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BILHARZIASIS SURVEY IN BRITISH WEST AND EAST AFRICA, NYASALAND AND THE RHODESIAS *

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SYNOPSIS

The author, in his capacity as a WHO consultant, undertook a survey of bilharziasis in British West and East Africa and Nyasaland during 1950-51. The information thus obtained has been revised and brought up to date and is recorded in the present article together with similar observations on Northern Rhodesia, which was not visited, and on Southern Rhodesia, the author's own country. In Part I, each country is dealt with in turn. The history of the disease and the findings of field surveys are reviewed, and, wherever possible, personal observations have been included. The fact that the information is of a scanty and incomplete nature is an indication that further local studies in all areas are badly needed. In Part II an attempt is made to survey the situation from the point of view of the various aspects of the subjects—methods of obtaining morbidity data, intensity of infection, effects of the disease on human health, treatment, and the molluscan vectors.

PART I. EPIDEMIOLOGICAL DATA

The Joint OIHP/WHO Study Group on Bilharziasis in Africa, meeting in Cairo in October 1949, recommended that the

" surveys on the geographical distribution of human bilharziasis and its vector snails . . . should be carried out by individual experts to be selected and sent by WHO to the countries and territories in which the presence of bilharziasis is known or suspected, but for which adequate information is not available."

As part of this plan, British territories in West, East and Central Africa were visited in 1950 and 1951 and the account given here is based on the

* This is the sixth of a series of articles, published in the *Bulletin of the World Health Organization*, describing the epidemiology of bilharziasis in the African and Eastern Mediterranean regions. The preceding articles are:

Gillet, J. & Wolfs, J. (1954) Les bilharzioses humaines au Congo Belge et au Ruanda-Urundi, *Bull. Org. mond. Santé*, **10**, 315

Gaud, J. (1955) Les bilharzioses en Afrique occidentale et en Afrique centrale, *Bull. Org. mond. Santé*, **13**, 209

Gaud, J. (1955) Les bilharzioses à Madagascar et aux îles Mascareignes, *Bull. Org. mond. Santé*, **13**, 259

Ayad, N. (1956) Bilharziasis survey in British Somaliland, Eritrea, Ethiopia, Somalia, the Sudan, and Yemen, *Bull. Wld Hlth Org.*, **14**, 1

Azim, M. A. & Gismann, A. (1956) Bilharziasis survey in south-western Asia, covering Iraq, Israel, Jordan, Lebanon, Sa'udi Arabia and Syria: 1950-51, *Bull. Wld Hlth Org.*, **14**, 403 reports of these visits and on a study of the literature which has appeared since.

The Gambia

The Colony and Protectorate of the Gambia has an area of 4132 square miles and consists of two long strips of territory, each 10 miles wide, stretching along both banks of the Gambia River and running 300 miles east of the Atlantic Ocean. The climate on the coast is one of the best in West Africa. The rainy season is from June to October.

Review of available data

The first record of bilharziasis in the area, in the reports available for study, appeared in the annual report of the Colony's Medical Department for 1925, although it is probable that the disease was endemic long before that time. Only *Schistosoma haematobium* infection has been reported, and there appears to be no record whatsoever of *S. mansoni.*

The disease has been reported in all areas of the Colony and Protectorate, but along the coast and around Bathurst, the number of cases is so small that local infection is unlikely. The prevalence increases progressively from west to east up the Gambia River and, in the Upper River Division, infection-rates as high as 60% have been recorded. On the whole, the intensity of infection is light, the more serious and chronic complications are rare and there is little demand by the people themselves for treatment. In 1953, only 93 in-patients and 517 out-patients were treated in hospitals and 228 at rural dispensaries (see Table I).

TABLE I. BILHARZIASIS IN THE GAMBIA

Period	In-patients		Hospital out-patients	Dispensary patients
	cases	deaths		
1946	12	—	102	129
1947	10	1	123	144
1948	5	1	138	121
1949	11	—	138	122
1950	21	1	126	164
1951	22	1	155	442
1952	7	—	258	485
1953	93	—	517	228

Field surveys

Three field surveys have been carried out in this region :

(a) The first, in 1945, was undertaken as part of a general medical survey by two Royal Army Medical Corps officers. Urine specimens from 1300 boys aged 5-14 years were collected and examined and 181 (13.9%) contained eggs of *S. haematobium*. When the results were analysed by administrative districts from west to east up the Gambia River, positive urines were found as follows: Kombo Division, 3/68; South Bank, 6/314; North Bank, 18/309; McCarthy Island, 28/249; and in the Upper River Division, 126/372.

(b) The second survey, carried out by Dr Ross in 1947 concurrently with a leprosy survey, was confined to three areas only. In the western area, no positive cases were found, in McCarthy Island 215/619 were positive and in the Upper River Division 558/1556 were positive.

(c) The third survey was made by Duke & McCullough [26] and over 1200 persons, mostly children between 3 and 15 years, were examined in 37 villages. The infection-rate was found to vary markedly from village to village. Apart from one focus on the northern bank of the Gambia River, no cases were encountered in the Western Division. However, the infection was found in the eastern part of the Central Division and in villages of the Upper River Division, both on the banks of the river and further away from it. In the river villages and swamp areas, the infection-rates in both adults and children were low (12%-14%), but in villages in the laterite soil area away from the river, where domestic water-supplies are obtained from wells and perennial ponds, infection-rates of 72.7% were recorded in children, as compared with 38.8% in adults. Despite the authors' statement that the disease is mild and regarded locally as unimportant, they record haematuria, frequency, bed-wetting and dysuria as common symptoms and signs in children. It is also noted that pyuria and urinary calculi are frequently encountered. When the infection is of such an intensity that these signs, particularly the presence of calculi, are common, it cannot be held that the disease is of little consequence.

McCullough & Duke [40] conducted, at the same time as the survey of the human population, one of the few snail surveys which have been carried out in this area.

The only planorbid snails collected were *Biomphalaria alexandrina pfeifferi*, which were found in six localities in the extreme west of the territory in clear, gently flowing, large bodies of water. As stated previously, infections of human beings with *S. mansoni* have not so far been recorded in the Gambia, but now that the presence of the potential vector has been established, the danger of human contamination must not be excluded In fact, Gaud,[28] in a map showing the distribution of *S. mansoni* infein West Africa, indicates the Gambia and the southern part of the Senegal province of French West Africa as being slightly infected. There are, however, no records of this infection in the Colony.

Of the other potential snail vectors mentioned by McCullough & Duke,[40] *Bulinus (Physopsis) africanus* were found in large numbers in only one locality—probably the northernmost habitat of this species in West Africa. *Bulinus (Bulinus) truncatus* were quite often found together with *Bulinus (Physopsis) africanus*, but were more widespread. *Bulinus (Bulinus) truncatus* from the Gambia were successfully infected with a Gold Coast strain of *S. haematobium*. *Bulinus (Pyrgophysa) forskalii* proved to be the most widely distributed potential vector, being ubiquitous in the eastern half of the territory and occurring focally elsewhere. Urinary bilharziasis is endemic in districts far beyond the areas where *Bulinus (Physopsis) africanus* and *Bulinus (Bulinus) truncatus* occur and where only *Bulinus (Pyrgophysa) forskalii* is present. McCullough & Duke found *B. (P.) forskalii* in areas where it appeared to be the only potential vector represented, shedding cercariae of human type in 1%-5% of the snails examined. These authors' incrimination of *B. (P.) forskalii* has been disputed by Wright,[57] who denies that the snails described are in fact of this species and suggests that they are *Bulinus senegalensis* or, as tentatively named by himself, "*Bulinus ludovicianus.*" These claims and counter claims are an interesting illustration of the sad state of knowledge of the identity of vector snails and their infectivity by the bilharzia parasite.

None of the vector snails were found in the Gambia River itself, probably because of the high salinity of the water far up this tidal river. The Gambia River is navigable for ocean-going vessels as far as 140 miles from its mouth and is tidal throughout its course in the territory. The following data show estimates of the river's salinity:

Miles from Bathurst (coast)	*Percentage of Nace*
40	2.10
60	3.05
80	1.42
100	0.72
120	0.33

The river generally has steep banks and in the rainy season it may rise as much as 30 feet (about 10 metres). The factors of salinity, the flood rise and the long tide probably all contribute to keep the main river free from snails. The findings of the 1945 survey confirmed the absence of vector snails in the main river.

Treatment

It would appear that the only patients treated are persons attending medical units who have presented symptoms of infection. According to the medical report of the Colony and Protectorate for 1953 only 838 cases were treated at hospitals and dispensaries. The intramuscular injection of antimonial preparations is the form of treatment which is most widely employed.

Sierra Leone

The Colony and Protectorate of Sierra Leone has an area of nearly 28 000 square miles and lies on the Gulf of Guinea with a coastline 210 miles long. It extends inland to the highlands of which the northern slope is the source of the Niger River. The Colony consists of the small Freetown peninsula and the neighbouring area of mainland in which released slaves settled in the middle of the last century. There is a big difference in education and culture between this group and the more primitive tribes living in the Protectorate. The population was estimated in 1952 to be about 2 000 000. The main resources of the territory are agricultural, but diamond and bauxite mining is increasing in importance.

Review of available data

Infections with *S. haematobium* have been recognized in Sierra Leone since 1909 and as early as 1920 it was noted that 46/150 boys attending the Chiefs' School at Bo were infected with *S. haematobium* but appeared to be little affected by the disease. Since the infected boys had their homes all over the Protectorate it was inferred that the disease was widespread. Between 1923 and 1925, Blacklock & Thompson [18] studied the disease and concluded that *S. haematobium* infections were common, particularly in the eastern part of the Protectorate. They reported, for example, infection-rates of 199/668 in males, 106/140 in females and 81/360 in both sexes in the age-group of 3 to 10 years. *Bulinus (Physopsis) globosus* were also found and some were shedding cercariae of human type. In an appendix to the annual report of the Medical Department of the Colony and Protectorate for 1952, Blacklock described an attempt to deal with the disease at Kaiyima, in the north-western part of the Protectorate, where 30% of the *Bulinus (Physopsis)* spp. were infected. The methods employed were to provide water-supplies in the villages and to encourage efficient refuse and faeces disposal. The initial results were encouraging but were not pursued and were soon abandoned.

In 1933, Peaston [48] reported that a focus of *S. mansoni* infection existed at Kabala in the most northerly extremity of the territory and expressed the opinion that the disease had recently been introduced into the area from French Guinea, where it had been recorded previously.

Gordon, Davey & Peaston [36] in a most painstaking investigation of bilharziasis which is by far the best of its kind in British West Africa established that :

(a) *S. haematobium* infections were widespread in the Protectorate and that *Bulinus (Physopsis) globosus* was the vector;

(b) *S. mansoni* infections were confined to a group of villages at Kabala in the far north and that the snail incriminated in this case was *Planorbis pfeifferi* (presumably *Biomphalaria alexandrina pfeifferi*);

(c) No infections were contracted on the Freetown peninsula and that the vector snails were absent from this locality.

Thereafter the disease seemed to excite little interest until 1945. The information published in annual reports was scanty and it would appear that the hospital cases recorded were only those which were admitted specifically for treatment of bilharziasis. The laboratory figures quoted are vitiated, as they apply almost exclusively to patients from the Freetown area where the disease is not known to occur.

In 1945, bilharziasis again began to attract some attention and it was noted that *S. haematobium* infections were common and severe in the area of Boadjibu, near the eastern border with Liberia, where the health of the inhabitants was generally poorer than in other places in the neighbourhood. The results of a survey showed that 10/14 men, 26/30 women and 71/91 children were infected. The investigators noted that the inhabitants were often ill and that the number applying for treatment was high. The local population know the disease as " red gonorrhoea ", a term much in use in British West Africa. Table II gives the relevant hospital statistics for the Colony.

TABLE II. BILHARZIASIS IN SIERRA LEONE

Period	In-patients		Out-patients
	cases	deaths	
1932-34	221	1	—
1935-37	259	2	83
1943-45	73	—	354
1946-48	72	3	434
1949-51	47	1	527
1953	25	—	311
1954	20	—	342

Field surveys

Gerber [35] in 1950 began a most intensive and careful investigation of bilharziasis at Boadjibu. He found 1251/1890 *S. haematobium* positive, an infection-rate tallying closely with Blacklock's finding of 68% in the same area.[17] Gerber examined urine specimens by microscopic and macroscopic methods. In 1527 urines examined by both methods, he found that 1060 (67%) were positive. Of these, 1006 were microscopically positive and 817 macroscopically positive.

He analysed his results further by age-groups. Miracidia were hatched from 91% of the microscopically positive urines in the 6-12-year age-group, the proportions in other age-groups being 89% in 13-20 years, 75% in 21-30 years, 61% in 31-40 years, and only 57% in older people. This interesting investigation stresses the value of examining the younger age-groups to ascertain the prevalence of *S. haematobium* infections. The macroscopic method is sufficiently accurate for the examination of children and adolescents. The discrepancy between the mircacidia hatching-rate and the presence of eggs in the urine of the older people confirms the view that children, in whom the infection is more recent and the eggs more easily hatchable, constitute a greater public health problem than adults who, by social tradition, are unlikely to contaminate streams and in whose case the eggs are, at any rate, less likely to be viable.

Samples of snails collected in the area were identified by Dr Rees at the British Museum as *Physopsis globosa, Physopsis africana, Bulinus forskalii, Lymnaea nyanzae* and *Planorbis stanleyi.*

During the course of the investigations in 1953, the urinary bilharziasis infection-rate in schoolchildren in the Boadjibu-Blama area was estimated to be up to 70%. It is interesting to note that when Dr Blacklock investigated the situation at Monghere 25 years before, he found the population heavily infected but could not discover any potential vectors. The infection-rate in children at Monghere was still about 50% at the time of the 1953 urine survey, yet again no snails could be found. This is a good example of the importance of repeated searches for molluscs at all times of the year.

Personal observations

As a result of the work of Gordon and his colleagues [36] more is known in Sierra Leone about the general distribution of bilharziasis and the snail vectors than in any of the other three territories in this region. Their work was, however, directed to a limited area and there is need for more investigation to delimit the western border of the area infected with *S. haematobium.*

The disease, certainly as far as *S. haematobium* infections are concerned, is probably of light intensity, but this cannot be proved until more post-mortem studies have been carried out in the endemic area.

Bilharziasis, at the present time, does not seem to be a very urgent health problem in Sierra Leone, but the survey work now in progress should be continued until the extent of the area infected with *S. haematobium* is known. The size of the *S. mansoni* focus at Kabala should also be ascertained, because if it is reasonably small an effort at eradication by using molluscicides would be well worth trying.

The fact that the numerous streams of the Freetown peninsula are free from vector snails is most interesting. As general conditions seem ideal for the furtherance of snail existence, it would be useful to know what factors intervene to prevent the streams from being infected. It is hard to believe that the mangrove swamp area between the peninsula and the mainland has acted as an effective barrier to molluscs for so long.

There appears to be little immediate danger of a spread and an increase in the intensity of the disease as a result of irrigation development, since such schemes seem rather nebulous at the present time.

Gold Coast and British Togoland

The Colony and Protectorate of the Gold Coast and the Trust Territory of Togoland lie on the coast of the Gulf of Guinea. The northern territories have a savannah character, becoming more arid to the north. In the south this terrain merges into a well defined forest belt in Ashanti. The coastal strip is on the whole dry and arid. The Volta River forms the main drainage system and by means of its barrage hydro-electric power and irrigation are now being developed. The population was estimated in 1953 to be 4 478 000. The African population, especially along the coast and in Ashanti, is more highly developed than in any other British territory in West Africa and was the first to be granted self-government.

The country gives the impression of great agricultural wealth and the cacao industry and gold-mining are the mainsprings of prosperity. Tsetse fly and trypanosomiasis constitute a serious problem in the north.

Review of available data

It is surprising to note that, despite the high state of development of the Gold Coast and the advanced medical services, so little has been published on bilharziasis in this area and so little is known of the disease. The annual reports of the Medical Department show, however, that the disease has been recognized for a long time. The earliest report available for study—that of 1929—notes that when a total of 337 patients admitted to the Gold Coast Hospital in Accra had their urine examined, 33 specimens, all of which were from male patients, were found to contain eggs of *S. haematobium*. It was found that in only a few cases was there naked-eye evidence of blood in the urine specimen. In a series of 45 post-mortem examinations at the Gold Coast Hospital, five showed evidence of bilharziasis of the bladder. Reference was made to the common occurrence of cirrhosis and primary cancer of the liver, and it was suggested that these conditions were associated with bilharziasis. In 1930, the disease was stated to be common in certain areas in the north of the territory, particularly in the extreme north-east, at Navrongo, Zwarungu and Nangodi, where it was reported to be rife. In 1932-38 general statements appeared concerning the treatment of bilharziasis in a number of patients in the coastal area within a radius of about 50 miles from Accra; Winneba, Oda and Swedru, with Akuse and Ada on the lower Volta, were especially mentioned. The hospital-treatment figures show no undue prevalence except at Akuse. In 1932, it was stated that bilharziasis was the least prevalent helminthic disease treated in hospitals and dispensaries, but it is probable, because the symptoms were either ignored by the sufferers or confused by them with gonorrhoea, that the infection was more common than was believed at the time. It is therefore surprising to learn that, despite this opinion, the trouble was taken to make experimental plantings of *Balanites aegyptica* along water courses. The fruit of this tree has been claimed to have molluscicidal properties.

In 1938, similar general statements were made, but Winneba, Ada, Akuse, Oda, Bawku and Navrongo were mentioned as stations where bilharziasis was treated in fair numbers. Treatment of cases was on the usual lines, using the intramuscular antimonials, with the intravenous route employed only at some of the larger hospitals.

Available hospital statistics, covering the period 1940-51, are given in Table III.

TABLE III. BILHARZIASIS IN THE GOLD COAST

Period *	In-patients		Out-patients	
	cases	deaths	male	female
1940	165	1	945	165
1941	171	6	673	153
1942	156	2	773	261
1943	138	2	739	193
1944	178	5	817	251
1945	123	2	1 246	276
1946	229	10	1 447	417
1947	344	16	2 019	725
1948	587	11	3 270	1 417
1950	606	25	3 669	1 299
1951	581	2	3 219	1 014

* Figures for 1949 are not available.

Personal observations

During the author's visit to the Gold Coast, is was not possible to visit Ashanti and the northern territory, and the observations were restricted to the Accra Plain between Accra and the lower Volta, the southern fringe of the forest area north of Accra and into Togoland.

North of Accra, at Adieso, evidence of *S. haematobium* infection was often found in schoolchildren. The majority had frank haematuria and a surprising number admitted to having nocturnal frequency, a symptom which may indicate early bladder damage and fairly long-standing infection.

At the time of the author's visit, the rivers in this locality were practically dry but a number of *Bulinus (Physopsis) globosus* could be found by scratching in the mud beds. Some of these snails were still alive despite the desiccation to which they had been subjected. Further west, a larger river, the Nyensu, was examined and notwithstanding its general suitability for *Bulinus* s.l. only a few planorbids were recovered. In the Accra plain itself, the country was arid, all river beds crossed were quite dry, and no snails whatsoever were found. The rivers come down from a steep escarpment and there is no doubt that during the wet season, the streams which reach the plain provide suitable *Bulinus (Physopsis)* habitats.

The Volta River was investigated carefully at a number of sites on its western bank. It is a noble stream, generally free from pollution and running fairly swiftly between high banks. Only meagre collections of vegetation were seen in the main river and no vector snails were found. A number of people in villages on the bank were questioned, and all claimed freedom from the disease and stated that only those living along tributary streams suffered from " red gonorrhoea ".

In British Togoland, the country is much more mountainous and, despite the general aridity, water was found in many of the streams in the level valley bottoms. *Bulinus (Physopsis) globosus* were found only at one or two sites. Dr G. A. Owen,[47] the Medical Officer at Ho, in the southern portion of the British mandated territory, has been conducting a general parasitological survey of village children. He has been using a miracidial hatching-technique only, examining a single specimen of urine from each case. This simple examination revealed *S. haematobium* infection in 303/2823 (10.7%).

The prevalence in villages varies very much from place to place. In Kapdze, for example, 223/504 (over 40%) of the children were infected, while in Akoefe, Iokokoe, Dzorkze, and Dzolopayene no cases were discovered in 304 children examined. Dr Owen's stool survey revealed a fairly consistent 25% infection-rate with hookworm, but no evidence at all of *S. mansoni* infection.

Nigeria

Nigeria is the largest Colony in the British Commonwealth. It is a Federation consisting of three Regions (Northern, Eastern and Western), the Federal capital, Lagos, and the Trust Territory of the Cameroons. The Colony has every variation of climate and terrain: coastal swamps, heavily forested high rainfall areas, grasslands, a superimposed isolated plateau with an almost temperate climate and finally a large area of semi-arid country, merging in the north into the southern edge of the Sahara Desert.

The Northern Region is mainly Moslem and is based on an agricultural economy with ground-nuts as the principal cash crop. In certain parts, particularly the Kano Province, it is heavily populated and the agricultural management of the land must be sound to maintain, as it does, populations as dense as 500 persons per square mile. The Eastern Region's economy is based on coal and the export of timber. The Western Region is probably the most advanced area and is prosperous, cacao being the source of much wealth.

The medical administration has had important problems to deal with, particularly trypanosomiasis and paralysing epidemics of disease such as the epidemic of cerebrospinal meningitis of a few years ago which resulted in 93 000 cases and in 14 000 deaths.

Review of available data

Bilharziasis has been known to exist in Northern Nigeria since time immemorial. According to legend, the Fulani tribe brought the disease with it in its migration from the Upper Nile basin. In the 1929 report of the Medical Department, it is stated that the disease had been known for a very long time and was widespread in distribution. In the same year, high infection-rates were noted at Katsina and Zaria in the north and Ibadan in the south-west. In schoolchildren at Katsina, infection-rates of 65%-95% with *S. haematobium* were recorded, a rate of 75% was noted near Zaria and at one school at Ibadan 73% of the children were found to be infected. At Kaduna, a number of *S. mansoni* cases were reported and 19/1065 stools examined were positive. An artificial lake in the public gardens at Kaduna was found to contain large numbers of planorbid snails.

In 1930, laboratory reports indicated that the coastal area of the Eastern Region, near Port Harcourt and Calabar, was only rarely infected. *S. mansoni* was found in 11/1373 stool specimens at Kaduna. School surveys in the Western Region showed some heavy urinary infections: 56/104 schoolboys at Abeokuta and 41/180 children at Ibadan. A year later, a survey in Lagos showed that 5/1025 children had urinary infections. In 1932, a special study of bilharziasis was made at Zaria and of 4574 males examined 32% were found to be infected. When studied by age-groups, the rate of infection was shown to increase rapidly up to the age of 14, when it reached 63%, and to fall to 12.5% in a group of elderly men. The following year in a continuation of this study it was demonstrated that *S. haematobium* infections were common and widespread throughout the Northern Region and that *S. mansoni* foci were quite limited. The possibility of the natural control of vector snails with the fruits of *Balanites aegyptica* was discussed and it is interesting to note that some of the trees planted at Katsina were still growing in 1951.

Interest in bilharziasis in Nigeria languished thereafter, as it apparently did in all British colonial territories, until the Second World War. Lovett-Campbell [39] recorded 63 *S. haematobium* infections and 15 *S. mansoni* infections in 582 army recruits from various parts of the Northern Region. He made the very significant statement that many of these cases broke down under the stress of military training, the general complaint being back-ache, caecal tenderness and a mucoid diarrhoea.

An interesting phenomenon occurred during the war when troops training for swamp warfare at Epe on a lagoon 50 miles east of Lagos were infected on a large scale. Although local inhabitants had suffered from the disease, the training area was held to be safe because of the salinity of the water in the lagoon, snails never having been known to infest fresh-water streams. The infection had the most serious consequences and delayed the departure of the troops for active service in the Burma campaign. The European element of the formation was the most seriously affected.

Subsequently, Epe was surveyed by a Medical Field Unit, and the results of a urine survey of 1940 persons out of an estimated total population of 8000 are of some interest. From the data in Table IV an over-all infection-rate of 76% can be calculated; and the figures by age-group show the high proportion of children infected. It is also interesting to note that in this investigation one case passing *S. mansoni* eggs in the urine was discovered; the presence of this worm had not previously been recorded in Southern Nigeria. It is therefore not surprising that when European troops were brought into close contact with a heavily infected local population of equal number an almost explosive outbreak of bilharziasis with serious morbidity occurred among them.

In 1949, 188 pupils were examined at Kaduna college, which draws its students from all parts of the Northern Region. The highest rates were found in those pupils whose homes were in the arid northern and eastern districts of the Region. Benue Province produced no infected students, but when the Medical Field Unit conducted a survey of this area, *S. haematobium* infection-rates of from 16% to 56% were recorded. It is not advisable to base an estimate of the distribution of bilharziasis in a locality on the examination at some centre of a few people from that locality.

The published hospital statistics on bilharziasis are of little value and are not, in any case, available after 1948, when bilharziasis ceased to be

TABLE IV. URINARY BILHARZIASIS IN EPE, NIGERIA

Age-group (years)	Number examined	Positive		Negative	
		males	females	males	females
0-5	186	58	65	32	31
6-10	768	474	152	103	39
11-15	481	371	53	46	11
16-20	114	78	10	17	9
21-29	151	69	22	41	19
30 +	240	103	27	96	14
Total	1 940	1 153	329	335	123

recorded separately from the other helminthiases. It is interesting to note that a high case-fatality rate was experienced in 1930-35. This may indicate that the organic damage in persons ill enough to seek specific treatment for bilharziasis had been sufficiently serious to increase the toxic effects of antimony. From 1930 to 1948, 16 899 cases were treated in hospitals and 73 deaths (0.4%) were recorded.

Field surveys

The system of Medical Field Units in Nigeria, particularly in the north, is an especially useful means of assessing the distribution of bilharziasis. Statistics based on hospital admission figures and laboratory examinations are notoriously misleading, but the Field Unit obtains a more accurate picture of the situation by examining whole groups of the population. The Medical Field Units have to undertake many other duties, including the diagnosis and treatment of other diseases such as cerebrospinal meningitis and trypanosomiasis, so that the bilharziasis picture must be built up from a large number of rather disconnected observations, in many instances, unfortunately, recorded only as a percentage of an unspecified sample of the population.

In 1951-52, it was said that it was difficult to assess the importance of the disease but that urinary bilharziasis was common in the Northern Region and rare in the Eastern and Western Divisions. In parts of the Cameroons, especially in the area of the crater lakes of the Kumba Division, there was, however, a high incidence.

In the following year, it was stated that the disease was especially prevalent in the swampy areas of the Northern Region along the courses of the great rivers, but that it might be equally high in villages where the only water-supply was obtained from borrow pits. The peak prevalence was said to occur in children, although adults who fish or who work on irrigated lands were also considered to be highly subject to the disease. The degree of infestation was claimed to be light, and cancer of the bladder and hepatic cirrhosis were rarely seen. In the Eastern Region, only 42 cases were treated in hospitals, and field surveys in the Rivers, Onitsha and Banauda Provinces revealed no cases whatsoever. (See Table V for the percentage distribution of bilharziasis in Nigeria.)

TABLE V. BILHARZIASIS IN NIGERIA AS REVEALED BY SURVEYS CARRIED OUT BY MEDICAL FIELD UNITS

Year	Region	Province or area	Distribution [a]
1947	Northern	Plateau	50 % [b]
1948	Northern	Adamawa (Yola)	Common
1949-50	Northern	Sokoto (Gusan)	12 %
	"	Bornu (Maiduguri)	18 % [c]
1950-51	Northern	Plateau	Rare in Jos Division
	"	Sokoto	10 %-50 %; *S. mansoni* infections, 0.2 %-1.0 %
	"	Bornu	13 %-18 %; *S. mansoni* infections, 0.6 %
	"	Benue	18 %-47 %
	Western	Abeokuta	12 %
	"	Colony (Epe)	63 %-83 %; *S. mansoni* infections, 2.0 %
	Eastern	Cameroons (Kumba)	69 %
	"	" (elsewhere)	1/80 000
1951-52	Northern	Sokoto (Rabah)	23 %
	"	" (Zamfara Valley)	50 %
	"	Plateau (Jos)	0.9 % [d] *S. mansoni* infections, 1.4 % [d]
	"	Bornu (near Biu)	30.5 %; *S. mansoni* infections, 3.6 %
	Western	Benin (Ibadan)	43 %
1952-53	Northern	Sokoto (Argungu)	90 % [e]
	Western	Abeokuta (Egbado)	100 % [d]

[a] *S. haematobium* infections, unless otherwise noted
[b] Schoolchildren and 11 044 treated cases
[c] 1250 persons examined
[d] Schoolchildren
[e] 87 schoolboys

The laboratory figures for the year 1952-53 are as follows:

Region	*Stools examined*	S. mansoni *positive*	*Urines examined*	S. haematobium *positive*
Northern	21 246	198	23 826	1726
Eastern	17 404	5	16 020	143
Western	13 910	24	14 465	304

Personal observations

The author's own observations and surveys were limited to the Northern Province, as transportation difficulties prevented a visit to the Epe focus, which must be of great epidemiological interest. The author was able to make observations at Kaduna, Katsina and Kano and at other localities during his journeys between these centres.

The visit took place in the dry season and there was very little surface water. Nevertheless, there was plenty of evidence of snails and numerous specimens of *Bulinus* s.s., *Bulinus (Physopsis)* and *Lymnaea* were found. *Bulinus (Physopsis) globosus* were having no difficulty in hibernating in the beds of streams and in isolated mud holes.

At Rigachicken, near Kaduna, a number of schoolchildren were examined. The cercarial antigen skin-tests were often positive, some blood being found in urines collected from these cases, and miracidia were hatched and easily observed. Few of the children complained of their disease and seemed to accept a heavy haematuria as a natural event of childhood and adolescence.

In Katsina the surrounding walls and most of the constructions are built of mud blocks dug out from large borrow pits throughout the city. Some of these act as sumps for street drainage and others are used as laundries and places for personal ablutions. Many of these borrow pits are devoid of vegetation, but in others a profuse horizontal vegetation of *Pistia* has been established. In a number of these pits *Bulinus (Physopsis) globosus* were found without difficulty. In one pit which was absolutely devoid of living vegetation, no living snails were found but a " beach " at one end was composed of the shells of *Bulinus (Pyrgophysa) forskalii.* At Kano, a similar situation exists, many hundreds of borrow pits being seen in the city as well as in the agricultural areas within the walls. Here, however, snails were found only after much searching.

The general impression gained is that *S. haematobium* infection is almost endemic in the Northern Province, but is generally of light intensity. It is, however, more intense that in any of the areas observed in the other West African colonies. Elsewhere in Nigeria, the disease is of more patchy distribution, but where it occurs it is generally very prevalent, such as at Epe, Ibadan and Abeokuta. Infections with *S. mansoni* appear to be rare and few cases have been discovered in the large number of stool examinations carried out by laboratories and the field units. These field units have, however, in their urine surveys, shown the existence of large numbers of cases of *S. haematobium*, particularly in rural areas where the inhabitants never ask for treatment for bilharziasis.

The borrow pit snail habitats associated with the walled cities and towns of northern Nigeria bring large urban populations into close contact with the intermediate hosts, despite the provision of purified pipe-water supplies.

The possibility of further agricultural development in Northern Nigeria would seem to depend on the availability of water and, no doubt, schemes of water conservation and irrigation must be under consideration. The existing peasant agricultural economy is geared to the physical capacity of the people, and while this situation continues the latent effects of bilharziasis will not be obvious. Lovett-Campbell [39] has shown what happens when such people are subjected to increased physical strain by military training. The same sequence of events can be expected when agricultural operations require a heavier output of work. There is little doubt that such development, especially if associated with irrigation projects, would find the stage set for an extension of the disease and also for an increase in the effect on the sufferers of existing disease.

Kenya Colony

The Colony includes the coastal area which is technically a protectorate forming part of the dominion of the Sultan of Zanzibar, but which is administered as an integral part of the Colony. The figures relating to the area and population of the Colony do not give a true picture, because the northern part, three-fifths of the whole area, is almost waterless and maintains only a scanty nomadic population. The rainy coastal strip and the area near the shores of Lake Victoria have a large population which perhaps reaches 500 per square mile. In the high volcanic plateau there are mountain peaks which, in the case of Mount Kenya, reach 17 040 feet. Most of the plateau is over 7000 feet above sea level. The Great Rift Valley cuts the plateau in two, from north to south, the Rift being 30 to 40 miles wide and 2000 to 3000 feet below the surrounding country. In the higher altitudes, the flora is temperate in character and winters are cold.

The indigenous population is largely employed in agricultural pursuits, and mining is confined to the extraction of gold near Lake Victoria and to the working of the soda deposits in the alkali lakes near the southern border. Kenya has a higher proportion of Europeans than any other British colony in Africa except Southern Rhodesia. Railway links to Uganda and north-east Tanganyika help the Colony to maintain its economic ascendancy over the other East African territories.

Review of available data

Bilharziasis was first reported in Kenya in 1910, but from a perusal of the annual medical reports available it does not appear to have aroused much interest. The reports of laboratory examinations are very scanty until 1928, when a field survey was conducted in the Digo district near the coast. Examination of urine specimens collected during the course of this survey yielded the following results: in children, 745/4379 were positive (17%); in adults, 312/2582 were positive (13%). The laboratory in Nairobi, in routine examination of stools, found 320/2136 *S. mansoni* positive.

In the next year, it was said that bilharziasis was more widespread than had been suspected and that the increase in the number of trained African microscopists had resulted in more routine examinations of stools. Many cases of *S. mansoni* infection which had previously been diagnosed, on clinical grounds, as dysentery were being detected. In Nairobi itself, there was an increase in the number of cases of *S. mansoni* infection in Europeans and especially in children. The laboratory in Nairobi reported *S. mansoni* in 122/4237 stools and *S. haematobium* in 39/482 urines.

The following data summarize laboratory findings in Nairobi and Mombasa in the years 1930-34:

	Infection-rate	
	Nairobi	*Mombasa*
Stool specimens	3.2%	2.1%
Urine specimens	12.0%	4.0%

During this period, the routine examination of faeces was on a much better basis than that of urine specimens, since in the former case the above percentages were arrived at after the examination of nearly 40 000 specimens, while in the latter they were calculated on a small sample only.

Hospital statistics for the period 1932-37 reveal that of 242 186 admissions for helminthiasis only 3118 were cases of bilharziasis. Taeniasis seems to have been, numerically at any rate, the principal helminthic problem in Kenya.

In 1936, a snail survey of Kenya was started but not pursued. The work done showed that *Biomphalaria pfeifferi* was present in districts where *S. mansoni* was endemic. There did not appear to be any association between *Bulinus (Bulinus) tropicus* and bilharziasis. The molluscan vectors in the Digo district were said to be *Bulinus (Physopsis) ovoideus* and *Bulinus (Physopsis) nasutus*, but no experimental work to prove this theory was done.

In 1950, the status of bilharziasis in Kenya was summed up by the Colony's Medical Department. Infections with *S. haematobium* predominated in the Coast Province, where in some areas they were reported to be very intense. This form of the disease was also prevalent on the banks of rivers feeding Lake Victoria and in patches in the northern Kitui and

Machakos districts, and near semi-permanent water-holes in the arid Northern Province. *S. mansoni* infection was more limited in its distribution and was found in the Lake and Central Provinces, around Nairobi, at Machakos and in the Fort Hall district. The total number of cases was said to be small. Treatment in hospitals, where direct medical supervision could be given, was usually with intravenous antimonials, only a few hundred cases a year being treated with intramuscular preparations. It was not possible properly to assess the efficacy of the treatments employed. Lucanthone hydrochloride was used only on a small scale, chiefly in European children in whom other methods of treatment are technically difficult.

Bulinus s. l. were found in Nairobi, Isiolo, Meru, Marsabit, Nyeri, Fort Hall, Kitale, Thika and Kisumu. *Biomphalaria pfeifferi* were reported at Isiolo, Meru, Kalacha, Kigalla Reservoir (Nairobi), Nyeri, Fort Hall, Moiben, Ktale, Thika and Kisumu. There would appear, therefore, to be plenty of overlapping of vector species. Some of these catches were identified at the British Museum.

In 1951, experiments using crushed *Dolichos pseudopachyrhizus* (a large onion-like tuber which is found in large numbers in the coastal plain) as a natural molluscicide in streams near the coast were continued and the biological control of snails by means of fish was studied in the Nyanza Province.

Cridland,[24] working at the Fisheries Research Laboratory at Jinga, claimed that he had been able to infect the following species with *S. mansoni*: *Biomphalaria sudanica sudanica*, *Biomphalaria sudanica tanganikana*, *Biomphalaria choanamphala* and *Biomphalaria adowensis adowensis* ; and the following species with *S. haematobium*: *Bulinus (Physopsis) globosus globosus* and *Bulinus (Physopsis) nasutus*.

In 1954 it was recorded that schoolchildren had contracted *S. mansoni* infections in streams within the City of Nairobi.

Table VI gives hospital statistics for the years 1950-54.

TABLE VI. BILHARZIASIS IN KENYA

Year	Admissions	Deaths	Out-patients treated
1950	1 415	8	3 493
1951	1 535	5	4 223
1952	1 994	13	4 796
1953	1 255	0	5 748
1954	1 368	15	4 129

Personal observations

At Mombasa, Teesdale has undertaken a study of the snails in the Coast Province. The effects of natural fish poisons are also being examined in the hope that a suitable natural molluscicide can be found. *Dolichos pseudopachyrhizus* is being tried out in this connexion.[54]

At Kilifi, Dr Barton, the medical officer, has treated 180 cases of bilharziasis in four months with the " fast " antimony treatment. He is very satisfied with the lack of serious reactions, since only one death occurred. (The patient in question played in a football match the day after treatment and collapsed and died.) In estimating the cure rate at 44%, Dr Barton has employed a very stringent criterion, namely, that only those patients who did not pass viable eggs (movement on slide-hatching) on the fourth day after the initiation of treatment were considered as cured. The treatment is so popular that patients come hundreds of miles to Kilifi to receive it.[13] Dr Barton has also been studying some of the more serious end results of urinary bilharziasis. The author was shown a late case of chronic cystitis with the veins on the abdomen engorged, a tender half-distended bladder which felt like a uterus, much dysuria and frequency with " trigger incontinence ". Dr Barton has also had a most unusual case of strangulation of the small bowel in a perforation of the bladder wall caused by an extensive bilharzial ulceration.

In this district, there seems to be evidence that *S. haematobium* infection is of a seriously high intensity. Snail surveys were made in the country about 15 miles from the coast and ample evidence of *Bulinus (Physopsis) globosus* was found, although most of the molluscs seen were small and young. One unusual habitat that was found infected with this species was a muddy, evil-smelling pool in a dry stream bed, so churned up that it seemed to be a wallow for animals. A few dead sticks floating in this water supported a number of *B. (P.) globosus*. In the drier, more open country further from the coast, water conservation by the construction of a number of small earth dams was well advanced. These are not being built on defined watercourses. The one examined had become filled with water in only one rainy season and already had vegetation suitable for snail propagation. These dams may be colonized by *Biomphalaria* spp., for which they seem to be particularly suited. A weir across the Kombeni River, which runs into Mombasa harbour, showed a varied and extensive molluscan fauna including *Bulinus (Physopsis) globosus*.

At Nairobi, there was little opportunity for field investigation. *Biomphalaria* spp. have been found widespread near this town and it has been observed that many newly created dams become colonized by these species very soon after construction. They have been found infected at an altitude of 6430 feet. *S. mansoni* infections in Europeans appear to be common in this neighbourhood and acute dysenteric cases are frequently reported.

At Kisumu, on the Kavirondo Gulf of Lake Victoria, an opportunity was given to study conditions in an area where *S. mansoni* infections were particularly prominent. Even in this area, however, there are foci of intense *S. haematobium* infections; it is said that the infection-rate on the peninsula to the north-west of Kisumu is nearly 100%. Snail surveys made on the lake-shore and in the small streams feeding the Lake were not very fruitful, but it is understood that numbers of *Biomphalaria* spp. have been recovered in these places. The neighbourhood of the slaughterhouse, which is a site of heavy organic pollution, usually yields large numbers. In the streams feeding the lake *Bulinus (Physopsis)* spp. have also been found.

Uganda

Uganda is a compact territory, 350 miles from east to west and 400 miles from north to south, lying astride the equator on the northern shores of Lake Victoria. The general elevation is about 4000 feet above sea level but in the north, on the Albert Nile at Nimule, the altitude reaches only 2000 feet. In the south-west, the highest peak of the Ruwenzori Range is nearly 17 000 feet above sea level. On the north-east and west, the territory is bordered by rift valleys. The mountainous areas have a heavy rainfall and forest vegetation. The western and northern margins of Lake Victoria also have a forest strip with a rainfall in excess of 50 inches. Further to the north-west are grasslands with a low rainfall, and further to the north-east the climate becomes drier. In the Karamoja district, in the north-east, there are no permanent rivers, and water in the dry season has to be drawn from deep wells. Uganda is a land of many lakes: the Lakes Victoria, Albert and Edward lie on the boundaries of the territory, a number of deep mountain lakes are situated in the mountainous Western Province and the drowned-valley system of lakes of the Victoria Nile runs north through the area. Most of the rivers are merely sluggish, vegetation-covered swamps with practically no fall. Only in the hill regions and on the slopes of the western rift valley are clear, running streams found.

The Protectorate is well endowed agriculturally and the population can produce their food supply without much trouble. The staple crop is cotton, on which the economic prosperity of the country depends. Coffee is also grown in the western highlands.

The majority of the inhabitants are of Bantu stock, but in the north and east the people are of Nilotic origin. The population is most dense in Buganda at the north-western corner of Lake Victoria, in the cotton-growing areas of the Eastern Province around Lakes Kioga and Salisbury and in the south-western mountainous area. There are large areas in the north-east and along the Victoria Nile and the east bank of the Albert Nile which are virtually uninhabited.

Review of available data

Bilharziasis has been known in the Protectorate for many years, the West Nile district focus of *S. mansoni* being described by Dr Rawson in the 1923 Medical Department report. He discovered *S. mansoni* in 72/319 stool examinations. He noted, too, that many of the infections were of an acute type and had originally been considered to be carcinoma of the rectum.

There was no record of infections with bilharziasis in Buganda—at least from 1905 onwards—until 1931. In that year, 8 cases of *S. mansoni* infection—3 of them fatal—were reported at Entebbe, and in the whole territory only 14 *S. mansoni* and 5 *S. haematobium* infections were recorded.

From 1932 to 1936, 652 *S. mansoni* and 82 *S. haematobium* cases were treated in hospitals. Most of the *S. haematobium* cases came from Busoga, east of the Victoria Nile near Lake Victoria. The *S. mansoni* cases, except for those being treated at Entebbe, came from the north and east of the Protectorate, north of the Lakes Kioga and Salisbury. These cases reported for treatment at Kitgum, Gulu, Lira and Soroti.

In 1935, at Lira, a routine stool survey of in-patients showed that 65/1053 were *S. mansoni* positive; and at one school 14/83 children were similarly infected.

From 1937 to 1948, an average of 580 cases of one or the other infection were treated each year, the number of cases reaching 949 in 1948.

In 1939, it was remarked that bilharziasis was widely but thinly distributed and that the majority of cases were reported from the Northern Province. In 1945, *S. mansoni* was said to be assuming serious proportions in the West Nile Province and was spreading eastwards. The infection was reported in 12% of schoolchildren. In 1947 it was stated that 5% of the population of this Province were infected with *S. mansoni*.

In 1950, the high incidence of *S. mansoni* infection was noted in schoolchildren in the West Nile district. At Packwach, on the Nile, 54% were said to be infected. No *S. haematobium* infections have been known to occur in this area. As a result of reports of *S. haematobium* infections on the south side of Lake Kioga, a survey was carried out and revealed that this infection-occurred at many points south of the Lake.

Isolated cases of *S. mansoni* infection were recorded in Mbale and Teso, a finding which indicates that this form of the disease can exist without attracting much attention. In the West Nile District, very high infection-rates with *S. mansoni* were reported; in fact at Panyamus at the north end of Lake Albert 88% of the children examined were found to be infected. The District Medical Officer noted the following infection-rates: in boys, 46%; in girls, 24%; in adult males, 45%; in adult females, 32%.

In 1951, the occupational hazards of infection with *S. mansoni* were well illustrated by the examination of stool specimens from twelve ferrymen at

Pakwach on the Albert Nile. Eleven were found to have *S. mansoni* eggs in the specimen and the twelfth man had only recently been treated.

In the Lango District north of Lake Kioga, 25% of children aged 5 years and 50% of children aged 10-14 years were found to have *S. haematobium* infections.

In 1953, it was noted that *S. haematobium* infections were present in about 8% of the children examined at Jinga in Busoga Province, east of the Victoria Nile, and that boys and girls appeared to be equally affected.

In 1954, attention was directed again to the heavy *S. mansoni* infection-rates in the West Nile District, where in certain parts of Joncum County 100% of the people were said to have the disease, while at Kaboko, in the extreme west corner of the Protectorate, the infection-rate was estimated at only 2%.

Field surveys

Apart from the records mentioned previously there had been little attempt at surveying the disease and the potential vector molluscs until Schwetz [51, 52] examined the two foci of *S. mansoni* at Lake Bunyoni, near Kabale, in the Western Province. Here he found *Biomphalaria pfeifferi* shedding cercariae at an altitude of 6300 feet and detected the eggs of *S. mansoni* in the stools of 4/17 boys he examined.

In the Lira area, it had been shown that *S. haematobium* infections were very common in children and there was evidence that, in some of the villages at least, this was a new infection. Near Lira there is a large swamp, through which a sluggish stream, the River Koli, flows to meet the Victoria Nile. Most of the swamp is occupied by papyrus and thick reeds and is accessible to the human population only where watering places have been cut on the margins and where causeways have been built. At certain places in this area, Schwetz reported the presence of large numbers of planorbids. *Bulinus (Physopsis) nasutus* was present in many habitats, which were similar to those occupied by *Bulinus (Pyrgophysa) forskalii*; rarely, however, did the two species share the same habitat. Schwetz attempted to transmit the infection from *Bulinus (Physopsis) nasutus* to small experimental animals with not altogether conclusive results, although he claims definitely that this snail is the intermediate host of *S. haematobium* in the area.

In addition to the published data, a statement on the unpublished findings of surveys, etc., conducted in Uganda was obtained. Surveys of schoolchildren in the West Nile Province revealed that 10%-12% of stools examined showed *S. mansoni*. The disease seemed to be particularly common in a zone 30 miles wide from Rhino Camp on the Nile to the Congo-Nile watershed. At Gulu and Kitgum, from 1945 to 1948, 15%-23% of hospital in-patients had *S. mansoni* eggs in their stools. At Butiaba, on Lake Albert, cases of *S. mansoni* infection in Europeans had been reported on a number of occasions in the past, and the district was second only to Entebbe in the number of such cases reported. At a school near Butiaba, 25% of the boys were infected with *S. mansoni.*

At Lira, Dr Williams, the District Medical Officer, has been carrying out a most intensive survey of bilharziasis. In the Adyeda sub-district, he found 144/653 cases *S. haematobium* positive and 40/586 similarly infected in the neighbouring Anyeke sub-district. He has made the interesting observation that the infection-rate appears to be just as high in adults as in children, a finding which supports the view that the infection is of recent introduction.

Personal observations

Snail searches were made whenever the opportunity occurred. Between Kampala and Masindi, a number of sluggish streams, covered with papyrus and reeds, were crossed. In water-holes and on causeways, water-lilies, *Pistia* and other horizontal vegetation were growing but no snails of vector species were found. The same situation prevailed on the Victoria Nile at the Atura Ferry, but here, at a much frequented and heavily polluted crossing, *Bulinus (Physopsis) nasutus*, *Lymnaea* spp. and some *Biomphalaria* spp. were found in fair numbers.

At Ayer, near Lira, it was interesting to note the change in fauna prevalence since Professor Schwetz's visit only two months previously. Pools in which planorbids had been seen in thousands were quite free from infestation, although there was still plenty of water and the muddy decayed vegetation favoured by those snails. It was suggested that lung fish, which are apparently very plentiful in the swamps, might have cleared out the snail population.

A number of potential snail vectors were identified by Cridland at the Fisheries Research Laboratory in Jinga as *Biomphalaria sudanica* and *Biomphalaria adowensis*; *Bulinus (Bulinus) strigosus and Bulinus (Bulinus) trigonus*; *Bulinus (Physopsis) wahlbergi*, *Bulinus (Physopsis) scalaris*, and *Bulinus (Physopsis) nasutus.*

During the author's surveys, near Ayer, enormous numbers of *Bulinus (Physopsis) nasutus* were seen, but in many habitats typical *Bulinus (Physopsis) globosus* were also noted. These, however, were difficult to pick out from the masses of *B. (P.) nasutus.* The fact that there were more shells of *B. (P.) globosus* than there were living specimens may indicate a seasonal decline in the species in question. The discrepancy between the author's observations and those of Professor Schwetz—although there was an interval of only two months between the two surveys—serves to stress the importance of making authoritative pronouncements regarding the presence or absence of any particular species of snail only after careful and repeated observations over a period of at least a year. This means, in fact, that accurate snail surveys can be carried out only by trained observers who are members of the health staff of the country concerned.

Further snail searches were made in the marshes north of Lake Kioga, at Namsale Ferry and also at a few streams south of the Lake, but with negative results. It was unfortunate that time did not permit of a visit to the West Nile Province to study the *S. mansoni* problem there.

Tanganyika Territory

Tanganyika has been administered by the United Kingdom as a United Nations Trust Territory since 1946. Before that date, it was administered under a mandate from the League of Nations, having been the Colony of German East Africa prior to the First World War. It has a coastline of 500 miles and borders on three important African lakes—Victoria, Tanganyika and Nyasa.

The Territory consists of a hot and humid coastal plain, a vast central plateau 2000-4000 feet high which has a hot, arid climate, although generally the nights are cool, and the plateau near Lake Victoria, where the altitude is about 4000 feet and the climate is more humid than on the central plateau.

To the north-west of Tanga are the Usumbara Mountains and the massif of Kilimanjaro and Meru where the climate is temperate with cool nights and the annual rainfall is between 40 and 80 inches. In the south of the Territory, north of Lake Nyasa, is another mountainous region with a pleasant temperate climate and even more rain than in the north. Between one-half and two-thirds of the area is infested with tsetse fly, predominantly *Glossina morsitans*, and this has a very serious effect on the agricultural and economic development. The area is rich in minerals, diamonds contributing substantially to the finances of the Territory. The African population is almost wholly agricultural and the communications generally are poor.

Review of available data

Attention was first directed to bilharziasis in 1911, when it was stated that *S. haematobium* infestation was both heavy and widespread. In the same year, Dr Wolff, at Lindi, found 33.4% of 1000 urines infected with *S. haematobium*. In 1913, Dr Beck found that 50% of the children he examined at Tunduru were infected. Few cases reported for treatment, as the disease caused little interference with daily life. The disease was also noted as prevalent at Tanga, near Lake Nyasa, at Mwanza and Magita, on Lake Victoria, and at Mkundani, near Arusha.

In 1921, Dr Butler found that 20% of 435 prisoners in a gaol at Dar-es-Salaam were infected. In 1936, the disease was said to be common at

Mwanza, Tabora, Dar-es-Salaam and Maswa. At Tanga, in a small survey, 9% of adults and 40% of children were found infected with *S. haematobium*. In 1938, of a total of 4258 cases treated, 1031 were at Mwanza, 420 at Shanwa, 312 at Dar-es-Salaam and 283 at Tabora. In the Tanga Province, the disease was said to be spreading, especially at Muheza.

In 1940, bilharziasis in army recruits was commented on; 30%-40% of the recruits from the Lake and Western Provinces were found to be suffering from *S. haematobium* of a mild type, the majority being quite unaware of the disease. In the next year, it was noted that there was a remarkable absence of bilharziasis in recruits from Bukoba on the west side of Lake Victoria. At Maswa, 85% of recruits showed evidence of the disease. Three urine surveys in 1941 showed *S. haematobium* infections in 44/211 schoolboys at Dar-es-Salaam, in 13/145 at Mpapwa and in 252/1123 army recruits at Dar-es-Salaam. In 1942, the effect of bilharziasis on the health and physique of Forces recruits and of the personnel of essential industries in the Southern Province was noted. In 1945, it was observed that *S. haematobium* was generally more common throughout the Territory but that *S. mansoni* predominated at Mwanza and near Lake Rukwa in the Western Province. In certain areas of the Tanga Province, it was said that the *S. haematobium* infection-rate was 100%.

In 1947, 3.9% of all patients treated at Mwanza were suffering from bilharziasis. Reference was made to the possibility that rice cultivation around the southern end of Lake Victoria had caused a spread of the disease. Increased irrigation in the Shanwa and Ngudu areas might have played a sinister role, despite the agricultural benefits. In 1948, the high incidence in the Southern Province, especially at Tunduru, was recorded. Most of the cases were of *S. haematobium* infection, but *S. mansoni* was also found. This is the place where Dr Beck reported a 50% infection-rate in 1913.

Table VII shows the numbers of in-patients and out-patients treated for bilharziasis during 1949-54.

TABLE VII. BILHARZIASIS IN TANGANYIKA TERRITORY

Year	Admissions	Deaths	Out-patients treated
1949	778	17	12 538
1950	827	10	11 418
1951	907	16	12 682
1952	2 323	15	14 740
1953	2 520	18	20 576
1954	2 780	20	17 480

During the first six months of 1950, the Government laboratories paid special attention to the incidence of bilharziasis. The results of the surveys, by province, are shown in Table VIII.

TABLE VIII. BILHARZIASIS IN TANGANYIKA TERRITORY: LABORATORIES SURVEY, JANUARY-JUNE 1950

Provinces	Urine examinations		Stool examinations	
	total	positive	total	positive
Tanga	6 024	899	9 503	45
Northern	3 986	98	4 650	92
Lake	6 321	550	6 651	394
Western	3 008	224	3 075	35
Eastern	6 861	663	5 987	33
Southern Highlands	2 750	98	2 865	61
Southern	1 671	400	2 157	40
Central	619	76	613	4

Individual stations with a high rate of *S. haematobium* infection are as follows:

	Percentage
Tanga Province:	
Muheza	40.8
Korogwe	39.4
Usangi	13.4
Tangi	12.1
Eastern Province:	
Morogoro	13.3
Kilosa	10.4
Southern Province:	
Songea	28.3
Lindi	22.8
Central Province:	
Dodoma	12.2

High rates of *S. mansoni* infection were found in the following places:

	Percentage
Lake Province:	
Musoma	9.6
Mwanza	4.6
Southern Highlands:	
Iringa	3.2
Chunya	2.7
Southern Province:	
Songea	5.8

In 1950, at Mbugwe, it was discovered that 178/196 schoolchildren were infected with *S. haematobium*, and the nearby water furrow was found to contain large numbers of infected vector snails.

Field surveys

Mozley [45] studied the molluscs of Tanganyika, including the species to be found in the coastal area, on the shore of Lake Victoria and in the plateau region, and revealed that *Biomphalaria pfeifferi* was the intermediate host of *S. mansoni* and *Bulinus (Physopsis) globosus* the host of *S. haematobium*. His survey showed a wide distribution of both vector species in the areas surveyed by him.

The East African Medical Survey began its work in 1949 in Sakumaland, south-east of Lake Victoria. The country here is bare and arid, cattle-breeding is the major occupation, and the population is scattered, a density of 28 persons per square mile being recorded for the chiefdom of 15 000 persons which was chosen for the initial survey. The number of urinary infections in over 600 persons examined in the first survey showed a rate of about 30%; in the age-group 5-9 years rates of about 15% were established.

In 1950, a parallel survey was started in Ukara, an island in Lake Victoria, 30 square miles in area and supporting 16 000 people. Here infections with *S. mansoni* were more common, while urinary infections with *S. haematobium* seemed to be rarer.

Later, a similar survey at Bukoba, a town on the western shores of the Lake, showed little evidence of bilharziasis.

Finally, in 1954 a survey of schoolchildren in Mwanza revealed that *S. mansoni* infections were very prevalent. In one school 120/227 pupils were affected; in fact only 28 were free from helminthic infection of one type or another. At a teachers training college, 31/236 students showed *S. mansoni* infections. The 1954 Territory report records the curious finding of four cases of *S. japonicum* infection. It is quite unlikely that this is correct and it is possible that the discovery of terminal-spined eggs in a stool specimen may have led to the classification of the infection as the eastern variety.

Personal observations

The areas examined were the neighbourhood of Dar-es-Salaam, Tanga, Mwanza and the route from Mwanza to Tabora. A number of rivers and marsh areas both north and south of Dar-es-Salaam were surveyed. It was noted that wherever antimalaria oiling was in progress, no snails could be found. In one marshy place on the Mazembazi River, which is fed by springs, large numbers of *Bulinus (Physopsis) globosus* were found in the hollows between sweet-potato mounds. The " built-up " type of cultivation employed by Africans in marshy areas appears to provide an especially suitable habitat for this species.

South of Dar-es-Salaam, a number of streams furnished good examples of the fact that the vector species of molluscs are concentrated at sites where the natural vegetation and configuration of the stream has been altered by man. Ten miles along the Kilwa Road, a small stream running in a deeply cut bed, well shaded by vegetation, was surveyed closely. In the natural stream, only one specimen of *Neritina knorri* was taken. At a bend in the road farmers had cut down the vegetation to the stream edge and were planting crops on the steep, exposed slope. Water-lilies and *Pistia*-type vegetation had become established and fair numbers of *Bulinus (Physopsis) globosus* were found.

At Tanga the country is more open and in seepage swamps which are used as the water-supply for the villages around, large numbers of young *Bulinus (Physopsis) globosus* were found. Only a very few older specimens were to be seen and it would seem that the recent rains had encouraged a reproduction cycle of the snails. At Tanga, more importance appeared to be attached to the effect of bilharziasis on the human population than was the case at Dar-es-Salaam. All in-patients have stool and urine examinations, but treatment is only given to those complaining of symptoms referable to bilharziasis.

In 1949-50, of 14 409 urine specimens examined, 1774 (12%) showed eggs of *S. haematobium*, while 15 240 stool specimens revealed only 85 (less than 0.6%) *S. mansoni* infections.

In the Lake Victoria area, the opportunity was taken, during a short stop at Bukoba on the western side of the Lake, to study conditions in an area where bilharziasis was said to be almost unknown. A number of streams, which appeared to be likely habitats, were searched but no molluscs were found. The wave action on the lake-shore in this sector is so marked that snail life is very unlikely.

From Mwanza, a visit was paid to Sakumaland, to the south-east, where in an eroded, rather arid, area agricultural rehabilitation is being attempted. At Ngudu, a district centre where a pilot scheme for the control of bilharziasis may be established by the East African Medical Survey, a number of water conservation dams were examined. These, it seems, were of fairly recent construction and already *Bulinus (Physopsis) globosus* and *Biomphalaria* spp. were well established. The Medical Survey group was conducting a urine survey of the inhabitants of the area; the results by age-groups are set out in Table IX.

There are several interesting aspects of this small-scale investigation. The over-all infection-rate of 33% contains a higher proportion of infections in the older age-groups. The sexes are nearly equally affected. The very close correlation between the results of the microscopic examinations of the

TABLE IX. BILHARZIASIS IN TANGANYIKA TERRITORY: URINARY BILHARZIASIS SURVEY IN NGUDU

Age-group (years)	Males			Females		
	number examined	microscopic positive	macroscopic positive	number examined	microscopic positive	macroscopic positive
1-4	3	—	—	5	—	—
5-9	25	6	4	15	2	1
10-14	21	11	13	22	7	8
15-19	33	10	11	15	5	6
20-29	41	19	20	21	10	12
30-39	19	8	8	11	5	5
40-49	15	3	3	17	4	4
50-59	17	5	4	13	2	—
60 +	5	2	—	2	—	—
Total	179	64	63	121	35	36

centrifuged urinary deposits and the results of the macroscopic examination of the hatched miracidia are also interesting. The usual finding is a reasonably good correlation between the two methods in the younger age-groups, but in the older groups, presumably because of the age of the infecting worms, more unhatchable eggs are passed out in the urine, and so the microscopic method reveals more positives. The interpretation of the results seems to be that *S. haematobium* infections in Ngudu are widespread but not of high intensity, and that probably the infection has been introduced fairly recently into the area. There is no doubt, however, that the water conservation schemes now contemplated will spread the disease and increase its intensity.

Mwanza is an endemic focus of *S. mansoni* and the clinicians here are agreed that this infection has a most debilitating effect on the sufferers.

Between Mwanza and Tabora many rivers and streams were examined but generally snails were not in evidence, probably because of the heavy flushing rains during the week before the author's visit. A number of sites recorded by Mozley [45] as infected with *Biomphalaria pfeifferi* and *Bulinus (Physopsis) globosus* were examined by the author with negative results. This observation stresses again the need for long-continued observation of potential snail habitats.

Zanzibar

Zanzibar is a Protectorate under the British crown and is ruled by a Sultan who is advised by a British Resident. The Protectorate consists administratively of the islands of Zanzibar and Pemba lying off the coast of Tanganyika Territory. The mainland territories of the Sultanate are leased to the British Government and administered by the Colonial Administrations concerned.

The climate is hot and moist but not so trying as that of the mainland opposite, because of the sea winds. The population is chiefly Moslem, and Arab influence is very strong. Many of the leaders of the community are descended from the Arabs who came to Zanzibar from Muscat in Southern Arabia in the sixteenth century.

The prosperity of Zanzibar depends to a very large extent on the clove industry, which has been seriously imperilled, especially on Pemba, by a disease of the clove tree known as " sudden death ".

The islands of Pemba and Zanzibar differ in their geological origin. Pemba would appear to have been part of the mainland of Africa at one time, while Zanzibar is of coral origin.

Review of available data

S. haematobium infections appear to have been established from time immemorial but *S. mansoni* is said not to occur at all. If this latter observation is a fact, then it must be due to the absence of the molluscan vector, because it is highly probable that many persons from the mainland who visit the island during the clove-picking season are infected with *S. mansoni.*

S. haematobium infections seem fairly general, but of light intensity, as little or no interest seems to be shown in the disease by the local population.

During the first ten months of 1950, a special survey of bilharziasis was made on Pemba. All patients at the three hospitals on the island had their urine examined microscopically and at the six dispensaries patients were asked whether they were passing blood in the urine. 328 cases were found at the hospitals and 243 presumptive cases at the dispensaries. Of these, 134 were reported from the dispensary at Kengeja, in the south-eastern corner of the island.

In addition, specimens of urine from children attending three village schools were examined microscopically with the following results: at Ole School 50/60 were found to be *S. haematobium* positive; at Pandani School, 13/15; and at Kengeja School, 52/57. Infections are said to be light but many of these children pass urine containing considerable quantities of blood. Since this is a Moslem community, post-mortem evidence on the ultimate effects of the disease is not obtainable. In 1954, 24/100 schoolchildren examined at Donge a few miles north of the town of Zanzibar had *S. haematobium* infections.

Figures for the treatment of both *S. haematobium* and *S. mansoni* infections are shown in Table X.

TABLE X. BILHARZIASIS IN ZANZIBAR

Year	In-patients treated		Out-patients treated	
	S. haematobium	*S. mansoni*	*S. haematobium*	*S. mansoni*
1952	25	—	639	156
1953	21	9	1 217	98
1954	83	2	1 238	44

Personal observations

Much time was spent on the search for snail vectors. Both islands have a large and varied molluscan fauna and this has been described fully by Mozley,[45] who spent many months on the islands.

The southern end of Zanzibar is an arid and waterless tract of exposed coral. Beyond this area, on the southernmost tip of the island in the Mtende District near Machinduchi, the sole surface water consists of five marsh areas which become ponds in the wet season. These ponds are hollows in the coral formation and have no surface outlet for drainage. When full of water, the ponds overflow on the surface and the water runs into the sea. During the dry season they dry up gradually, probably mainly as a result of evaporation, although there may be some underground seepage. The flat, marshy bottoms of the ponds are cultivated as the water recedes. At the time of the author's visit, the Mtajabuni pond was dry and even in the deepest part consisted of dry, cracked mud. In this mud was found a number of shells of *Bulinus (Physopsis)* and, no doubt, if more digging had been possible, hibernating specimens of this species would also have been discovered. A similar area was examined at the Bambi swamps near Mpapa, to the east of Zanzibar town. In this site there remained a considerable quantity of water covered with heavy horizontal vegetation and protected here and there by dense banks of reeds. *Bulinus (Physopsis) globosus* were found in some numbers, particularly on decaying vegetation.

In the northern part of Zanzibar Island, there are a number of slowly flowing streams, generally with sandy bottoms and well shaded by trees. In the Mwandugu stream, near a school, numbers of *Bulinus (Physopsis) globosus* were found on decaying fronds of conocut trees and on waterlogged bamboos. It was also evident from the activities observed that the stream was the water-supply and recreational centre for the neighbourhood.

North of Zanzibar town, on the west side of the island, is an extensive swamp area at Mbigi, which is drained by a short, narrow stream flowing to the sea. The local population draw their supplies of water from holes dug near the edges of the swamp which fill with seepage water. Those still in use were clean and free from snails but others, which had been abandoned, were overgrown with water-lilies and sedges and contained *Bulinus (Physopsis) globosus*. Some specimens of *Bulinus (Pyrgophysa) forskalii* and a very small planorbid, probably *Planorbis gibbonsi*, were also seen here. At one place the main water of the swamp could be approached and many *Bulinus (Physopsis) globosus* were collected from the dead vegetation.

Southern Rhodesia [a]

Southern Rhodesia is a land-locked territory in the south of Central Africa, occupying the high plateau watershed between the Zambesi and Limpopo Rivers which rises from 3000 to 5000 feet above sea level. The altitude ranges from 800 to 8000 feet, the majority of the population living above 3000 feet. The average rainfall is about 23 inches but the northern and eastern parts are much wetter than the western and southern, which are not far from the Kalahari Desert. Most of the rain falls in the hot summer season, which is followed by a long, cool, dry winter.

Apart from the Union of South Africa, Southern Rhodesia has the biggest European population of any territory in Africa south of the Sahara, and Salisbury, the capital city, has a population of over 200 000.[b] The country is rich in minerals, and the base metals, which include chromium, asbestos, coal, tin, lithium and many of the other rare minerals, have outstripped gold production, the most important source of wealth in the earlier years of the country's development.

With regard to agriculture, tobacco is the most important crop, but cattle-raising, maize, dairying, forestry, citrus fruits and sugar-cane are all important elements in this branch of the economy. There has been a great expansion in industry since the war, including steel, cement and an extensive production of consumer goods.

Review of available data

The existence of bilharziasis in the Colony was first noted in 1908, but it is probable that it was present at a much earlier date, perhaps even before the occupation in 1890. At first, cases of bilharziasis in Europeans were attributed to infection in Natal and other recognized endemic foci to the south, while it was thought that the disease in Africans was to be found only in immigrant labour coming from the north. It was soon shown,

[a] When the original survey of bilharziasis in British African territories was undertaken, Southern Rhodesia, Northern Rhodesia and Nyasaland were administered separately. Southern Rhodesia was a self-governing colony with her external relations controlled by the United Kingdom, while Northern Rhodesia and Nyasaland were protectorates and were administered directly by the Colonial Office in London. In 1953 the three regions united to form the Federation of Rhodesia and Nyasaland, and as from 1 July 1954 their health and medical services became a Federal responsibility. For the purposes of this account, however, it is considered advisable to deal with the regions separately.

[b] 1956 estimate

however, that urinary bilharziasis was just as prevalent among the indigenous population. It was originally believed that the disease was limited in its distribution, but as time went on more and more areas were shown to be infected. Indigenous foci of *S. mansoni* were reported in the Eastern Districts, particularly at Umtali, during the early 1920s.

The full significance of bilharziasis was better realised as a result of the work of Blackie.[16] He showed that both types of infection were more common and widespread than was generally believed. Little was done, however, to follow up Blackie's work until 1938, when a Research Unit was established to investigate, in the first place, malaria and bilharziasis. The First World War upset plans and only Mozley [46] continued the work in this field with his studies of the molluscan vectors.

In 1945, the threads were taken up again and, with a much reduced staff, investigations into bilharziasis from a number of aspects were started. These included improved methods of diagnosis, cercarial skin-test antigen,[8,20] rectal biopsies,[29, 44] miracidial hatching-techniques,[43] and therapeutic methods including the introduction of intensive treatment of the disease by repeated doses of antimony given intravenously by a slow injection technique [2, 7] and trials of lucanthone hydrochloride,[3, 4, 6, 21, 22] which was shown to be an effective oral treatment of *S. haematobium* infections. Much work has also been done on the effects of copper sulfate as a molluscicide,[9, 10, 19] large-scale field trials having been carried out. Possible vector snails [11] and the effect of changes in their environment in natural watercourses, including hibernation phenomena, have been studied systematically. Gelfand and his co-workers,[12, 30, 31, 33, 34] in investigating the pathology of the disease, have obtained ample proof of the widespread distribution of eggs throughout the tissues. Attempts have also been made to assess more accurately the effects of the disease on general physical and mental fitness.[38] Alves [5] has made an examination of the *S. haematobium*-like schistosomes in cattle and has shown that these infect man much more than is generally realized.

There is little evidence from hospital and laboratory figures as to the prevalence of bilharziasis. It is appreciated that, given the usual pattern of multiple diagnoses in African patients, hospital morbidity figures are of little value when information is being sought on the prevalence of a disease which rarely compels a sufferer to seek treatment specifically for that disease. Mortality figures are equally unilluminating.

The results of laboratory investigations give some indication of the distribution of bilharziasis in hospital in-patients at the main hospital units of the Colony, where practically every in-patient in the African hospitals has a stool and urine examination performed. The results are shown in Table XI.

Infection-rates in non-Europeans as assessed by laboratory data show a consistent urinary infection-rate of about 20% and an intestinal infection-rate of about 5%.

TABLE XI. BILHARZIASIS IN SOUTHERN RHODESIA: RESULTS OF LABORATORY EXAMINATIONS, 1932-55

Period	Material examined	Europeans			Non-Europeans		
		specimens examined	positive		specimens examined	positive	
			number	%		number	%
1932-38	Urines	9 674	458	4.7	7 064	1 330	18.8
	Stools	7 403	333	4.5	8 885	1 240	14.0
1946-50	Urines	25 994	578	2.2	42 979	8 076	18.8
	Stools	41 353	350	0.8	60 881	3 026	5.0
1951-55	Urines	61 823	1 561	2.5	92 859	19 107	20.6
	Stools	39 648	269	0.7	79 774	3 315	4.1

The infection in Europeans

The data for Europeans would seem to show a drop in infection-rates, but this apparent decline is perhaps merely a reflection of an enhanced " bilharziasis awareness ", as witnessed by the great increase in the number of specimens brought for examination. Regular examinations of stool and urine specimens for evidence of this helminthic infection are becoming more and more common.

Table XII shows the distribution of anomalous infections. The figures were recorded during examinations performed at the Public Health Laboratory, Salisbury. The disparity between the findings in Europeans and those in non-European patients is probably not a real one, and is due to the fact that most of the specimens from European patients were examined by European technicians, who are more likely to take careful note of anomalous infections than are the African microscopists, who as a rule examine the material from the African Hospital. The importance of terminal-spined egg infections is well illustrated.

These data are, of course, only of value as a general indication; the variations in the figures for the two population groups may be attributable to a number of factors apart from the actual prevalence of the disease. During the period 1932-38, Blackie at his laboratory reported on the number of stool specimens positive for schistosome eggs, by species. In Europeans the distribution of positive cases was 181 *S. mansoni*, 19 *S. haematobium* and 3 *S. mattheei*. In African cases there were 1028 *S. mansoni*, 110 *S. haematobium* and 21 *S. mattheei*.

Until more recent years, there was very little evidence available as to the prevalence of bilharziasis in specific localities and in age-groups. At a small school for European children at Marula, south-west of Bulawayo, each of the 19 children attending had one specimen of urine examined.

TABLE XII. BILHARZIASIS IN SOUTHERN RHODESIA (ANOMALOUS INFECTIONS): SALISBURY PUBLIC HEALTH LABORATORY, 1951-55

Year	Population group	Urine specimens positive		Stool specimens positive	
		S. haematobium	*S. mansoni*	terminal-spined eggs	*S. mansoni*
1951	European	155	1	5	27
	Non-European	2 310	2	34	423
1952	European	247	1	6	45
	Non-European	2 732	5	35	560
1953	European	259	7	2	20
	Non-European	2 798	—	31	535
1954	European	269	8	10	23
	Non-European	1 705	5	21	378
1955	European	258	14	4	30
	Non-European	2 927	—	37	495
1951-55	European	1 188	31 (2.54%)	27 (15.7%)	145
	Non-European	12 472	12 (0.096%)	158 (6.2%)	2 391

Fourteen contained eggs and 4 showed numbers of red blood cells. Despite this parasitological evidence, only one child complained of symptoms referable to bilharziasis.

In 1938, the Schools Medical Service examined both urine and stool specimens from a random sample of European schoolchildren. 1229 urines revealed 80 *S. haematobium* infections, 1 *S. mansoni* and 1 *S. mattheei*; 1155 stools revealed 40 *S. mansoni* infections, 8 *S. haematobium* and *1 S. mattheei*. In addition, a group of special cases was examined. These children were referred to the medical officers by their teachers because they were thought to be in poor health. 248 urines showed 25 *S. haematobium* infections and 235 stool specimens showed 40 *S. mansoni* infections, 8 *S. haematobium* and 1 *S. mattheei*. This small survey drew attention to the fact that the infection-rate in European children was much higher than had been realized.

In 1954, Bennie & Blair [15] surveyed the urinary bilharziasis position in over 10 000 European children attending schools in the Greater Salisbury area. A single specimen of urine from each child was examined and 4.2% of the children were found to be infected (3.6% of the girls as compared with 4.8% of the boys). Nearly 2% of the school entrants (children in the age-group 5-7 years) were found to be already infected. The infection-rate increases with age until it reaches the level of 6.1% at 11-14 years. Thereafter it would appear to decline, but this is probably fallacious and due to the eggs' difficulty in traversing the bladder wall. For example, an infection-rate of 9% was found among 800 boys attending the two senior schools on a single examination. When they were re-examined two months later, the rate had risen to 17%. It is interesting to note that the children of immigrants into the Colony have acquired a urinary infection-rate of 4% by the second year of their residence.

The infection in Africans

Young [58] described his survey of the African labour on a farm in the Umvukwes district; he examined 80 male adults and found only 11 (14%) free from parasitic infection on a single examination. Infections with bilharziasis were found in 53. Of these, 35 were infected with *S. haematobium* only and 8 with *S. mansoni* only; 10 had both infections. All the infections thus revealed were treated and six months later 61 of the 80 were re-examined. At this time, 46 (74%) were free from any infection on a single examination; 6 (10%) had *S. haematobium* and 2 had *S. mansoni* infections, seven patients in all having bilharziasis, as one of them had both infections.

In 1954, at Karoi in the northern part of the Colony, the Medical Officer conducted a bilharziasis survey of 1168 African patients admitted to his hospital. In all, 298 cases showed infections with *S. haematobium* and 90 with *S. mansoni.* He then arranged the infections by the patients' country of origin. The following results were obtained:

Country of origin	*Number of patients*	*Number infected*	*Percentage*
Southern Rhodesia	759	285	37.5
Northern Rhodesia	189	26	13.8
Nyasaland	100	55	55.0
Portuguese East Africa	120	22	18.4

The figures for Southern Rhodesia included a number of women and children, while those for the other three territories consisted almost entirely of adult males in employment on local farms.

Field surveys

In recent years, bilharziasis surveys have been made of samples of children of various age-groups living in the African Reserves of the Colony, in whom, if an infection were found, it would be reasonable to suppose that the disease had been contracted in the immediate neighbourhood. Such surveys are confined to the examination of a single specimen of urine, collected soon after the child has taken part in some physical exercise.[14] As a general rule each specimen is examined on the spot by both microscopic and macroscopic methods, using the miracidial hatching-technique. The survey results are shown in Table XIII.

TABLE XIII. BILHARZIASIS IN SOUTHERN RHODESIA: A TYPICAL URINE SURVEY IN AN AFRICAN RESERVE, NORTHERN MASHONALAND

Age-group (years)	Males			Females		
	specimens examined	positive		specimens examined	positive	
		number	%		number	%
1-5	1 881	731	30.9	1 673	692	40.1
6-10	2 591	1 563	60.4	2 285	1 452	63.5
11-16	714	464	65.0	1 029	659	64.0

It is interesting to note that as a general rule girls are more heavily infected than boys until the age of five years. This may be due to the fact that girls at an early age accompany their mothers to the river to draw water and so become infected earlier.

Infection-rates in some of the areas examined were extremely high: in the Chiweshe Native Reserve 218/239 males and 218/242 females were *S. haematobium* positive in the 6-10 age group. In Mtoko, 433/650 males and 432/498 females in the 6-10 age-group, and 113/150 males and 229/250 females in the 11-16 age-group were *S. haematobium* positive.

In the eight Native Reserves, which have a total population of over 200 000, the lowest infection-rate in the 6-10 age group was found in the Chindamora Reserve: 33% of the boys and 27% of the girls. The lowest rates in the 11-16 age-group were seen in the same area: 44% of both sexes. In all other areas, the rates were over 50% and actually reached 100% in the 11-16 age-group in several reserves; in one reserve this percentage applied even to the 6-10 age-group.

In another survey of 2500 boys and 2500 girls from 1 to 15 years of age, 50% were found to be infected with *S. haematobium*. In this case the results of microscopic and macroscopic methods of examination were compared:

1.	Positive by both microscopic and macroscopic examination	2014
2.	Positive by microscopic but not by macroscopic examination	470
3.	Positive by macroscopic but not by microscopic examination	83
	Total infections discovered	2567

In addition to the *S. haematobium* infections seen, the total diagnosed by microscopic methods included 31 cases of *S. mattheei* and 3 of *S. mansoni*. Examination by the macroscopic method does not, of course, permit of species diagnosis, as the free-swimming hatched miracidium is all that is seen with the hand lens.

Distribution of the disease

Urinary bilharziasis caused by *S. haematobium* is truly endemic throughout the Colony except in the extreme south and west, where collections of surface water are scarce and ephemeral. Even in this area, however, there may be isolated groups with a high infection-rate, owing to the fact that the persons concerned have to draw their water-supplies from a dam or waterhole infested with vector molluscs.

In the north and east of the Colony, the disease is very common indeed, particularly in the area near Salisbury where, as field surveys have demonstrated, from 50% to 100% of African children are infected, and infection-rates even in adults reach about 20%. Here surface water is extensive even right through the long dry season, and most localities, unless they are more than 6000 feet above sea level, are well infested with vector molluscs.

Infections with *S. mansoni*, on the other hand, are not nearly so frequent or widespread, although in certain very limited localities high *S. mansoni* infection-rates have been recorded. This is particularly so in the eastern districts of the Colony. There is an impression that *S. mansoni* infections are commoner at lower altitudes, where hotter and more humid conditions prevail.

Methods of diagnosis

Routine examination of urine and stool specimens of African patients admitted to hospital is standard practice. This is carried out by the laboratories at the larger centres and by specially trained African microscopists at the smaller hospitals and larger African clinics. General population surveys are continuing and it is hoped to have more information on district prevalence by arranging for the simpler diagnostic equipment to be taken to the patient instead of his transporting specimens to the laboratory. The routine stool and urine examinations of schoolchildren have not been possible because of the difficulty involved in bringing specimens to the laboratory.

The standard urine examination is at present the microscopic scrutiny of a lightly centrifuged deposit of urine which has been passed after the subject has taken exercise. Macroscopic methods are generally used as a supplementary check, especially in tests of cure in cases which have been given treatment. Increasing use is, however, being made of macroscopic diagnosis as the sole method in field and school surveys, especially as this gives an accurate picture of the public health importance of the disease.

Stools are examined by microscopic investigation of the centrifuged sediment of a sample of emulsified stool. Direct smears and concentration methods are rarely, if ever, employed. Miracidial hatching-techniques are being used more frequently, because they are labour- and time-saving and reveal a higher proportion of light infections. Rectal smear techniques are never employed. Rectal biopsies are being used to a small extent, especially in European practice, where doctors have realized that the examination of a rectal biopsy snip is often of value in the diagnosis of *S. haematobium* infections which are not obvious in the urine. Sigmoidoscopy and cystoscopy are being used more frequently in the diagnosis of the more obscure types of European case. Many patients admitting evidence of *S. haematobium* infection of the bladder in childhood, when they reach the 30-40 age-group, complain of backache and urinary dysfunction, which is often due to organic damage to bladder and ureters resulting from long-standing bilharziasis. Older medical practitioners still place some reliance on eosinophilia in diagnosis, but the general view now held is that this index is of no value whatsoever, except perhaps in the diagnosis of the very early case, even before the worms have reached maturity and have begun to produce eggs.

Cercarial antigen tests are used not only by doctors in the preliminary investigation of their private patients but occasionally by public health personnel in mass surveys. The Government issues the antigen free of charge to any medical practitioner in the Colony. Nearly 50 000 doses were distributed in 1950. The amount of cercarial antigen now being issued has dropped greatly. This is to a large extent due to the fact that snail control measures applied in areas near Salisbury are making it increasingly difficult to collect large numbers of naturally infected *Bulinus (Physopsis) globosus*, from which the cercariae used for preparing the antigen are harvested. Provided that doctors realize that the skin test in individual patients is merely a good negative screen and that positive reactors must be further investigated before specific treatment is undertaken, the method is of very great value in diagnosis. In mass surveys, injection technique becomes standardized and it is undoubtedly the easiest and quickest way of finding the general incidence of bilharziasis in any particular area. Complement fixation-tests are not carried out locally.

Fortunately, routine post-mortem examinations can be made without any serious protest and much useful knowledge of the pathology of the disease has thus been learnt. Special attention has been paid to the study of the lesions of bilharziasis and much work has been published on this aspect of the disease. Studies of liver damage and the investigation of egg deposits in unusual sites by means of potassium hydroxide digestion methods are being pursued. The association of bilharziasis with malignant change in liver and bladder has been carefully studied, but the evidence of direct cause is inconclusive. Carcinomata of liver and bladder are among the most frequent malignant growths seen in the African.

The general impression of the post-mortem study of the disease is that the organ damage and destruction due to bilharziasis far exceed what would have been suspected on clinical and parasitological grounds. In Southern Rhodesia, the general impression is therefore of widespread infection of an intensity far in excess of that to be expected from the signs and symptoms ante mortem. In Europeans, the symptoms of infection are generally more marked, although the immediate danger may not appear to be serious. These cases seem, however, to experience serious urinary system damage more markedly than does the African patient. Evidence of infection with *S. bovis* and *S. mattheei* is greater than the parasitological evidence in stool and urine specimens would indicate. It seems that worms of these species readily invade the human being, but it is comparatively rare for them to be able to complete their life cycle and void eggs into excreta. The indications are, therefore, that the patient infected with worms of these species is of little danger to others. Human beings seem to be infected via the snail from cattle and sheep and not from another human being through the intermediate host.

Treatment

Lucanthone hydrochloride is the standard treatment of urinary infections and is also being used to an increasing extent in the treatment of cases infected with *S. mansoni.* The Government issues the drug in uncoated compressed tablets containing 0.5 g, scored for easy division. The recommended dose schedule is based on 60 mg per kg of body-weight. The total dose is spread over three days, one dose being given at night and one in the morning during this period.

The drug is taken well by children but adults complain of abdominal pain, sleeplessness and nausea. Signs of mental depression are often observed in European patients. These symptoms pass off rapidly when the course has been completed. The cure rate has demonstrated that lucanthone hydrochloride is the most satisfactory of all the types of treatment which have been tried, except intensive sodium antimony tartrate (SAT) given intravenously.

Apart from treating cases in its own hospitals and clinics, the Government supplies free drugs for the treatment of bilharziasis to any local authorities, mining companies and missions who in turn agree to make them available to any person who seeks relief. The drugs issued free are lucanthone hydrochloride and SAT, in sealed ampoules or as a glucose saline solution in 50-ml rubber-capped vials. All children of school age with bilharziasis are entitled to free treatment as out-patients in the hands of a government medical officer. Specimens of stool and urine submitted for examination by any person within the Colony are examined without charge at the Public Health Laboratories.

Mass treatment has been attempted; one such campaign used the intensive method of intravenous SAT, while a number of others experimented with lucanthone hydrochloride. These latter were very effective, and when they are combined with snail-killing in the same region promise to provide effective control of the disease. The limiting factor is finance, because the drug remains rather expensive despite the increased quantities which must now be in use throughout the world. Lucanthone hydrochloride is administered to African schoolchildren at kraal schools by the following simple and effective method. The children are given their tablets twice daily, once when they arrive in the morning and again before they disperse for the afternoon. The defaulters from treatment at African schools are few in number even on the third day of treatment. A number of farmers and some mining companies give routine treatment to all Africans who enter their employ. If a safe water-supply is provided to prevent reinfection, the increased health and energy displayed by the labourers will amply repay the cost of the drug.

There is no definite information on the number of cases of bilharziasis treated with lucanthone hydrochloride each year, but an estimate can be based on the amounts of the drug issued annually (see Table XIV). Despite the large numbers of persons being treated and the unpleasant side effect encountered in some patients, no dangerous toxic effects persisting after the course of treatment have been reported or observed. No deaths attributable to the drug have been recorded, a result which is in very marked contrast with the sinister record of the antimonial drugs over the past 40 years.

TABLE XIV. BILHARZIASIS IN SOUTHERN RHODESIA: TREATMENT WITH LUCANTHONE HYDROCHLORIDE

Year	Amount issued (kg)	Number of cases treated *
1950	46.5	13 280
1951	86.0	24 570
1952	63.6	18 170
1953	80.8	23 058
1954	139.7	39 914
1955	181.5	51 857

* Estimated on the basis of 3.5 g per patient

The snails

Bulinus (Physopsis) globosus and *Bulinus (Physopsis) africanus* have been shown experimentally to be the intermediate hosts of *S. haematobium* in Southern Rhodesia, and both species are to be found within the territory. Further to the north, *B. (P.) globosus* is the main vector, while in South

Africa *B. (P.) africanus* predominates. The snails have been identified by Connolly, Alves and Mandahl-Barth. In the past there have been doubts as to the separate identity of these snails, but it is now accepted that they are two distinct species.

Biomphalaria pfeifferi is the intermediate host of *S. mansoni* but the long-held view that it was the only representative of the family in the Colony has now been shown to be wrong. At least two other species are represented and in the light of information from other regions in Africa, these must also be regarded as vectors.

Bulinus (Pyrgophysa) forskalii is also a local species, sometimes present in very large numbers. No snails of this species have ever been found infected in Southern Rhodesia, nor have they been infected experimentally. The species would therefore appear to be of no importance in the transmission of bilharziasis, despite the evidence from West Africa and Mauritius that it can be infected experimentally.

Bulinus (Bulinus) tropicus is found extensively, favouring the same habitats as *Bulinus (Physopsis) africanus* and *Bulinus (Physopsis) globosus*, but no infected specimens have ever been discovered. It is interesting to note that, following a series of drought years, *B. (B.) tropicus* appeared to predominate in many of the habitats it was sharing with *B. (P.) globosus*.

Biomphalaria pfeifferi appears to be more limited in its distribution than the other vectors, a fact which is borne out by the patchy distribution of *S. mansoni* infections. It seems to remain in discrete colonies even in a flowing stream, and often not one specimen is to be found outside these colonies. *B. pfeifferi* snails favour storage dams, perhaps because they are attracted by the muddy margins and animal pollution which are generally present. The shells may form a " beach " on the concrete wall of the dam itself, and living snails seem to be attracted to the steep, algal-covered wall below the water surface. *B. pfeifferi* is also the commonest snail found in irrigation canals and ditches in the hotter areas at lower altitudes, where it generally far outnumbers the other species mentioned.

The World Health Organization has established a Snail Identification Centre in Salisbury to which all African territories have been invited to submit material for identification. Arrangements exist whereby suitable material is sent to the experts in malacology nominated by WHO.

In natural watercourses, snails seem to breed twice or three times a year. In irrigation works breeding would seem to go on practically all the year round, and as many as five generations may be produced. Cercarial infection-rates in *Bulinus (Physopsis) africanus* and *Bulinus (Physopsis) globosus* are generally very high and the cercarial output from infected snails is very high indeed. In batches of snails taken from pools in rivers exposed to heavy pollution, infection-rates of 20%-40% are not at all uncommon.

Individual snails appear to be able to maintain a high daily output, some specimens producing thousands of cercariae. For this reason the raw material for the manufacture of cercarial antigen has been easy to obtain.

Some of the vector snails survive the long dry winter months (June to October) by going into hibernation. When pools dry up, the snails burrow deep down into the hard caked dry mud. Living snails have been found as deep as 18 inches from the surface, completely enveloped in the mud. Snails which can be artificially revived from hibernation are always found to be uninfected. It would seem, therefore, that the hibernating stage in the intermediate snail host is quite unimportant in the survival of bilharziasis from one rainy season to the next.

Control measures

Since 1945, much work has been done on the use of copper sulfate as a molluscicide. This substance has been tried in operations of every scale; on one occasion it was used in an attempt to obtain clearance of a whole river catchment-area nearly 2000 square miles in extent. The Government makes copper sulfate available free of charge to any landowner who is prepared to treat his streams and dams in the way recommended. Riparian owners are being encouraged to treat one catchment-area simultaneously. On the whole, this scheme has not been very successful, because the best time for applying copper sulfate to streams coincides with busy periods in the farming calendar. Local health authorities are also encouraged to undertake this work in their areas. In towns, of course, the population at risk is much greater than in rural areas and, because of the heavy pollution of streams, the snail population is also large and generally heavily infected.

The Government has embarked on a project for the joint control of malaria (by residual insecticide) and bilharziasis (by copper sulfate) in Native Reserves, using a single team for both tasks, and it is possible that this may be the most efficient way of using molluscicides.

In the years 1949 and 1950 the teams were employed on spraying concentrated solutions of copper sulfate on all rivers and streams in the Mazoe Valley catchment-area, in which a pilot malaria control project was in operation from October to April, the wet summer months. In 1951 the same area was carefully surveyed and checked, and where snails were still to be found molluscicide was applied. In 1952 the control teams extended their sphere of operations to the Native Reserves around the Mazoe Valley, treating all sites where snails were likely to be found and to which human beings had easy access: village water-supply points, washing places and path and track crossings of streams and small rivers. In the following year the same programme was pursued. There is no doubt that this campaign greatly reduced, even if only temporarily, the molluscan population of the area.

In 1954, the tactics were changed and all efforts were concentrated on the Mtoko Native Reserve, 90 miles north of Salisbury, where all the streams in an area of 500 square miles were treated. Twenty-seven tons of copper sulfate were applied to over 400 miles of stream. During this season the increase in the snail population of Lake McIlwaine, an artificial lake on the Hunyani River 20 miles south of Salisbury, caused alarm and 4½ tons of copper sulfate were applied to the more frequented shores of the lake. In the 1955 winter season a concentrated effort was made to control the snail population on the lake and this was so sucessful that careful surveys at the end of 1955 failed to find any vector snails at all.

Experimental work with sodium pentachlorophenate, which had been started in 1954, was expanded in the following year. This molluscicide would seem to have a residual effect and has the very great advantage of killing snail eggs. Experiments were continued to devise means whereby a slow and prolonged release of this most potent molluscicide could be effected.

The Native Affairs Department took direct responsibility for the application of copper sulfate to all canals and furrows on their irrigation settlements in the Sabi Valley, where, despite the agricultural prosperity of the area, it was evident that bilharziasis might soon jeopardize the whole irrigation scheme.

Table XV shows the amounts of copper sulfate and sodium pentachlorophenate which were used in campaigns during 1948-55.

TABLE XV. BILHARZIASIS IN SOUTHERN RHODESIA: USE OF MOLLUSCIDES, 1948-55

Year	Copper sulfate (short tons)*			Sodium pentachlorophenate (short tons) *
	by control units	by other agencies	total	by control units
1948	—	5.00	5.00	—
1949	—	5.50	5.50	—
1950	25.25	3.25	28.50	—
1951	9.75	6.85	16.60	—
1952	22.52	3.66	26.18	—
1953	26.25	6.25	32.50	—
1954	27.00	7.25	34.25	0.85
1955	41.75	5.50	47.25	1.75

* 1 short ton=2000 lb.

Prevention

For purposes of antibilharziasis education, the European population can be reached by pamphlet, press and radio. It is no easy task, however, to steer a course between creating mass bilharziaphobia and allowing carelessness to rule. It has also been difficult to convince the large influx of post-war immigrants of the risks of infection and that the enticing granite-pooled streams of the high veld are a potential source of danger.

The educated African can derive benefit from the same channels of information, but the less educated are approached through the African vernacular press by means of cartoons and simple lessons. The radio is also used for the simple instruction of Africans. The teaching of hygiene is undertaken at all schools, films and film-strips playing an important role. A shortened version of the film " African Schistosomiases " is much used and is included in the general science and biology courses in senior schools.

In the native reserves, the services of African health demonstrators are used to give instruction at the simplest level on how the disease spreads. The provision of a safe water-supply, and the construction and proper use of latrines are encouraged. Few rural African villages have any water-supply other than the nearest stream. The recent cycle of drought has, however, forced the sinking of wells and boreholes in certain places, and this has considerably reduced the local risk of contracting the disease.

In some areas, owing to diminished soil fertility and increased populations, resettlement of Africans is now being undertaken. Efforts are being made to locate the new villages away from streams and provide them with wells. This should do something to diminish the risk. The villagers wash their clothes in streams and nothing has yet been done to encourage the making of communal laundries. When there is evidence that bilharziasis is related to a particular village water-supply, an attempt is made to break the transmission cycle by snail-killing with copper sulfate. The African health demonstrators undertake this work. In the same way, snail control at road and path crossings of rivers and streams, near village schools and at other sites where human beings are likely to come into contact with water is being tried. Wherever possible, every effort is being made to provide, at low cost, safe, clean water-supplies from a protected spring, in order to discourage villagers from using the nearest stream for their domestic supplies. A propaganda film, describing the advantages of this system and giving full details of its construction by the villagers themselves, has been made.

In ten years Southern Rhodesia has made considerable advances in water conservation and the country is dotted with water-storage dams on streams and rivers and at the heads of valleys. As surface and underground storage of water increases, streams tend to flow all the year round, snail breeding-cycles extend and the normal heavy mortality of snails caused by the long winter drought is very much reduced. Water conservation, so necessary for the agricultural prosperity of Southern Rhodesia, is seriously increasing the risks of even more widespread and intense bilharziasis.

Irrigation is only in its infancy in Southern Rhodesia and existing projects are all on a small scale. Projected schemes, however, give cause for grave anxiety for the future, since if they are implemented vector snails will find a better environment and be able to breed faster. Liaison between those responsible for irrigation plans and health department personnel is not good and it is feared that, unless very great care is exercised in the planning and administration of these schemes, the increase in economic wealth will be offset by a deterioration in health.

The following are the main points to be borne in mind:

1. Main canals must be cement lined.

2. No night-storage dams should be allowed. These have been proved to be one of the most serious dangers in existing schemes, as they are usually overgrown, unfenced, and, therefore, heavily polluted.

3. There should be a central organization to undertake weed clearance of all furrows and drainage ditches. Water-management rules should be strict and carefully administered.

4. All domestic water-supplies should be either (*a*) drawn from wells or boreholes, or (*b*) piped from a water-purification plant. To make this central purification possible, all people who live and work on irrigation projects should live together in villages. This would reduce the risk of pollution of the agricultural areas and would thereby lessen the occupational hazards of farmers.

5. Sanitary arrangements should be provided whenever houses are constructed.

6. All labourers should be encouraged to settle in the area with their families. It would then be worth while to treat these groups and to rid them of their infection before they started work on the irrigation scheme.

Experience with existing schemes has shown that the disease becomes widespread and of increased intensity. This has affected not only the workers but the whole population at risk, because no attempt has been made to provide a safe domestic water-supply. The nearest irrigation furrow is held to be adequate.

Northern Rhodesia

The Protectorate is third in size of the British colonial possessions in Africa. It lies to the north of the Zambesi River and consists of a wide plateau situated between the Zambesi and Congo River basins. Over most of the territory the climate is subtropical rather than tropical. There is a single rainy season lasting from October to April and the annual rainfall varies from 20 inches in the south to 60 inches in the north in the Copper Belt on the borders of the Belgian Congo. The prosperity of the Protectorate rests to a very great extent on the copper-mining industry. Agricultural development by the European farmers is limited to a strip of land on either side of the railway line from north of Livingstone to Ndola, and to an isolated tobacco-growing area at Fort Jameson in the Eastern Province. In African hands, farming is chiefly on a subsistence basis.

Review of available data

The existence of bilharziasis has long been suspected, as *S. haematobium* infections were reported in migrant labourers from Northern Rhodesia seeking work in Southern Rhodesian mines as early as 1908.

From the annual reports of the Protectorate's Medical Department which have been consulted it would appear that in the earlier days no attention was given to the disease. In 1925-26, it was claimed that bilharziasis was seen only on the border with Portuguese East Africa and in the Kasempa District, and that it was not at all prevalent. In 1928 it was noted that the disease was rare near Livingstone but that at Fort Jameson where 17 cases, including 15 children, were treated, the native inhabitants affirmed that the disease was common. In 1933, the Roan Antelope Copper Mine Hospital began the routine parasitological examination of all admissions and calculated a bilharziasis infection-rate of 15%.

The 1937 report goes into the question more fully and states that the interest in helminthic disease centres on bilharziasis. While little or nothing was then known of its prevalence, each year seemed to show the disease to be more common than was realized, even though it was frequently present without causing signs and symptoms. Whenever a microscopist was attached to the staff of a hospital, he found that 20% of the patients were infected either with *S. haematobium* or with *S. mansoni*.

At Balovale, *S. mansoni* was the predominating parasite, since 95 cases were treated, as compared with only 24 *S. haematobium* cases. *S. haematobium* infections were reported as common at Broken Hill, Choma and Mazabuka, on the railway, and in the Fort Rosebery District. *S. mansoni* infections were reported to be common in the Luapula Valley.

In the 1939 report, much space is given to bilharziasis and the surveys of a number of medical officers are recorded. At Mazabuka, 131 out of 752 patients (17.5%) were found to be infected with *S. haematobium*, but of these only 6 had come to hospital because of this infection. At Broken Hill, there were 403 cases in 1903 admissions. A survey of Lake Bangweule seemed to indicate the absence of *S. haematobium*, as no infections were found in 446 specimens of urine examined. On the Luapala River, downstream from Kapalala, many cases were found, the infections being most common in villages on the Lwela River and its tributaries.

Reference is also made to the apparent drop in infection-rates in older people, a decline which is rightly attributed not so much to cure as to the inability of the worms to pass their eggs through the scar tissue in the bladder wall into the urine.

In the ten years 1943-52, 9744 cases of bilharziasis were treated and 32 deaths were recorded. Instances are given which show the widespread nature of *S. haematobium* infections in the Territory. One hundred Africans at Namwala were taken at random and 68 were found to be infected, as were 29 % of all admissions to a hospital in Choma. At Livingstone, 75 cases were admitted specifically for bilharziasis treatment but 239 other patients were also found to have *S. haematobium* infections. The occurrence of *S. mansoni* at Balovale is again noted, 51 cases being treated along with 225 patients with *S. haematobium* in the urine. In Mongu, 150 miles down the Zambesi, the disease was shown to be less common, 4 *S. mansoni* and 35 *S. haematobium* infections being recorded.

Field surveys

The most important investigation into bilharziasis carried out in Northern Rhodesia is the survey by Buckley,[23] and his results provide the most reliable data on the prevalence of the disease. Apart from short investigations at other centres, the work was confined to the area of the Northern Province lying within the arc formed by the Chambezi and Luapula Rivers and including the area round Lake Bangweule.

Buckley showed that the *S. haematobium* infection-rate was very variable throughout the area, but that rates of from 25 % to 60 % were found in localities near the southern end of Lake Tanganyika and on the arc of the Luapula River to the south-west. He noted that Lake Bangweule and the main stream of the Luapula River were free from infections and vector snails. High infection-rates with *S. mansoni* were found by him at Mamkola at the southern end of Lake Tanganyika (61 %), at Luena Wantipa on a river flowing north to Lake Mweru (34 %) and at Kafulwe, where this river enters the lake (42 %).

He observed the close correlation between endemic *S. haematobium* and the presence of *Bulinus (Physopsis) globosus* and/or *B. (P.) africanus*. He also mentioned the possibility that the distribution of the planorbid vectors of *S. mansoni* was not nearly so well correlated with the intensity of this infection, an observation which has been made in other areas of Central Africa. Buckley analysed the nature of the habitat from which he collected vector snails. Specimens were notably scarce or absent in large rivers, lakes and swamps and were most often found in small streams. He made snail collections from the areas that he visited in the Northern Province and also from a number of localities in the Copper Belt. All the species were identified by Major Connolly at the British Museum. The data thus accumulated provide what is probably the most complete and accurate survey of molluscan fauna in any area of British Africa.

Nyasaland

The Protectorate of Nyasaland lies along the western side of Lake Nyasa and includes the high escarpment of the Rift Valley. At the southern end of the Lake, the territory includes both sides of the Shire River Valley and the high mountainous plateau of the Shire Highlands, which projects as a salient south and east into Portuguese East Africa. The Lake has an altitude of 1400 feet and the Shire River at Port Herald, where it leaves Nyasaland, is only 120 feet above sea level. The plateaux bordering the Rift Valley have an elevation of 3300-4400 feet and the Shire Highlands rise to 3500 feet.

On the shores of the Lake the temperature seldom rises over 100°F (38°C) and the humidity remains high throughout the year. Temperatures of up to 115°F (46°C) have been recorded on the Shire River. In the highlands, the climate is equable and fairly healthy. The rainy season extends from October to March. Until December, the rain comes in storms accompanied by thunder. Steady rains begin in January and tail off in March. The annual rainfall varies from under 30 to over 70 inches.

The country is given over to agriculture which is mainly in the hands of the African peasant, but tea, coffee, and tung trees are grown by European settlers in the Shire Highlands. Tobacco is widely cultivated by the Africans.

The Protectorate is the most densely populated area in Central Africa and consequently the African males leave in large numbers to seek employment in neighbouring territories and sometimes in the Union of South Africa.

Review of available data

Bilharziasis has long been recognized in the Protectorate. In the annual report of the Medical Department for 1913—the earliest available—mention is made of an investigation by Dr Conran in Karonga, at the extreme northern tip of the Protectorate, on the shores of Lake Nyasa. He examined 522 stool specimens and found that 32% contained eggs of *S. mansoni*. He also noted that in some specimens terminal-spined eggs were to be seen and attributed their presence to urine contamination of the sample. A high proportion of children were infected (49% of the boys and 44% of the girls). In adults, Conran reported that the infection-rate fell away to 31% in males and 16% in females. He compares this picture with conditions at Fort Hill, 40 miles away from the Lake near the border with Northern Rhodesia and 4400 feet above sea level, where the infection-rate was 10%.

The report for 1922 gives a full account of a study by Dr Dye, which is a model of close observation and painstaking work under what must have been very difficult conditions. Dye describes the situation at Karonga, the station at which Conran worked. Seventy-five per cent. of the population gave a history of " red water " but did not seek treatment. On questioning, they admitted discomfort over the bladder and pain on micturition, but this did not seem to inconvenience them. What did worry them was the frequency of micturition.

Dye noted that although the infection occurred in the mountainous area it was uncommon, since here the streams are generally rushing torrents. Cases were more common on the banks of rivers such as the Henga where the water moves slowly through rank vegetation. Most of the cases, he noted, lived in villages near the banks of the slow-moving lower courses of rivers flowing from the foothills of the Rift Valley escarpment to the shore of Lake Nyasa. He also noted the association of an enlarged liver with *S. mansoni* infection in the stool and was surprised at the number of eggs seen in cases apparently free from signs and symptoms.

In the report for 1923, the account of Dye's work is continued. He claimed that there was heavy mortality from *S. mansoni* infection in young children. He infected planorbid snails with *S. mansoni* miracidia and thereafter the snails produced typical human-type cercariae. He found *Physopsis globosa (Bulinus (Physopsis) globosus)* markedly attractive to miracidia of *S. haematobium*, but all his snails died, apparently as a result of the infection. The snails collected by Dye were examined at the British Museum by Mr B. C. Robson and named *Physopsis globosa* and *Planorbis sudanicus*.

In 1925, Wiltshire at Mlanje examined the stools of 30 patients and 30 apparently healthy persons, and found *S. mansoni* infections in 6 of the former and in 2 of the latter.

Reports on the prevalence of the disease continued in 1930 and 1931 at Kota Kota on Lake Nyasa where there is an extensive area of marsh subject to inundation. 263/322 urines were *S. haematobium* positive and 38/526 stools showed *S. mansoni* eggs.

In 1931, Gopsill's work on bilharziasis on the Lower Shire River was recorded. In routine examination of all in-patients he found that of 500 specimens of stool, gravity precipitated for 30 minutes, 20% were infected with *S. mansoni* and 1% with *S. haematobium*. In the same number of urine examinations, 400 (80%) were infected with *S. haematobium*. He noted that none of this group gave any history of urinary disease, had no cystitis and did not appear to be inconvenienced at all by their infections. In a search for the snail hosts he was able to find only *Melanoides tuberculata*. This species was present often in enormous numbers in muddy parts of the Shire River. His attempts to infect specimens failed, but on the rather insecure basis of the commonness of the snail, he incriminated this operculated species as the vector of both types of bilharziasis. Snails collected at Port Herald were examined by Mr. T. Woodine at the British

Museum and identified as *Melanoides tuberculata, Cleopatra bulimoides* and *Lanistes ovum.*

In 1932, at Cholo, in the southern part of the Shire Highlands, an examination revealed that 209/712 stools were positive for *S. mansoni.* In addition it was noted that, contrary to the experience in Karonga, at the northern end of Lake Nyasa, enlarged livers were not often detected.

In 1935, the inhabitants of an island in Lake Chilwa were examined; 74/158 urines were *S. haematobium* positive and 13/166 stools were *S. mansoni* positive. These people live an isolated existence and were almost certainly infected on the island.

In 1936, an investigation at Chinteche, north of Kota Kota, showed 330/504 *S. haematobium* positive urines and 6/508 *S. mansoni* positive stools. Again it was noted that children rarely showed signs of bladder trouble or anaemia but in the older people the infection was claimed to be of grave significance and possibly a primary cause of death.

During the same year, a number of field surveys were started to ascertain the prevalence of both urinary and intestinal bilharziasis in high and low altitude villages in the same district, sometimes only a few miles apart. The results showed a tendency, but nothing more, for infection-rates to be higher in the lower altitude villages. Some surprisingly heavy *S. mansoni* infection-rates were recorded, including 179/300 examined in the North Nyasa District.

Gopsill in another survey in North Nyasa examined the population living within 200 yards of the Lake, south of Karonga. In 204 people he found 163 stools *S. mansoni* positive and 79 urines *S. haematobium* positive. He attributed these high rates to the fact that, owing to the rise in lake level, the land behind the foreshore was being inundated and the people refused to move from their villages until the last moment. These swampy areas were all heavily polluted with excreta. He could find only *Bulinus (Physopsis) africanus* present and assumed that this species was a vector of both types of disease.

In the 1939 report, the general situation in respect of bilharziasis was summed up. Although no proper survey of snail habitats had been made, it was claimed that the lake-shores, the banks of slow-moving streams and swamps harboured the vectors. A pessimistic view was taken in regard to this disease, given the difficulty of treating patients without skilled staff and the apparently vast extent of the snail habitats. A suggestion was made that something might be done to clear and demarcate bathing places on Lake Nyasa and on the Shire River.

In 1945, the first organized attempt to control the snail vectors was made. The problem was tackled by treatment of the infected population, by education and propaganda, and by the application of an infusion of *Tephrosia vogelii*, a recognized fish poison. The immediate effects of the poisoning were good, but the final results were disappointing.

Ransford [50] described the situation at Kota Kota on the western shore of Lake Nyasa, about half way up its length. He found eggs of *S. haematobium* in 51% of 1857 children examined, boys being slightly more frequently infected than girls. No cases were found in children under four years. The infection was most prevalent at Kota Kota itself (81%), decreasing away from the lake-shore at higher altitudes. *Bulinus (Physopsis) globosus* was found in great numbers in residual pools in the flood plain near villages, but not so in pools far from human habitation. Ransford also stated that this species was found in rice fields in the rainy season. He was of the opinion that *Bulinus (Physopsis) globosus* required a polluted habitat to thrive. He noted also that the Lake itself was safe, even in the backwaters.

Maclean [41] and Maclean & Hay [42] have described a most interesting attempt to control and even eradicate bilharziasis on Likoma Island in Lake Nyasa. The island is small but densely populated and lies close to the Mozambique shore, more than half way up the Lake. A snail survey showed that *Bulinus* s.l. was present, and in one limited area a planorbid species was found. The plan of attack was directed not only against the snails but against the helminths in the human population. Copper sulfate was applied in a dose estimated at 10 parts per million to pools, rice fields and the most frequented parts of the island shore. Reinfestation occurred but treatment was repeated monthly for five months at the selected habitats.

The whole island population was examined for urinary bilharziasis and 801/3600 (22%) were found to be cases of *S. haematobium* infection. All these were treated with lucanthone hydrochloride, 30 mg per lb. of body-weight (roughly equivalent to 60 mg/kg) being given, in six doses, night and morning for three days. About half the persons treated were re-examined once only but the remainder were re-examined two or three times. In the latter group, 28 of 349 persons who were negative at the first examination after treatment were subsequently found to be positive. In a final mass survey five months after the conclusion of treatment, 145 infections only were discovered, including 45 of the group of 801 persons treated. This shows a very satisfactory response to lucanthone hydrochloride, because it is possible that a proportion of the positive cases in the treated group might have been due to reinfection rather than to failure of treatment. The 100 new infections discovered would seem to indicate either that the snail control had not been very effective or that the island population had had good opportunities for reinfection on their visits to the mainland.

Available hospital statistics for the number of cases treated in 1949-53 are given in Table XVI.

Personal observations

For a territory with such a small medical staff, Nyasaland has a better idea of its bilharziasis prevalence than many a larger and more wealthy

TABLE XVI. BILHARZIASIS IN NYASALAND: PATIENTS TREATED, 1949-53

Year	In-patients		Out-patients
	cases	deaths	
1949	995	4	9 959
1950	938	2	8 232
1951	1 035	6	10 086
1952	1 051	2	10 470
1953	2 115	—	10 008

territory. Owing, however, to its small budget, the Medical Department has not been able to do much about trying to control the disease.

The general impression obtained on reading the previous history of the disease in Nyasaland is of the widespread distribution of *S. haematobium* infections, which are generally not of high intensity. However, it is one of the few areas in Africa where the prevalence of *S. mansoni* infections in certain localities—Karonga in the north and Port Herald in the extreme south—rivals and perhaps even overshadows that of *S. haematobium* infections. In his report for 1950, the Director of Medical Services makes the following observation: "... although not a killing disease, bilharziasis has a tremendous influence on the standard of education attained at school and on the level of productivity of the adult population."

The author's visit was of rather short duration and, unfortunately, it was impossible to inspect the Karonga area. It was therefore decided to limit the survey to the Shire River, the Shire Highlands at Cholo and the Lake Nyasa shore near Fort Johnston. Around Blantyre no vector snails were seen, but as *Lymnaea* spp. were present, it is possible that a longer search, or a search conducted at a more favourable time of the year, would have revealed the presence of *Bulinus* s.l., as the habitat appeared to be ideal. A number of small dams were examined but no *Biomphalaria* spp. could be found.

The lower Shire valley was surveyed on its east bank, from Chiwawa to Chiromo. The main stream runs swiftly between steep banks with extensive beds of reeds at some points. Several marshy areas behind the main river bank were also searched, again without result. The Shire River is fed on its east bank by a number of rivers which rush down the escarpment into the valley and then flow slowly across the plain into the main stream. In pools at many points children were bathing and water was being drawn, but despite a most careful search no potential vector snails could be found. From the debris tide-line it was obvious that the rivers had been in spate. At one road-crossing of a stream, an irrigation furrow leading to a sawmill was examined and thousands of *Bulinus (Physopsis) globosus* were found concentrated in a few yards of an 18-inch-wide furrow, sticks and debris being covered with snails. It seemed likely, therefore, that, as has been noted elsewhere, a flood can apparently banish snail life temporarily. In this particular instance the furrow provided the conditions for survival of the snails.

At Chiromo, the Shire was again examined and, despite the presence of some horizontal vegetation, no snails were seen. In the highlands near Cholo several swift-flowing streams with irregular beds were inspected; these werev deoid of snails. A number of dams on tea estates were examined. For antimalaria purposes, these were free from marginal vegetation and were clean banked. Despite this, however, on pieces of bark, *Bulinus (Physopsis)* spp. and *Lymnaea* spp. and their egg masses were seen. Some of the dams are used for recreational bathing. Snail control could be exercised simply by marginal spraying with copper sulfate.

The general impression gained in the highlands was that at certain seasons of the year the vector snail population would be fairly large, but that at the time of the visit it was in temporary eclipse. Streams in the Domasi district, north of Zomba, an area known to have a population heavily infected with *S. haematobium*, produced no living snails, but a few shells of *Bulinus (Physopsis) globosus* were found on two occasions. The Shire River at Liwonde showed the same broad, swift-flowing stream with predominantly vertical vegetation. In the shallows near the ferry, water-lilies and sedges growing in the artificial backwaters thus created were examined and no snails were found. On the west bank towards Fort Johnston, a number of dry river-beds were crossed and these were examined for snails, but the few pools of water seen were foul and devoid of snail life. Near Fort Johnston, the Shire River spreads out to form a small lake with many backwaters. In one of these, in which masses of horizontal vegetation were growing, many *Bulinus (Physopsis)* spp. were found. Again, in Fort Johnston itself, in a vegetable garden hacked out of the papyrus beds, large numbers of *Bulinus (Physopsis)* spp. and *Biomphalaria* spp. were found in the muddy water in between sweet-potato mounds. On the sandy beaches of the Shire River, however, no snails whatsoever could be found.

On the shore of Lake Nyasa itself a number of beaches were inspected with negative results and, because of the constant wave action, snail life in these stretches is very unlikely. In the coves and sheltered bays, where banks of reeds are established, it is possible that wave action is reduced and that the vegetation is sufficient to maintain snail existence. The general impression gained from the areas of lake-shore visited is that, under normal conditions, snail infestation should not be a problem. It is realized, however, that changes in level may cause flooding and marsh formation, or the creation of quiet backwaters where snails can multiply. In the same way interference with the reed-beds for the cultivation of wet gardens also creates good living conditions for the vector snails, particularly *Biomphalaria* spp. Unless such artificial conditions are created on the lake-shore, it is much more likely that the inhabitants of the shore area will be infected by snails living in the lower reaches of the streams coursing across the plain from the escarpment of the Rift Valley.

PART II. DISCUSSION AND CONCLUSIONS

Bilharziasis has roused little interest in the countries surveyed and from the attempts made to answer the questionnaire which each territory was asked to complete in advance of the visit it is obvious that no real information does exist in many of the countries.

It is really not surprising that the disease should have attracted so little interest. Normally, it neither kills nor incapacitates the sufferers, provided that their activities are permitted to remain within the limits of their physical and mental capacity. When the effects of bilharziasis are compared with those of malaria and trypanosomiasis, particularly in the West African territories, it can readily be understood that the control of these latter diseases must take precedence over that of bilharziasis, and that such funds and personnel as are available must be devoted to the combating of the more serious public health problems.

Lack of funds and the need for more trained personnel have been the chief obstacles in preventing the territories in the area under review from taking an extensive interest in anything more than existing commitments. While it is conceded that finance is not everything, no medical or health service can be maintained or progress unless money is available. In many of these territories the money will not be obtainable from internal sources until the health and standard of living are improved.

Methods of Obtaining Morbidity Data

It is tempting to make a guess at the number of cases of bilharziasis in British Africa, although such an estimate, based of necessity on very tenuous evidence, would be of little value. In many territories, all that can be said is that the disease occurs in one or both of its African forms. The need for further investigation is obvious.

No attempt has been made to prepare distribution maps of bilharziasis in British Africa because of the paucity of information. For the same reason, it would have been unrealistic to try to depict various degrees of intensity of infection in the human population. It can, however, be stated that *S. haematobium* and *S. mansoni* infections are known to occur in all the territories surveyed, with the exception of the Gambia, where indigenous *S. mansoni* infections have not been encountered, although potential vectors are believed to exist.

Hospital statistics

In Part I of this report, hospital statistics of the disease in each area have been given wherever they were available. In tropical countries, however, nosological returns are quite the most unsuitable material on which to base any opinion as to the prevalence of an infection, since multiple diagnoses are the rule and the patients may well be tagged with a selection of disease labels.

Bilharziasis, a disease of relatively easy diagnosis, particularly in the case of *S. haematobium* infections with the passage of eggs into the urine, must often figure as one of the parasitic and helminthic infections from which a patient is found to be suffering. Until recently the treatment of the disease would, however, have daunted the most enthusiastic doctor and the most amenable patient. It seems likely, therefore, that the number of cases shown in hospital records as having been treated for bilharziasis represents only a small fraction of the sufferers from the disease who pass through the hands of the medical services.

Field surveys

Up to the present, little has been attempted in the way of field surveys to assess the prevalence of bilharziasis, although such investigations provide the most valuable information on which to base infection-rates. With modern improvements in techniques, field surveys of urinary bilharziasis can be organized with the simplest equipment and with a staff which can be trained quickly for the particular operation. If surveys of population samples are confined to children and adolescents the work can be done in co-operation with village schools, and the probable site of infection can be localized with more precision than is possible when adults are examined. It will generally be found that in surveys conducted in rural areas there is little difference between the infection-rates in boys and girls; in fact, contrary to the old beliefs based largely on experience with European children in South Africa, girls tend to acquire the infection at an earlier age than boys.

The immediate findings of such field surveys may reveal the existence of foci heavily infected with *S. haematobium*, upon which to concentrate any resources as may be available in an endeavour to improve water-supplies and sanitation, to eradicate the molluscan vectors, and even to introduce mass treatment campaigns. The long-term result would be the accumulation of background information as to the distribution of the disease. With this knowledge, the effects of such economic and agricultural development as schemes for large-scale irrigation and water conservation could better be gauged.

Use of the miracidiascope

This simple device, by removing the necessity for trained microscopists, enables sample surveys of urinary bilharziasis to be undertaken on a much larger scale. The equipment costs little, since it consists merely of hand centrifuges and tube-containers for collecting urine specimens, and a number of examination racks which can be made cheaply by local carpenters. The technique and equipment have been described by Meeser, Ross & Blair.[43]

Gerber [35] in Sierra Leone, and other workers in Rhodesia and East Africa have shown that the examination of single urine specimens from children in a particular locality gives a fairly accurate idea of the prevalence of *S. haematobium* infection in that locality. The data in Table IX, page 231, attest to the accuracy of the miracidial hatching-technique when its results are matched against the findings of orthodox microscopic examination. In fact, if the figures relating to children of both sexes up to the age of nineteen years are examined, it will be found that the miracidiascope revealed 5% more cases than the microscopic examinations. The essentials of the technique are: (*a*) the collection of specimens after the subject has taken exercise, and (*b*) the examination of specimens immediately or as soon as possible after collection.

There is no doubt that even in children the cases which pass non-hatchable eggs will be missed, but this disadvantage is outweighed by the fact that the macroscopic method reveals some very light infections which are not detected by microscopic examination. The macroscopic method is not so accurate when urine from adults is being examined, since a larger proportion of people in these age-groups shed dead or non-hatchable eggs. From the public health viewpoint, however, it is the measure of the potential pollution of local surface waters that is the most important factor. There is little doubt that the great bulk of *S. haematobium* eggs which hatch in water and infect the vector snails are shed by the children of the community.

Antigen surveys

The use of the cercarial antigen skin-test as a speedy means of ascertaining the infection-rate in population samples has not fulfilled its early promise. While there is no doubt that many hundreds of persons can be examined by this method in a day, the need for a highly skilled and experienced operator and the fact that the reading of the results must keep pace with the actual testing have prevented its wider use. Nevertheless, it is the speediest method of getting an idea of the frequency of bilharziasis in an area before more-detailed sample surveys, based on urine and stool examinations, are undertaken.

Cercarial antigen has been shown to be a very stable product even when in liquid form ready for injection. The preparation of the antigen is a very simple matter, and in most countries where skin-test screening surveys are to be instituted, it should be easy to arrange for the local manufacture of ample supplies of antigen.

Stool surveys

The position in regard to large-scale stool surveys in the field is much less satisfactory. While many hundreds of urine specimens can be examined and reported on daily with a fair degree of accuracy by a small team who need only simple training for this work, the examination of stool specimens is tedious and time-consuming and requires much dearer equipment and more elaborate techniques. There are two factors to be taken into consideration. The general impression gained is that *S. mansoni* is much more limited in its distribution than is *S. haematobium* and that small sample surveys might show whether the infection occurred in any particular area. If any cases were found, then a more intensive survey could be made. The microscopic examination of specimens of stool can further be justified on the grounds that it reveals the presence of other infections.

The miracidial hatching-technique was originally described by Fülleborn [27] in the examination of stool specimens for *S. mansoni.* The method is, however, more tedious than the same technique used in the macroscopic examination of urine specimens. While miracidial hatching from stools is just as economical in equipment and staff as the macroscopic examination of hatched miracidia in urine specimens, the lengthiness of the procedure renders it rather impracticable in a large series of examinations. Moreover, as has already been stated, the microscopic examination of the centrifuged deposit of a stool specimen has the advantage of revealing other infections.

Rectal biopsies have been used to a considerable extent in South America and would appear to give good results. In Africa [29, 44] it has been shown that many *S. haematobium* infections can be diagnosed by this method, even when the urine specimen is quite clear of eggs. It is not, however, a method which is generally applicable in the field and its use in general surveys would have to be confined to groups subject to discipline. With practice, however, the taking of the biopsy snip and its microscopic examination can be done quickly and with remarkably little pain and inconvenience to the patient. The conclusion is therefore that for field surveys of *S. mansoni* infections there is as yet no satisfactory technical short cut.

Intensity of Infection

One of the most striking aspects of the survey in West Africa was the general agreement that bilharziasis was a mild disease with few symptoms, causing little morbidity and mortality. It is difficult to try to assess the true importance of the disease as a public health problem. Some authorities maintain that bilharziasis is of absolutely no significance and should be ignored in any scheme to raise the standard of health. At the other extreme are those who believe that bilharziasis is one of the most important, if not *the* most important, endemic disease in Africa. In recent years this school of thought has gathered many adherents, who have no doubt been encouraged by the increased interest in the study of the disease. The true status of bilharziasis lies somewhere between these two extremes. Before a more accurate picture can be obtained, further study of the reactions of the human host to the infection is required.

Clinical studies

The compiling of case-histories in respect of African patients is a notoriously difficult matter. Apart from language problems, the description of symptoms and signs is often inadequate. Where a disease affects a very large proportion of the population, the signs associated with the particular condition may be accepted as normal. For example, in a section of the European population of southern Africa, haematuria in boys was accepted as a usual condition associated with puberty. Upon interrogation, African children may state that they are perfectly well, although when posed direct questions they may admit to having haematuria, terminal dysuria and even frequency, especially nocturnal frequency. From African patients who are chronic sufferers, one can rarely obtain any satisfactory history. The haematuria has passed away and has been replaced by a mild pyuria which is again accepted as normal. African patients very seldom complain of the symptom-complex which is exhibited by the European patient suffering from chronic bilharziasis—lassitude, lack of mental concentration, vague indigestion and backache.

Egg counts

In the past, much store has been set on the value of egg counts. However, since so much depends on factors such as physical exercise, the egg-laying cycle and position of the female worm, and the extent of the fibrous-tissue reaction to long-standing injury of the mucous membrane of bladder and bowel, this method seems to be of very little practical worth in assessing the intensity of a bilharziasis infection. A patient in whose urine only an occasional egg has been found may, on post-mortem examination, reveal extensive visceral damage, and large numbers of worms may be recovered from the tissues and vessels.

Post-mortem examinations

This method of investigation is without doubt the most accurate means of ascertaining the intensity of infection in bilharziasis. Obviously, only a very small sample of the population can be examined in this way. Patients dying as a result of injury or accident or from some definite cause such as pneumonia, cerebrospinal meningitis or tuberculosis, if submitted to a full post-mortem examination, may show very advanced lesions of bladder and ureters, bowel and liver, the case-history having given very little evidence that there was anything amiss with these organs.

More-detailed histological investigations and, in particular, caustic-potash digestions of organs may reveal the presence of eggs in many different parts of the body. This widespread deposition of eggs always comes as a surprise to those who have been taught to believe that the effects of bilharziasis are confined to the bladder, the bowel and the liver. The scope of such investigations has increased greatly in recent years and no doubt the findings go far to support the contention that bilharziasis is a serious cause of morbidity and mortality. This type of investigation can, however, be carried out only where there is an adequate number of trained pathologists and when no religious or other difficulties intervene. It is felt, however, that in each territory where bilharziasis is known to occur, some attempt should be made to assess the general level of intensity of infection by sample post-mortem examinations and by the carrying out of a series of organ digestions. The results of such an investigation are generally rather startling.

Much has been done in this field in Southern Rhodesia and the results have been described in a series of papers by Gelfand,[29, 30] Gelfand & Ross,[32, 34] and Alves, Woods & Gelfand.[12] All these investigations serve to show the very wide distribution of eggs throughout the organs of the body. In some instances the numbers of eggs recovered on digestion were quite considerable and it is difficult to accept the theory that the presence of the eggs does not affect organ function.

Effects of Bilharziasis on Health

The effect of bilharziasis on general health is a subject of much controversy. In the same station there are sometimes two conflicting opinions: one doctor will state that the disease matters little, while another will attribute to its baneful effects most of the unexplained factors in African ill-health. An authoritative answer to this question is badly needed, but it is hard to see how the solution can be found by means of experimental investigation.

In most areas, bilharziasis is only one of the parasitic and helminthic infections affecting the human population, and it is difficult to disentangle the effects of malaria, malnutrition, hookworm and other infections from those of bilharziasis.

Bilharziasis would not seem to have any very marked effect on fertility, despite the fact that the eggs tend preferably to be deposited in the female genital organs and—in the case of *S. mansoni* infections—in the prostate and seminal vesicles. Intelligence and the ability to absorb instruction do not seem to be seriously affected, although the little work which has been done to investigate this aspect has had inconclusive results. One point on which there has been more agreement is that persons suffering from bilharziasis who are subjected to unaccustomed physical exertion, particularly at an increased tempo, often experience an aggravation of their latent symptoms and become unfit.

The position is, therefore, that while bilharziasis, even when the infection is of low intensity, does produce quite extensive visceral damage, it is without any very marked effect on the health as estimated by clinical, physical and educational standards. One method of settling this question would be to attempt to eradicate bilharziasis from an island like Zanzibar. Prolonged observation of the protected population might offer some kind of solution to this most important problem, provided that the other factors causing general ill-health remained unchanged.

Treatment

Treatment of patients in itself is rather a waste of money and effort if it is not linked with an endeavour to prevent reinfection. In fact, effective treatment may actually be disadvantageous to the patient if he is later subjected to an infection which is more severe than on the first occasion.

Treatment has, almost without exception, been confined to hospital and dispensary patients. In some places it is given only to those patients who complain of symptoms which are eventually attributed to bilharziasis, while in other areas there is a tendency to treat all patients in whom the disease is diagnosed on routine examination of urine and stool, whether or not they have complained of the condition. Thus, treatment of bilharziasis is often an integral part of the general treatment plan to free each patient not only from the disease for which he himself has sought relief, but from all his endemic and parasitic infections. It has been noted that occasionally this regimen applies only to patients admitted to the medical wards, while other patients, who are admitted to the surgical wards of the same hospital, receive attention or treatment only for their presenting injury or condition.

In assessing whether or not specific treatment should be administered, too little attention is given to the possibility of natural cure of the condition by the death of the worms from old age. While there is every proof of the longevity of bilharzia worms, there is also some evidence [55] that their life-span does not generally exceed five years. It is also possible that intercurrent illnesses, especially those causing consistently high temperatures, may kill the worms. This has been noted when lobar pneumonia or typhoid fever occurs in a person suffering from bilharziasis.

It is surprising how little thought is given by clinicians to the aim of treatment. Many fail to realize that antimony salts and the newer preparations will only destroy the parasites and thereby prevent *further* damage to organs by toxic substances excreted by the worms or by additional depositions of eggs. Patients are buoyed up by the belief that, following the treatment, their signs and symptoms will disappear. Generally this is not so, as many of these signs and symptoms are due to chronic tissue damage and organ dysfunction for which specific treatment is of no avail. Much time and money could be saved if cases were more carefully considered and specific treatment given only to those persons in whom there was strong evidence of the presence of living worms.

Priorities for treatment

From both the public health and the economic point of view, the treatment of infected children should take precedence over that of older people. Children are the most likely members of the population to be harbouring living worms and their organs and tissues are not yet irreparably damaged. They are an important source of living and hatchable eggs and, because of their habits, are almost certainly the chief agents in maintaining the cycle of infection in urinary bilharziasis. There is some evidence, too, that eggs passed by aging worms, even though they may hatch living miracidia, are not so readily able to invade the vector snail.

Children tolerate treatment very well and are especially amenable to lucanthone hydrochloride therapy. They form only a small proportion of the in-patients and out-patients at hospitals and dispensaries, and institutional facilities are therefore of little help in reducing the amount of snail infection in a particular area. The best method of using therapy as a means of reducing the snail infection-rate is to concentrate all possible resources on the treatment of children at village schools with the new oral drugs. This entails little expenditure over and above the cost of the drug, the defaulters are few and the results of treatment are very effective.

Treatment with lucanthone hydrochloride

In Southern Rhodesia it is estimated that nearly 200 000 persons, mostly Africans, have been treated with lucanthone hydrochloride. No fatalities have been associated with treatment and there is every reason to believe that the side effects, which may be unpleasant at the time, completely disappear very soon after treatment is concluded. There is a large body of evidence that the drug is better tolerated by children and young adolescents than by older people. Numerous investigations in various parts of Southern Rhodesia have shown that 80% of patients suffering from *S. haematobium* infection are cured by the first course of treatment with a total dose of 60 mg/kg given in six doses night and morning for three days. Lucanthone hydrochloride was originally thought to be much less effective against *S. mansoni* infections; however, if it is given for a longer period—five days, for example—in a total dose of 100-120 mg/kg, satisfactory rates of cure are achieved.

There has been a substantial reduction in the price of this drug over the past five years. When first launched as a therapeutic agent, lucanthone hydrochloride in wholesale quantities cost about £65 ($182.00) a kilogram. The price is now about £27 10s. ($77.00). Since the average total dose is 3.5 grams (seven tablets), the cost of the drug in the treatment of a case is a shade less than 2/– ($0.28).

Treatment with antimonials

The intramuscular antimonials are the most widely used form of treatment, even in hospitals. Under the best conditions, however, the default rate is very high indeed and it is doubtful if many cases have their infections cured. One grave disadvantage of long courses of treatment, lasting from three to six weeks, is that there is a clinical improvement from the tonic properties of antimony before the worms are destroyed and the disease is completely cured.

Frankly, the results of treatment with the intramuscular antimonials by the orthodox methods are so unsatisfactory that these preparations should be used only when antimony by the intravenous route is quite out of the question. It should be realized that the intramuscular antimonials achieve only a temporary relief of symptoms and rarely ever cure an infection. Their use in *S. mansoni* infections is even more ineffective.

Sodium antimony tartrate (SAT) is the preparation most generally employed for intravenous medication; nowhere did the author see the potassium salt being used. Generally, the orthodox 4-6 weeks' course with a total dose of 25-35 grains of SAT is adopted. At several centres in East Africa, the 2-day intensive method was being employed very successfully, with much saving of bed-space and with excellent results, even in the case of *S. mansoni* infections. The patients, too, are quick to appreciate the speed of treatment, and medical centres using this method are inundated with patients, some of whom have to travel long distances. The intensive use of SAT by means of a slow injection technique probably remains the most effective way of treating cases of *S. mansoni* infection, although fears of untoward reactions and high toxicity have given rise to some reluctance to use the method. It is now becoming more popular and is being employed, especially in East Africa, to very good purpose.

The Molluscan Vectors

Knowledge of the distribution and habits of the potential molluscan vectors in the areas surveyed is practically non-existent. Short visits by experts are of little value, because only general impressions can be formed. In order to obtain a better picture of the distribution and habits of these snails, close and constant observation for at least one year is indispensable. In countries subjected to drought cycles, the period of observation should be even longer.

A number of snail surveys over limited areas have been made in Africa, notably by Gordon, Davey & Peaston [36] in a small area of Sierra Leone, and by Mozley [45] in Zanzibar and Tanganyika. In most cases, however, the survey of molluscs has been carried out by someone who has not been very interested in the bilharziasis problem. From this failing, the work of Gordon and his colleagues is a notable exception.

Reports are made from time to time of human cases of bilharziasis occurring in the absence of vector snails or of snails without human infection. In many instances, the search for snails either has not been sufficiently thorough or has been made at the wrong season; and the identification of species cannot be relied upon. The published literature is full of instances where a species of snail has been incriminated as a vector on the most slender evidence. These claims are carried over by later workers, who make no effort to prove or disprove the statement. Rarely has the infection from snails been passed into experimental animals in order to prove that the developmental forms being shed by the snail are, in fact, those of human schistosomes. Even where this has been attempted the difficulties of identification and classification of adult worms recovered from small experimental animals have been great, especially in the case of *S. haematobium* and *haematobium*-like worms. Too often a snail is incriminated as a vector and accepted as such by other investigators, merely because it is found in large numbers in an area where human infection is known to occur. There is a very great and urgent need for a dispassionate review of the evidence on which a number of species of mollusc in the African continent have been designated vectors. With the modern facilities of air transport, snails believed to be infected with human bilharziasis can be transported to centres where skilled examination can be made.

Snail collecting

The World Health Organization has provided the methods and means for the identification of vector molluscs, but the practical details of methods for collecting material in the field in the individual territories have not yet been fully worked out.

So little is known about habitat preferences of vector snails that much time and patience is required to carry out an adequate survey, even in a limited area. In surveys involving large bodies of water, the value of palm-leaf traps as a concentration technique for snails is well in evidence. This method, which was introduced by Egyptian workers as a means of checking the efficacy of sulfation of canals, is a useful way of attracting vector snails in a large expanse of water to the food-supply provided in the trap. A local variation of this method, which has been employed with success, is the use of young bamboo shoots. If such traps are set in a stream or pool which appears to be free from snails, one week later a surprising number of specimens will often be found.

Snail surveys in natural watercourses are much more arduous than similar investigations in canals, which have regular margins and are easy of access. The hibernation of snails in drying stream-beds necessitates a certain amount of digging and a patient search for specimens. No doubt, when snail collecting and observation are more widely undertaken, improvements in methods will be discovered.

The World Health Organization has not only provided a panel of expert malacologists who are prepared to identify or give an opinion on material submitted to them, it has also established a Snail Identification Centre in Salisbury, Southern Rhodesia, which is anxious to receive mollusc material from all parts of Africa south of the Sahara. The Centre undertakes the identification of as much of the material as possible; any species of doubtful classification are submitted to members of the expert panel of malacologists for further study. The Centre supplies habitat questionnaires and instructions for collecting and preserving material.

Identification of Bulinus *and* Physopsis *species*

Snails classed under these generic names are now considered to have con-generic status in the subfamily Bulininae within the family Planorbidae. The fact that these snails have often been confused in the past is not surprising in view of the similarity of their shells; moreover, they are often to be found sharing the same habitat. Their differentiation is, however, a matter of no little importance in the epidemiological study of bilharziasis.

Bulinus (Bulinus) truncatus is of course the proved intermediate host of *S. haematobium* in Egypt and the Sudan. Its southern relative, *B. (B.) tropicus*, which is to be found over vast areas of the African continent, has never been incriminated as a vector; in fact most of the evidence is to the contrary. It would be interesting and important to know at what point in Africa *B. (B.) truncatus* is replaced by *B. (B.) tropicus* (perhaps somewhere in the Sudan) and whether at this same point *Bulinus (Physopsis)* *globosus* takes over the role of vector of *S. haematobium*. McCullough & Duke [40] would appear to have defined the Gambia as the meeting place of the *Bulinus (Bulinus)* spp. This is probably a matter of academic interest only, but it may help to explain why snails of this genus (identified by one or another of the names in common use) are found in areas where no urinary bilharziasis is known to occur.

There is some evidence from Central Africa, where *B. (B.) tropicus* and *B. (P.) globosus* are found living side by side in the same habitats, that the former species shows powers of tenacity and survival under adverse climatic conditions which far exceed those of the latter. In fact, during a series of drought years *B. (P.) globosus* seems to die out, leaving a pure colony of *B. (B.) tropicus*.

Bulinus (Pyrgophysa) forskalii is also a potential vector and has been incriminated as such by McCullough & Duke [40] in the Gambia. Le Roux [37] confirmed that he was able to infect snails bred from Gambia stock in the laboratory. This species was originally incriminated as a vector by Adams [1] in Mauritius in 1935. Cowper,[25] also working in Mauritius, was able to infect *B. (P.) forskalii* in the laboratory, but was never able to confirm Adams' claim that it was infected in nature.

Vector role of Bulinus (Physopsis) *spp.*

Wherever it occurs, *Bulinus (Physopsis) globosus* appears to be an efficient intermediate host of *S. haematobium*, although it must be admitted that in many areas this is merely an assumption which is not supported by any experimental evidence. Reference has already been made to the overlapping of this species with *B. (P.) africanus*—its southern relative—which is the proved vector in South Africa. The two species share the same territory—a broad band across Africa, south of the Belgian Congo.

In East Africa other vectors have been investigated, notably *Bulinus (Physopsis) nasutus*. Schwetz [51] contends that he found this mollusc acting as a natural vector of *S. haematobium* near Lira in Uganda. *B. (P.) nasutus* is generally encountered in enormous numbers, but since this species shares habitats with *B. (P.) globosus*, which is however at times completely eclipsed, its specific role as an efficient vector may be difficult to prove conclusively.

Vectors of S. mansoni

The systematic classification of *S. mansoni* vectors is most obscure. The snails differ greatly in appearance, and there has been a considerable multiplication of species. The variations in appearance, colour of shell, etc., can often be produced by rearing snails hatched from the same egg mass under different water and soil conditions. The amount of variation observed is so great that tentative names for individual specimens, such as " near pfeifferi ", " near adowensis " " near sudanica ", are in common use even by expert malacologists.

A start has been made in coping with this problem, and the report of a study-group on bilharzia snail vector identification and classification in equatorial and southern Africa [56] has cleared up many anomalies. If investigators are prepared to accept the report as a basis for future work a most important step forward in the elucidation of these problems will have been accomplished. The report suggests that in Africa all known and presumptive vectors of *S. mansoni* are to be found within the genus *Biomphalaria*, subfamily Planorbinae, family Planorbidae.

Biomphalaria pfeifferi (previously known as *Planorbis pfeifferi*) has been traditionally accepted as the molluscan vector all over Africa south of the Sahara. It is typically found in South Africa and further study may reveal that its northern range is in fact rather limited. It seems likely that a number of *Biomphalaria* spp. are effective vectors of bilharziasis in various parts of Africa. Schwetz's plea for a simplification of the nomenclature [53] has much to recommend it, especially as practically every form of *Biomphalaria* seems to differ but slightly from the next.

It has always been considered that *Biomphalaria* spp. thrive better at higher temperatures than *Bulinus* spp.; they are often found where the water is fairly warm, for example, on the sloping concrete walls of dams, in pools formed by cooling water from boilers and engines, and in shallow pools with no surface flow. It has been shown by various workers in East Africa, however, that *Biomphalaria* spp. are frequently encountered at high altitudes. Schwetz [52] in Lake Bunyonyi, in the Kigezi District of Uganda, at 6300 feet, collected specimens, and J. R. C. van Someren (personal communication) claims that dams near Nairobi have been colonized by specimens shown to be infected with *S. mansoni*.

There is fairly general agreement that *Biomphalaria* spp. are more closely linked with human habitation and pollution than are other vector snails. It has often been observed that large numbers of *Biomphalaria* snails are to be found in streams, pools and particularly irrigation ditches where human pollution is evident, while very similar habitats nearby—even in the same stream—may be entirely devoid of specimens. On the other hand, *Bulinus* spp., which also tend to concentrate at polluted sites, are encountered in smaller numbers elsewhere in the stream. If this impression is correct, there is hope that the eradication of *Biomphalaria* spp. with molluscicide will be more successful than the endeavours to extirpate *Bulinus* spp.

Status of other molluscs as vectors

In the past, attempts have been made to incriminate a number of other snails as intermediate hosts of *S. haematobium* and *S. mansoni*, often on little or no evidence. None of these claims is now seriously recognized, as they were based either on an incorrect naming of the snail or on inconclusive proof that the cercariae emitted from an infected snail were in fact those of a human schistosome. In some instances, snails have been designated vectors merely because they happened to be the only fresh-water mollusc that the investigator could find in the area at the time of his visit. On such a basis, *Melanoides tuberculata* has been considered a vector in Nyasaland, and Porter [49] claimed to have shown *Lymnaea natalensis* as a vector of *S. haematobium* and *Physopsis africana (Bulinus (Physopsis) africanus)* as a vector of *S. mansoni*. Workers in all parts of Africa should be encouraged to study such claims, in addition to any work that may be undertaken to produce conclusive proof that accepted intermediate molluscan hosts, which are found locally, are in fact the vectors in that area.

Control

Type of habitat. A survey of the vector snail problem in Africa may give an impression of the utter hopelessness of attempting to control the infestation, when the molluscs are to be found in every type of surface-water collection. The shape, depth, rate of flow and vegetation cover of the average African river are so irregular as to prevent easy access for treatment. A reasonably accurate dose scheme can be adopted only in the treatment of canals, with their regular shape, freedom from vegetation and steady rate of flow.

During the survey, a study was made of the conditions on the shores of the great lakes and along the banks of some of the larger rivers, such as the Nile, the Volta, the Zambesi and the Shire. If these collections of water were to maintain large numbers of vector molluscs, then eradication would present an enormous problem. The impression gained, however, is that they are not suitable habitats for vector snails and that the inhabitants of these localities are almost invariably infected in pools, in tributary streams feeding the main river, or where the vegetation of the lake-shore is seriously modified by human activities, for example, the cultivation of the swampy areas lying behind reed-beds. This opinion should be put to the test by prolonged observation of such localities, in order to plot the habitats and assess the infection-rates of the vector snails. In territories with long lake-shores and large rivers, the responsible authorities are likely to be disheartened from the outset by the problem of vector control unless they can be shown that these large bodies of water may in fact present little or no difficulty.

Molluscicides. Comparatively little work has been done with copper sulfate as a molluscicide applied to natural watercourses. The optimum times for treatment, means of access to the water surfaces, dosage, and the method of application require considerably more study. The work undertaken in Egypt on canals and irrigation furrows has provided sound basic knowledge, but in the area under review the dissimilar nature of the natural water collections demands very different methods of attack.

Sodium pentachlorophenate shows promise of some residual effect, and—unlike copper sulfate—is toxic to snail egg masses. It is hoped that further work on this chemical can be promoted. With copper at a high price on the world market, sodium pentachlorophenate is now well worthy of consideration by countries contemplating an extension of their molluscicide campaigns.

RÉSUMÉ

En 1950-51, l'auteur a effectué une enquête, comme consultant de l'OMS, sur la bilharziose dans les territoires de l'Afrique orientale et occidentale sous administration anglaise ainsi que dans le Nyassaland. Les données recueillies ont été complétées par des renseignements réunis en Rhodésie du Nord et du Sud.

On savait fort peu de chose sur la maladie, peu importante dans ces régions, si on la compare au paludisme et à la trypanosomiase. Les informations actuellement disponibles sont encore trop fragmentaires pour que l'on puisse établir une carte de répartition. On peut dire cependant que les infections à *S. haematobium* et à *S. mansoni* existent dans tous les territoires visités, sauf en Gambie, où *S. mansoni* indigène n'a pas été rencontré, malgré la présence de mollusques vecteurs potentiels.

L'auteur passe en revue la situation dans chacun des pays et territoires étudiés.

Dans les rapports des hôpitaux, il est difficile de distinguer les effets de la bilharziose de ceux du paludisme, de la filariose ou de la malnutrition. Pour préciser la situation, il faudrait instituer des enquêtes sur le terrain et rechercher les schistosomes dans les urines au moyen du miracidiascope, dont le maniement est facile et qui donne des résultats satisfaisants.

Le traitement est sans grand objet s'il n'est accompagné de mesures permettant d'éviter la réinfection. Jusqu'à maintenant, le traitement a été limité aux malades des hôpitaux et étendu parfois à un grand nombre d'entre eux, même lorsque la bilharziose n'avait pas été diagnostiquée à coup sûr. Il faut souligner que ce sont souvent les lésions et dysfonctions des tissus causées par les œufs de schistosomes qui font souffrir les malades, alors que les parasites eux-mêmes ont déjà disparu; le traitement est alors inopérant. Le traitement spécifique ne devrait être appliqué que dans les cas où la présence du parasite vivant a été reconnue.

Le traitement des enfants devrait avoir la priorité. Il pourrait être appliqué dans les écoles, grâce aux nouveaux médicaments administrés par voie buccale.

On n'a que peu de données sur la répartition et la biologie des mollusques vecteurs dans les pays considérés, et une étude objective et systématique de la question est indispensable.

L'auteur discute ensuite les méthodes pratiques de capture des mollusques au moyen de trappes-appâts en feuilles de palmiers, en vue de leur étude. L'OMS a établi à Salisbury (Rhodésie du Sud) un centre de détermination des mollusques, auquel peuvent être adressés pour identification les spécimens récoltés en Afrique au Sud du Sahara. Ce centre donne également des instructions pour la récolte et la conservation des échantillons.

L'enquête a montré que les grands lacs et fleuves — dans lesquels les traitements molluscocides paraissent quasi impossibles — n'offrent pas aux mollusques des habitats favorables. L'infection est contractée le plus souvent dans les étangs ou les cours d'eau secondaires.

On a peu étudié encore l'action du sulfate de cuivre dans les canaux, et il reste à déterminer les méthodes qui conviennent aux types de cours d'eau de ces régions, très différents de ceux de l'Egypte.

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