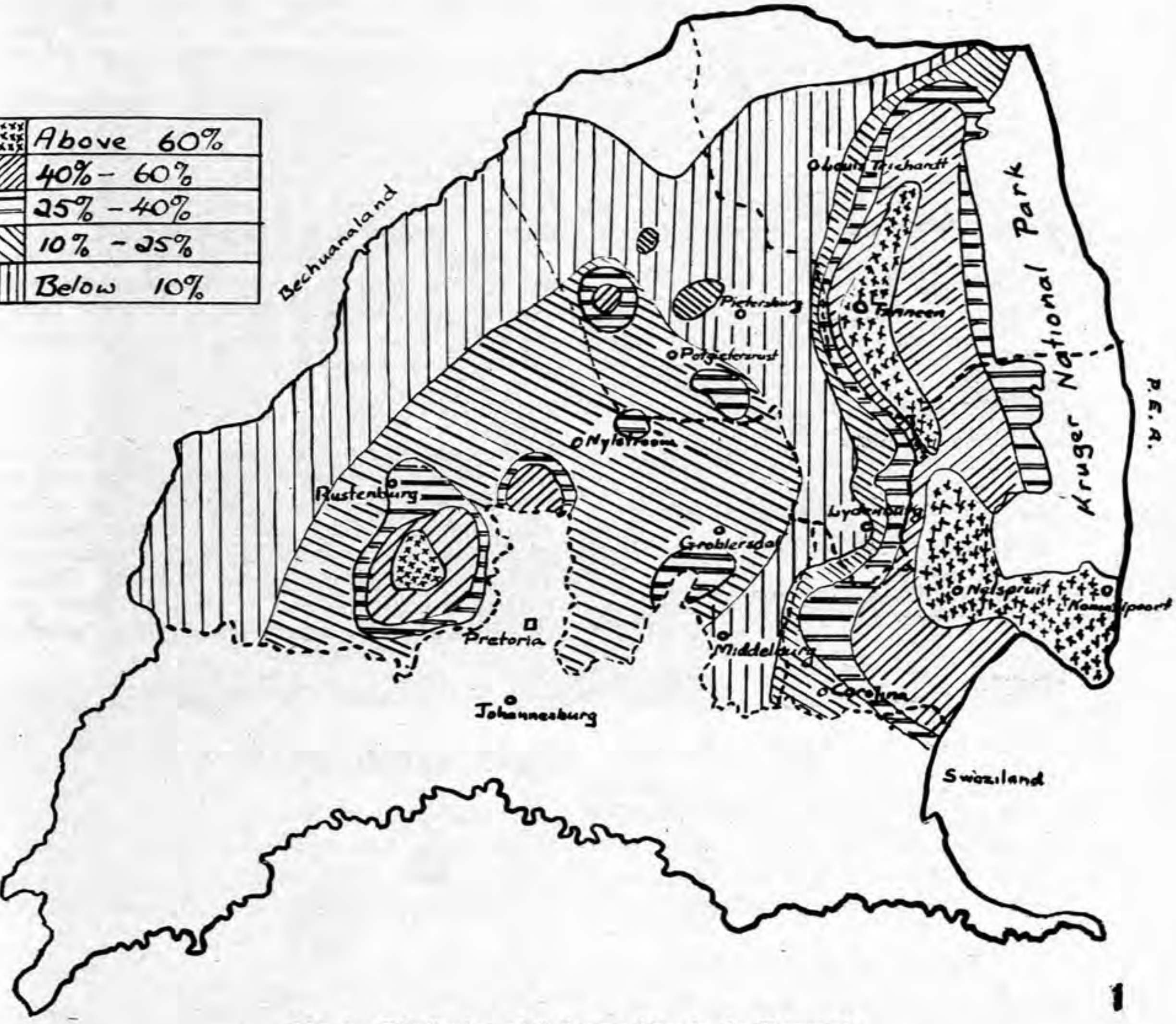
The natural streams throughout the Bushveld and Lowveld harbour *Physopsis* and *Biomphalaria* snails, the suspected snail hosts of *Schistosoma haematobium* and *S. mansoni* respectively. Constant contact between human and snail has therefore probably been maintained ever since Natives inhabited the country, well over a century ago.

The extent of this area exceeds 60,000 square miles and it is inhabited by more than 1½ million Natives and 160,000 Europeans. It is shown in Map 1, in which the distribution of *S. haematobium* is indicated. Maps 2 and 3 show the distribution of *S. mansoni* in parts of the Lowveld (the survey in Letaba—Map 2—is not completed). The major part of it corresponds with the malaria areas of the Transvaal but bilharziasis extends beyond the borders of the malaria areas north of a line from east to west through Johannesburg.

The greater movement of Natives, both within and without the Union, has undoubtedly led to infection of snails and incidence of human bilharziasis where the disease was previously unknown. The snail hosts of the disease are distributed throughout and, if infection is brought to them, human bilharziasis must occur.

S. haematobium for example has been found as far west as the magisterial areas of Waterberg, Rustenburg, Brits and Zeerust, with incidence up to 90% amongst Native school children.[1] The distribution of the disease in these vast areas in the west in association with streams flowing west into the Limpopo basin is patchy; it is extraordinarily intense in pockets. One would imagine that cattle, using the same waters, would show evidence of disease; and it is in one such pocket that humans have been found infected with 'probable cattle schistosomes' and the infection has been under observation for some years now.[1]

In the Johannesburg area *S. haematobium* incidences up to 20% have been found.[2] In the south-east both forms of the disease stretch continuously from the



Map 1. Distribution of *S. haematobium* in the Transvaal.

Transvaal into Mozambique in the east and into Swaziland and Natal in the south; thus the continuity of the Transvaal hyper-endemic bilharzia area east of the Drakensberg is maintained into the adjoining territories.

The two major townships in this hyper-endemic bilharzia region, Tzaneen (long. 30° 15′ E, lat. 23° 45′ S) and Nelspruit (long. 31° 0′ E, lat., 25° 30′ S) form the extreme northern and southern ends of the hyper-endemic bilharzia region, between the Drakensberg escarpment in the west and the borders of the Kruger National Park in the east.

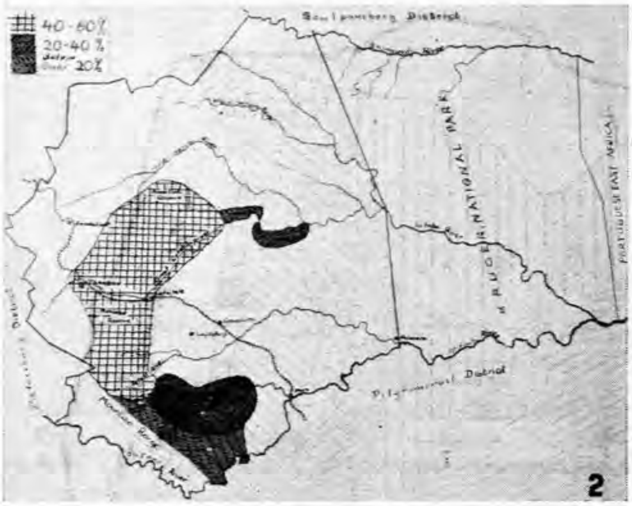
EARLIER SURVEYS

S. haematobium has been known to exist in the Northern Transvaal for many decades. Blood in the urine and other unpleasant symptoms of the disease are the main reasons why attention was directed to it in the past. Pioneer work was done to determine the incidence of *S. haematobium* as far back as 1935 when the Transvaal malaria staff examined urine specimens from Natives in the Northern Transvaal. At the time it was not realized that *S. mansoni* was also rife, although occasional cases were diagnosed by examination of urine. In recent surveys cases presumably of *S. bovis* have been discovered in urine [3] and faeces,[1] but these are few in number.

Table A gives the incidence of *S. haematobium* among Native school-children in the vicinity of Nelspruit in 1935, Table B the incidence along the eastern slopes of Zoutpansberg in 1937, and Table C the incidence in the vicinity of Tzaneen along the eastern slopes of the Drakensberg in 1938. In all these surveys a single

TABLE A. INCIDENCE OF S. HAEMATOBIUM IN NATIVE SCHOOL-CHILDREN IN THE VICINITY OF NELSPRUIT IN 1935

Age-group (years)	*Number Examined*	*Number Positive*	*Percentage Positive*
5— 9	342	187	51·4
10—14	464	291	61·2
15—19	209	150	71·8
20—29	41	29	70·7
Total	1,056	657	62·2



Map 2. Letaba District, Eastern Transvaal. Incidence of *S. mansoni.*

TABLE B. INCIDENCE OF S. HAEMATOBIUM IN NATIVE SCHOOL-CHILDREN LIVING ALONG THE EASTERN SLOPES OF THE ZOUTPANSBERG 1937

5—9	485	184	37·9
10—14	747	281	37·6
15—19	309	102	33
20—29	26	7	27
Total	1,567	574	36·6

TABLE C. INCIDENCE OF S. HAEMATOBIUM IN NATIVE SCHOOL-CHILDREN LIVING ALONG THE EASTERN SLOPES OF THE DRAKENSBERG IN THE VICINITY OF TZANEEN 1938

5—9	83	50	60·2
10—14	109	82	75·2
15—19	110	67	60·9
20—29	9	4	44·5
Total	311	203	64·3

TABLE D. INCIDENCE OF S. HAEMATOBIUM AMONG NATIVES IN THE VICINITY OF NELSPRUIT IN 1939

Number Examined	1,773
Number Positive	683
Percentage Positive	38·5

specimen of urine from each person was examined and a mechanical centrifuge was used. This technique will probably give a slightly higher incidence of the disease than sedimentation of urine for a fixed period of time, which is the technique used in recent work.

It will be seen that there is no significant difference between the incidences at Tzaneen and Nelspruit, both of which fall in the highly endemic area east of the Drakensberg escarpment. The eastern slopes of the Zoutpansberg area is very mountainous and the Natives live along the main mountain streams, which have a relatively small snail population, which factors almost certainly account for the lower haematobium rate in this area.

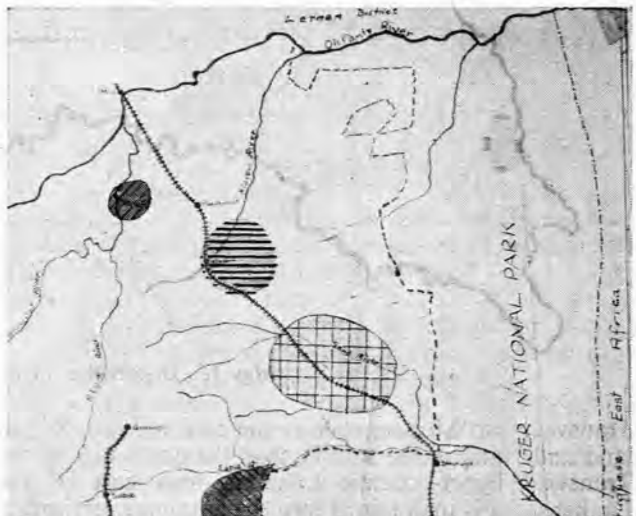
Further work was done in 1939 on the incidence of *S. haematobium* in the vicinity of Nelspruit—Table D. Unfortunately the investigator did not record the age-groups of his cases and we can therefore only give the grand total of his findings. The figure is lower than that of 1935, but more adult Natives may possibly have been examined in the 1939 survey, which might account for the lower incidence.

Further evidence of the incidence of urinary bilharzia in the Northern Transvaal has been given by Annecke and Peacock.[4] It was found that urinary bilharzia was widespread to a greater or lesser degree throughout the Northern Transvaal, with incidences in Native school-children varying from 80% to less than 10%.

Although no intensive survey work on *S. mansoni* has been done in the Bushveld area of the Northern Transvaal the disease is known to occur there, but probably not to such a large extent as occurs in the Lowveld areas.

RECENT SURVEYS

Lack of staff in post-war years, not to mention the war years, accounts for slow progress in survey work such as that on the incidence of disease and the ecology of vector snails; and it is entirely owing to staff shortage that the veterinary services of the country have not been able to participate with us in this field work. The position is however improving and for the last 2 years one of us (R.J.P.) has been largely concerned in carrying the



Map 3. Pilgrimsrest, Nelspruit and Barberton Districts, Eastern Transvaal. Incidence of *S. mansoni.*

problem forward in a small, but intensely infected, area situated precisely where the greatest ravages of malaria also occurred.

With the recession of malaria, both the lay public and the medical profession are becoming more and more concerned about the bilharzia position, which over large tracts of country has assumed gigantic proportions. There is no reason to think that the incidence has lessened over the last 20 years. All evidence in fact points to the contrary; and it is certain and obvious that with the introduction of irrigation schemes, the position has greatly deteriorated in European farming areas in the Lowveld region from Tzaneen to Komatipoort.

Technique. In putting the survey work into action the following technique was gradually evolved: All urine was collected about 10 a.m., thus ensuring at least a little exercise on the part of the patient beforehand. The whole contents of the bladder was voided into a bottle. The urine was then allowed to stand for at least 1½ hours and examination was made of urine pipetted from the bottom. No centrifuge was used, only one examination of each specimen was carried out, positives were recorded only when ova were recovered, and only a single examination was made on each patient.

The diagnosis of *S. monsoni* was likewise made on a single examination of stool. The glacial acetic acid and ether technique was used, again without centrifuge, the specimens being allowed to sediment after the addition of ether for at least ½ hour before examination. All collections of specimens were made in the field, where the amount of faeces that could be held on the tip of the index finger was put directly into 5 c.c. of glacial acetic acid. The remainder of the procedure and examinations were done later in the day.

It is admitted that a single examination of urine and faeces is insufficient to produce an accurate bilharziasis *rate*, but that was not the intention; what was intended was to get comparative figures which would give an idea of the intensity, extensiveness and severity of the two diseases.

Age was guessed at.

Country and People. Unless otherwise stated all material under subsequent discussion was taken from the Lowveld farming areas between Komatipoort and Kaapmuiden and further north round Klaserie, and from the Native Reserve areas east of White River and north of the eastern border of Swaziland. All areas are strictly comparable as far as geographical, climatic and general ecological factors are concerned. The survey is confined to non-Europeans.

Geographically the country is gently undulating (varying to hilly) low-lying (600-3,000 feet) bush country, breaking into 'park land' in the Native Reserve areas where the thick bush has been cleared, and of course giving way to cleared, cultivated, irrigated lands in the European farming areas. The soil is largely red with a high calcium content. The rainfall, about 550-800 mm. a year, occurs in the hot summer months from about the end of September and beginning of October to about March. The average maximum and minimum summer temperature is about 87·6°F and 65·9°F respectively and winter about 73·0°F and 46·0°F. These figures are based on Nelspruit town.

The Natives are Shangaans, with an admixture of Swazis more pronounced further south. For practical purposes their habits, diet, etc. are similar. A large proportion of them are detribalized or bastardized and it was felt that it would be an impossible and useless task to attempt to separate them for the purpose of this survey.

The area can conveniently be divided up into European farming areas with irrigation systems, and Native Reserve areas with no irrigation systems.

European Farming Areas

These areas, as far as bilharzia is concerned, can be further divided up into (1) farms that offer no protection against bilharzia and (2) farms where there is a measure of protection. The farmer is usually completely unconcious about the protection his farm offers; he has done nothing to bring it about, and it is due entirely to factors beyond his control.

All farm land in the Lowveld is dependant for its water supply on irrigation systems. The water is either pumped into canals and dams from the main rivers or the canals open directly from the main river, and feed a series of subsidiary canals and dams from which lands are irrigated. The Natives are housed in compounds, the huts usually being built in close proximity to each other, generally on the banks of the canals and small streams, or on the banks of the large rivers. Faecal contamination of the waters is maximal in the rainy season when all faeces is washed down into the waters. The Native does not walk very far from his hut to defaecate. Latrine accommodation is almost entirely non-existent and bathing and washing facilities are afforded by the canals and dams or by a small stream which might run through or near the compound; occasionally washing is done in the large rivers. This then is the general picture of the Natives' living conditions in relation to bilharzia in the European farming areas of the Lowveld.

(1) *Farms affording no protection against bilharzia*. The above general picture of living conditions suffices. The waters are polluted by faeces washing into them during rains and by Natives urinating when bathing and washing. The dams act as *culs-de-sac* for snails and cercariae, and are ideal bathing places for the Natives. The small streams, too, are often dammed up by the Native to enable him to do his washing. The total percentage *S. mansoni* intensity on these farms (for all ages) is 68·5 and *S. haematobium* 66·7. Detailed figures in age-groups are given in Table I.

Table IB is compiled from evidence in the adjoining district of Letaba and covering the examination of 1,600 specimens of urine and 1,600 of faeces taken from areas with various densities of snails and bilharzia, over the whole region (including European farming areas, Native Reserves and Trust Lands). It shows the same curve of the graph. Commencing in the age-groups below 4 years bilharzia (both forms) reaches its peak in the age-groups from 10 to 20 years and then the incidence gradually diminishes.

The picture is one of continuous re-infection starting in earliest childhood (the youngest infant found infested with *S. haematobium* was 5 months old and with *S. mansoni* 7 months) and continuing almost daily throughout life. The snail infectivity rates, although varying with the time of the year (see Table IA), are evidence that re-infection by both parasites can easily occur during every month of the year.

In Table I the *S. haematobium* intensity does not appear to diminish until 20-29 years of age, after which it declines with increasing age. The *S. mansoni* intensity remains high till the 'over 50' age-group is reached.

(2) *Farms affording the Natives some protection from bilharzia.* These farms are found scattered amongst the preceeding ones and though the protection afforded is not great, particularly as the Natives are prone to wandering about, it is sufficient to cause a significant difference in the bilharzia intensity, especially with *S. mansoni.*

The living conditions of the Natives differ in no way whatsoever but differences are found in the water supplies. For example (i) the dams are built up above the ground and receive a pumped water supply, (ii) there are closed canals, (iii) some structure such as a railway line is situated between the compound and the dam or canal, (iv) there are piped water supplies either from boreholes or dams, or (v) the Natives repeatedly wash in large flowing rivers, where contamination is rapidly diluted. All the above conditions will tend to reduce faecal contamination of the water supply.

The total percentage *S. mansoni* intensity in these protected areas for all ages is 29·3% and *S. haematobium* is 49·5% for all ages. Detailed figures in age-groups are given in Table II. The differences for both the forms of bilharzia is significant, compared with the 'no protection' farms. In *S. haematobium*, the difference lies in the 0-4 and 5-9 age-groups and the more gradual build-up of *S. haematobium* in Natives on the 'protected' farms might very well be due to bathing and migrating habits of children increasing with age—i.e. they become more heavily infected when bathing outside their own protected area (they need not necessarily of course go and bathe in areas heavily infested with *S. mansoni*; in fact the difference in all age-groups of *S. mansoni* intensity in the two groups of European farming areas is sufficient to show that they do not, and probably prefer to return in the summer to the Native Reserve areas (where the *S. mansoni* rates are comparable) to help with ploughing and planting.

Unfortunately no snail infectivity rates are available for these areas. There are only 2 observations: (i) Of 38 *Biomphalaria* snails taken from the sides of a large flowing river directly below a compound 33% were found shedding mammalian cercariae in March, (ii) No infected *Biomphalaria* have ever been recovered, after diligent search, from built-up dams which are protected from contaminated flood waters washing from the compounds.

The picture then in the two sets of European farming areas is (*a*) an area of very high endemicity for both *S. mansoni* and *S. haematobium* in all age-groups, and (*b*) an area of moderately high endemicity for *S. mansoni* in all age-groups and for *S. haematobium* a moderately high endemicity in age-groups up to 9 years followed by high endemicity in later years. It is realized that the phrase 'moderately high endemicity' is a gross understatement but it does serve as a means of comparison, where one group of conditions causes complete saturation with the two diseases and the other group not such complete saturation.

Native Reserve Areas

These are large tracts of country where the Natives live more or less scattered about, never as closely congregated as in the compounds of European farming areas, usually in close proximity to water but very seldom actually on the banks of the streams or rivers. There are no irrigation systems and the very few dams that exist have been built in the last year or two and probably have not yet (at time of survey) had time to alter the general bilharzia picture. It may be that they will not alter it, as long as the Natives remain living scattered about. All washing and bathing is done in the small streams and rivers. These, with few exceptions, pool up in the dry winter months.

The *S. haematobium* intensity throughout the Reserves is high and in every way comparable to that in the European farming areas with no protection; there is, however, a significant difference between the *S. mansoni* intensities of these two areas, whereas there is no difference between the *S. mansoni* intensities in the Reserves and those areas where farms offer some protection (Table III). This comparatively low *S. mansoni* intensity in the Reserves is thought to be due to the fact that the Natives live more or less scattered about and further away from water. Their faeces likewise are scattered and further from the water, with the result that the contamination in polluted water reaching the streams during the rainy season is not as great as it is in the concentrated compounds of European farming areas.

The Native Reserve areas can then be classified as areas of high *S. haematobium* endemicity and moderate *S. mansoni* endemicity.

The *snail infectivity rates* (Table IIIA) throughout the year is considerably higher for *Physopsis* snails throughout the Native Reserve area than it is in European farming areas. This might easily be due to the decrease in volume of water and increase in the number of snails per unit volume of water during the dry winter in the reserves. No such decrease of water volume occurs in the controlled irrigation systems of European farms, with the result that contamination by urine in these farming areas will tend to decrease when coupled with the fact that very little if any bathing goes on during the winter months.

The Biomphalaria infectivity rate (Table IIIA) is, as expected, much lower throughout the year in the Reserves, and is very low indeed during the winter. The same chances therefore of continuous re-infection with *S. mansoni* do not exist in the reserves as they do in the European farming areas. The risk of re-infection with *S. haematobium*, however, remains high throughout the year.

Native Immigrants to European Farming Areas

A great deal of the farm labour is migrant from Portuguese East Africa. Living conditions there differ in no way from conditions in the Native Reserve areas in this country, and in a small series of some 200 odd cases it would appear that the bilharzia picture is the same. These Natives, (all ages) arrive in the European farming areas and for the first 3 months have a *S. mansoni* intensity of 40% as against 33% amongst Natives in the Eastern Transvaal Reserve areas. After a further 3 months the figure has risen to 55% and after 6 months more the figure is 65% as against 68% amongst Natives (all ages) who had lived some years in the European farming areas (see Table IV).

There is a much less marked rise in the *S. haematobium* intensity for the same period amongst the same Natives.

It would appear then that it takes 6-12 months only for Natives immigrant to the European farming areas of the Lowveld to become saturated with intestinal and vesical bilharziasis.

Snails

The vector snails, *Physopsis spp* and *Biomphalaria spp*, are widespread throughout the area. *Biomphalaria spp* are about twice as numerous as *Physopsis spp*, even though pockets occur where *Biomphalaria* is apparently non-existent. No such pockets have been observed in the case of *Physopsis*. The most heavily infested waters are small dirty streams and ditches, with ground dams and irrigation systems coming a close second. Both vector snails are capable of prolonged 'hibernation' in dried-up mud during the winter months, but for how long this hibernation is possible, is unknown.

Bulinus (Bulinus) forskali occurs in the area, but so far it has not been found shedding mammalian-type cercariae. *Lymnaea natalensis* likewise has never been found infected with mammalian blood flukes. These findings agree with those of previous workers (forskali, however, has been incriminated as vector on the island of Mauritius, though doubt has been cast on this[5,6]).

Snail infectivity rates for the whole area are given in Table V. The numbers in this table (and also Tables IA, IIIA and VA) refer to adult snails only. Baby snails were not examined after it was ascertained that very few if any of them shed cercariae. The *Physopsis* infectivity rate shows some variation from month to month. The *Biomphalaria* infectivity rate shows a marked drop during the winter months, while, unlike *Physopsis* the number of snails taken from month to month does not alter to any marked extent. Table VA, compiled from evidence in the Letaba district, bears out further that there is no time of the year when one can enter surface waters with safety. Chances of infection are, however, slightly diminished during the winter months owing to lowered snail infectivity rates, but it must not be forgotten that in Native Reserve areas the total volume of water is greatly diminished at that season, which will tend to increase chances of infection (*a*) because the rivers become pooled and (*b*) because the number of infected snails per unit volume of water will increase.

CONTROL

It is true that the work of the Transvaal Bilharzia Committee over 20 years has lessened to some extent the incidence of the disease in the lightly afflicted areas (*a*) by treatment of school-going children (chiefly European) at school treatment camps and (*b*) by preventive propaganda carried out by school-teachers, which in certain areas, e.g. Brits irrigation settlement, has brought about the provision of closed and piped water supplies and school swimming pools. This improvement without State aid has taken 15-20 years to bring about.

Nevertheless no *sustained* measures have yet been carried out, even in the hot regions of *hyper-endemic* bilharziasis, with the result that bilharzia today in the Transvaal is running a completely unchecked course.

Control measures should take the form of 2 and possibly 3 lines of attack against the disease:

(1) *Against the Vector.* Pilot schemes under varying field conditions are necessary to test techniques of snail vector control. Such measures, in the beginning, could more profitably be concentrated on small collections of water such as small streams and ditches, constituting as they do a source of re-infestation of humans, who in their turn reinfect broods of snails in the irrigation systems.[7] To spread control measures over large volumes of water would involve considerable initial expenditure which would not be justified. More advisable is a pilot-scheme attack against the snail vector, which would resolve itself into the application of some chemical to the small waters. This would be greatly facilitated by the enclosing or cementing of canals. Enclosure would prevent contamination by urine and faeces and by bathing, and make the use of molluscicides unnecessary. The cementing of canals would render denudation of vegetation unnecessary, and enhance the effectiveness of the molluscicide applied. Constant experimentation in the field is needed to determine a nice relationship between the molluscicide in use and water life generally. The destructive effect on water biology of molluscicides such as copper sulphate is appreciated. Trial and error alone will overcome these obstacles. Certain chlorophenols have been used with success in the East.[8] Preliminary field tests in our hands, however, are not very encouraging and this observation is supported by workers on the West Coast of Africa (Sierra Leone).[9]

(2) *Prevention of Contamination.* This form of control is applicable (*a*) to humans and (*b*) to waters.

(*a*) Decent adequate ablution facilities should be provided, with a piped water supply.

(*b*) (i) Latrine accommodation should be provided; one very big difficulty to surmount is the Native's habit of filling up a pit latrine or a water-borne sewage system with stones. (ii) Dams should be built up above the ground so that floodwater contaminated with faeces cannot wash into them. (iii) For the same reason canals should be covered.

These measures are formidable ones to institute in a country where today no latrine accommodation exists, no canals (with one or two exceptions) are cemented or covered, and all washing is done in the canals or dams because there are no ablution facilities. Nevertheless in time it should be achieved.

(3) *Mass Treatment.* As visualized today, mass treatment by drugs requiring injections over a period of at least 7-10 days is not thought practicable. It is time-consuming and expensive, it requires too many highly skilled staff (in the form of doctors and their attendants),

and the response both from the patient and his employer is not encouraging. It entails the treatment of *every Native* except possibly those under 3 months old. Mass treatment by nilodin or miracil D does not produce satisfactory results. Over 200 patients were treated with these drugs, but the follow-up results after 3 months obtained with the first 76 were not thought to justify re-examining any more (see Table VI). The test after treatment for *S. haematobium* was the finding of viable ova in the urine, and for *S. mansoni* the finding of normal-looking ova in two specimens of stool. The results before treatment were based on one examination of stool and urine. During the 3 months' interval the canals and dams were kept as free as possible of snails to minimize risk of reinfestation.

It is felt that until some effective form of treatment is discovered mass treatment of the *whole* Native population in this part of the country is impracticable. In any case it is useless unless some form of attack is instituted simultaneously against the vector. It might, however, be very well worth while to 'mass treat' children before they have had time to become saturated with the flukes and so attempt to prevent the later pathological lesions caused by the disease.

Control measures in Native areas present a far greater problem than the control in irrigated farming areas, where, theoretically, canals and dam systems offer a comparatively easy vector-problem compared with the small-river systems of the Native Reserve areas. Moreover, satisfactory ablution and washing facilities cannot be visualized in the Native Reserve areas.

To summarize, control of the disease involves (1) simultaneous attack on the vector and mass treatment of children only (we still lack a good drug for this purpose), and (2) general sanitary measures combined with cementing or covering-in of canals.

DISCUSSION

It is felt that conditions could hardly be worse in Natives on irrigated farming areas, with intensities of *S. mansoni* at 70% and *S. haematobium* at 80% (on one stool and urine examination, without centrifuge). This is thought to mean that 100% of the population who can be infected with schistosomes are in fact infected with both forms of the disease. Only infants who have not yet been allowed to play, or have not yet been bathed in the water, will be free. In a picture such as this whether the ova of *S. mansoni* and *S. haematobium* found in the survey are viable or not matters not at all. In actual fact no urine or faeces was discovered where the ova were obviously all dead, i.e. black, empty shells or grossly malformed. The important thing is that for all practical purposes the whole Native population is suffering from bilharziasis.

In the Reserve areas the same holds true for *S. haematobium* though the position is not quite so bad for *S. mansoni*.

Wright [10] has estimated that in Egypt the disease costs the country £20 million a year and reduces productivity by 35%. If this is so in Egypt, surely, on a proportionate basis, the same holds good in the Transvaal and other areas of South Africa where bilharzia is known to occur. It is hoped by a comparative study of Natives to be able to estimate to some degree what the disease is costing the country.

Effects

An attempt has been made in Table VII to tabulate the cause and effect of the disease:

(1) *Water Contamination*

(*a*) *By Urine*. This in summer is maximal in all waters that can be contaminated. The children spend most of their day in the ground dams, rivers and streams and of course empty their bladders at the same time. In winter they hardly spend more time than is necessary to wash themselves in the water and this source of contamination is greatly reduced compared to the summer.

(*b*) *By Faeces*. Although faeces has never been found actually deposited in the streams and dams the banks of both are favourite latrine sites for 2 reasons—(i) they afford some privacy and (ii) water is a more satisfactory cleansing material than a stone. Added to this, in summer-time a great deal of the faeces is washed into the water by rains and broken up. Floods will wash it away but not every rain that falls causes a flood. In the Reserve areas the river banks are not so heavily contaminated with faeces, probably because the Natives have further to walk and there is not the same need to seek privacy. Water contamination then is largely caused by (*a*) complete lack of latrine accommodation, (*b*) compounds being concentrated in the immediate vicinity of the water supply, (*c*) the water supply being unprotected, and (*d*) the washing of faeces by the rain into the rivers, dams, canals and small streams.

(2) *Snail Infectivity Rates*

Physopsis. In summer, out of 1,656 snails collected, 116 were discharging mammalian cercariae, i.e. 6·9%; in winter out of 697 snails collected 48 were discharging them, i.e. 6·8% (Table V; winter taken as May to September both inclusive). In the Letaba district 152 out of 1,132 *Physopsis* snails shed mammalian cercariae in summer, i.e. 13·4%; in winter 105 out of 1,062 snails discharged them, i.e. 9·4% (Table VA). There is no significant difference between the figures for the two seasons. There are possibly two cattle schistosomes which would upset these figures for human infectivity rates of *Physopsis*.

Biomphalaria. In summer, out of 3,680 snails collected, 87, or 2·3%, were infected; and in winter out of 1,926 collected, 20, or 1·03%, were infected (Table V). There is a significant difference between these figures. Further, this difference applies not only in Native Reserve areas, where in winter the infectivity rate is nil and in summer 1·3% (Table IIIA) but also in the European farming areas, where in winter the infectivity rate is 1·2% and in summer 3·2% (Table IA). This might be due to any of several reasons: (1) very little contamination of water by faeces occurs in winter (this is in fact true), (2) fluke development is protected in the snail during winter, and (3) the mortality of infected Biomphalaria during winter is high. In the adjoining Letaba district, in summer 44 out of 2,441, or 1·8%, *Biomphalaria* snails shed human-type cercariae; in winter 52 out of 1,040, or

5%, discharged them (Table VA). At the moment this high winter rate of infectivity is inexplicable and is receiving our closest attention.

It is assumed that *Biomphalaria* is the carrier of *S. mansoni* and that *Physopsis* is the carrier of *S. haematobium*. It is appreciated that *S. mansoni* not uncommonly infects the bladder,[11] and that therefore a certain amount of *S. mansoni* can be distributed *via* the urine; are these *S. mansoni* ova in the bladder viable? Certainly the greater number of *S. haematobium* ova in snips from rectum are non-viable.

Snail infectivity rates then appear to be dependant for *Physopsis* on (1) water supply and (2) volume of water and for *Biomphalaria* on (1) latrine accommodation and (2) summer rainfall.

(3) *Chances of re-infection*

These are obviously dependant on continued washing and bathing in the infected water. The chances are somewhat diminished from *Biomphalaria* during winter and remain high throughout the year from *Physopsis*. This last statement refers to snail infectivity rates only; the chances of re-infection from both snails are automatically diminished during the winter when much less time is spent by the children in bathing.

(4) *Bilharzia Intensity*

This is almost certainly dependant, for both forms of bilharzia, on lack of latrine accommodation, for *S. mansoni*, on concentrated housing in close proximity to water in European farming areas and scattered housing further from water in Native Reserves and, for *S. haematobium*, on open water supplies in both types of area.

SUMMARY

1. A picture is briefly given of the extent of the bilharziasis problem over the Northern Transvaal.

2. A more detailed account of the problem covering a small area of the Northern Transvaal has been attempted.

In both (1) and (2) the extraordinarily high incidence of both *S. haematobium* and *S. mansoni* in the Native population is revealed.

3. Control measures and some snail problems are briefly discussed.

TABLE I. NATIVES IN EUROPEAN FARMING AREAS WITH NO PROTECTION FROM BILHARZIA

Age Group	*S. haematobium* Number Examined	Number Positive	Percentage Positive	*S. mansoni* Number Examined	Number Positive	Percentage Positive
0— 4	60	35	58·3	19	15	78·9
5— 9	91	73	80·2	133	87	65·4
10—14	78	65	83·3	182	140	76·9
15—19	59	51	86·4	88	64	72·7
20—29	62	38	61·2	55	36	65·4
30—39	86	52	60·4	68	49	72·0
40—49	76	36	47·3	72	45	62·5
50+	48	24	50	58	27	46·5
Total	560	374	66·7	675	463	68·5

TABLE IA. SNAIL INFECTIVITY RATES IN AREAS WITH NO PROTECTION FROM BILHARZIA

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Biomphalaria												
Number of snails ..	219	363	442	284	178	179	474	339	330	266	135	237
Number discharging cercariae	0	7	15	20	8	2	4	2	2	12	3	6
Percentage discharging cercariae	0	1·9	3·3	7·0	4·4	1·1	0·8	0·5	0·6	4·5	2·2	2·5
Physopsis												
Number of snails ..	150	161	113	136	51	38	74	56	55	22	19	24
Number discharging cercariae	9	8	6	5	3	1	2	4	12	1	1	0
Percentage discharging cercariae	6	4·9	5·3	3·6	5·8	2·6	2·7	7·1	21·8	4·5	5·2	0

TABLE IB. THE NATURAL INCIDENCE IN THE LETABA DISTRICT OF S. HAEMATOBIUM AND S. MANSONI AMONGST NATIVES OF ALL AGE-GROUPS FROM AREAS OF DIFFERENT DENSITIES OF SNAILS AND BILHARZIASIS

Age-Group	*S. haematobium* Number Examined	Number Positive	Percentage Positive	*S. mansoni* Number Examined	Number Positive	Percentage Positive
0— 4	84	26	33·3	84	19	22·6
5— 9	326	162	49·4	326	89	27·3
10—14	426	264	62·0	426	185	43·4
15—19	196	117	59·7	196	63	32·6
20—29	186	71	38·2	186	45	24·2
30—39	222	53	23·9	222	64	28·8
40—49	133	30	22·6	133	30	22·6
50+	42	12	28·6	42	6	14·3
Total	1,615	735	45·5	1,615	501	31·0

TABLE II. NATIVES IN EUROPEAN FARMING AREAS WITH SOME PROTECTION FROM BILHARZIA

Age-Group	*S. haematobium* Number Examined	Number Positive	Percentage Positive	*S. mansoni* Number Examined	Number Positive	Percentage Positive
0— 4	86	21	24·4	109	13	11·9
5— 9	73	42	57·5	85	24	28·2
10—14	35	28	80	42	17	40·4
15—19	29	23	79·3	26	9	34·6
20—29	47	24	51·0	42	18	42·8
30—39	82	45	54·8	80	31	38·7
40—49	64	30	46·8	58	17	29·3
50+	19	6	31·5	18	6	33·3
Total	435	219	50·3	460	135	29·3

TABLE III. NATIVES IN RESERVE AREAS

Age-Group	*S. haematobium* Number Examined	*S. haematobium* Number Positive	*S. haematobium* Percentage Positive	*S. mansoni* Number Examined	*S. mansoni* Number Positive	*S. mansoni* Percentage Positive
0—4	22	10	45·4	20	4	20
5—9	21	15	71·4	126	34	26·9
10—14	30	22	73·3	232	63	27·0
15—19	53	42	79·2	89	40	44·9
20—29	74	54	72·9	52	26	50
30—39	50	31	62	33	16	48·4
40—49	23	9	39·1	18	8	44·4
50+	11	4	36·3	7	2	28·5
Total	284	187	65·8	577	193	33·4

TABLE VI. PATIENTS TREATED WITH NILODIN AND MIRACIL D

	S. haematobium Percentage positive before treatment	*S. haematobium* Percentage positive 3 mths. after treatment	*S. mansoni* Percentage positive before treatment	*S. mansoni* Percentage positive 3 mths. after treatment
Patients treated with nilodin 130 mg. per kg. body-weight (46)	80·4	47·8	69·5	71·7
Patients treated with miracil D (30)	60·0	66·6	70	63·3

TABLE IIIA. SNAIL INFECTIVITY RATES IN NATIVE RESERVE AREAS

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Biomphalaria												
Number of snails ..	163	162	281	124	33	70	39	33	78	92	101	60
Number discharging cercariae	7	2	0	0	0	0	0	0	0	4	0	0
Percentage discharging cercariae	4·2	1·2	0	0	0	0	0	0	0	4·3	0	0
Physopsis												
Number of snails ..	119	187	115	123	67	63	52	49	31	51	53	16
Number discharging cercariae	13	18	8	13	5	12	1	3	3	5	2	0
Percentage discharging cercariae	10·9	9·6	6·9	10·5	7·4	19·0	1·9	6·1	9·6	9·8	3·7	0

TABLE IV. S. HAEMATOBIUM AND S. MANSONI INTENSITIES IN NATIVES IMMIGRANT TO EUROPEAN FARMING AREAS FROM PORTUGUESE EAST AFRICA

Time in European Farming Areas (months)	*S. haematobium* Number examined (all ages)	*S. haematobium* Number Positive	*S. haematobium* Percentage Positive	*S. mansoni* Number examined (all ages)	*S. mansoni* Number Positive	*S. mansoni* Percentage Positive
0—3	128	82	64·0	121	49	40·4
4—6	44	31	70·4	43	24	55·8
7—12	76	60	78·9	63	41	65·0

TABLE V. TOTAL SNAIL INFECTIVITY RATES FOR WHOLE AREA

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Biomphalaria	485	687	932	446	224	297	535	387	483	435	335	360
Number infected	11	10	15	22	9	2	4	2	3	20	3	6
Percentage infected ..	2·2	1·4	1·6	4·9	4·0	0·6	0·7	0·5	0·6	4·5	0·8	1·6
Physopsis	355	475	319	296	144	137	162	144	110	79	88	44
Number infected	23	35	28	21	10	13	3	7	15	6	3	0
Percentage infected ..	6·4	7·3	8·7	7·0	6·9	9·4	1·8	4·8	13·6	7·5	3·4	0

TABLE VA. SNAIL INFECTIVITY RATES IN LETABA DISTRICT

	1953 Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	1954 Jan.	Feb.	Mar.	Apr.	May
Biomphalaria												
Number of snails ..	176	151	168	391	407	437	616	366	246	242	127	154
Number discharging cercariae	9	8	11	24	12	9	5	2	12	0	4	0
Percentage discharging cercariae	5·1	5·3	6·6	6·1	3·0	2·1	0·8	0·5	5·0	0	3·1	0
Physopsis												
Number of snails ..	224	278	144	253	140	146	151	90	175	207	223	163
Number discharging cercariae	32	32	4	20	38	12	27	17	12	22	24	17
Percentage discharging cercariae	14·3	14·6	2·8	7·9	27·9	8·2	17·9	19·0	6·9	10·6	19·5	10·4

TABLE VII

Cause	European Farming Areas: (1) *No protection afforded*	European Farming Areas: (2) *Some protection afforded*	*Native Reserve Areas*
Housing	Concentrated in compounds in immediate vicinity of water	Concentrated in compounds in immediate vicinity of water	Scattered
Water supply (bathing and washing)	Irrigation systems. Sunken dams and open canals, small streams	Built-up dams, closed canals, standpipes, large rivers etc.	Small streams and rivers which pool up in the winter
Latrine accommodation	Nil	Nil	Nil
Volume of water			
Summer	100%	100%	100%
Winter	100%	100%	100%
Rainfall	In summer	In summer	In summer
Effects			
Water contamination*			
Urine	Maximal in summer. Moderate in winter	Maximal to nil in summer. Low in winter	Maximal in summer. Moderate to minimal in winter
Faeces	Maximal in summer. Low in winter	Never maximal at any times	Low to moderate in summer. Very low in winter.
Snail infectivity rate			
Physopsis	Winter (May to Sept.) 8·02% Summer (Oct. to Apr.) 4·7%	Winter ? Summer ?	Winter 9·1% Summer 8·8%
Biomphalaria	Winter (May to Sept.) 1·2% Summer (Oct. to Apr.) 3·2%	Winter ? Summer ?	Winter 0 Summer 1·3%
Bilharzia intensity			
S. haematobium	High. Total 66%. Over 80% age-groups 5-19	Moderate. Total 50%. Over 80%, age-groups 10-19	High. Total 65%. Over 70%, age-groups 5-29
S. mansoni	High. Total 68%. Over 70%, age-groups 0-4, 10-19, 30-39	Moderate. Total 29%. Over 40%, age-groups 10-14, 20-29	Moderate. Total 33%. Over 40%, age-groups 15-49
Chances of re-infection			
S. haematobium	High throughout the year	?	High throughout the year
S. mansoni	High during summer. Moderate during winter	?	Low during winter

* Based on general observations, rainfall, volume of water and habits of Natives; not on snail infectivity rates

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