WORLD HEALTH ORGANIZATION PROJECT EGYPT 10*: A CASE HISTORY OF A SCHISTOSOMIASIS CONTROL PROJECT

Henry van der Schalie
The Museum of Zoology, University of Michigan, Ann Arbor, Mich.

1. Introduction
   Description of disease, its cycle and effects on humans
2. Egypt 10 Program
3. General Problem - incidence rises when irrigation is introduced
4. Comparison between Egypt and the Sudan; the old versus the newly developed regions
5. Methods for Schistomiasis Control
   (a) Health Education
   (b) Sanitation
   (c) Medical
   (d) Snail Control
6. Prospects for the High Dam at Aswan
7. Fascioliasis in Relation to Schistosomiasis in the Sudan
8. Summary

1. Introduction

One of the best summary statements of the dilemma in the control of Schistosomiasis (Bilharziasis) appeared in the article "Bilharziasis as a Man-Made Disease" (WHO Chronicle, 1959:19):

> "It is a tragic irony that in many parts of the world the vast irrigation schemes constructed with the aim of improving the standard of living have had the effect of undermining the health of the areas they serve. The network of canals designed to carry water to arid territories have proved ideally suited for carrying bilharziasis - and sometimes other diseases - to the inhabitants. Still more important is the fact that before the introduction of perennial irrigation bilharziasis was unknown in many of these areas. For this reason, bilharziasis has been termed a "man-made" disease."

*Mubh of the original planning for the Egypt 10 project of the World Health Organization was initially by Drs. Claude Barlow and Abdel Azim, then of the Egyptian Ministry of Public Health. A good summary analysis of the situation was given by Abdel Azim (1948); Barlow (1951) also reported on the nature of the problem for the public at large (Egyptian Gazette, 1951).

At present, human blood fluke is one of the most serious parasitic human afflictions. In newly created agricultural developments in many emerging countries schistosomiasis has assumed serious proportions since such modern changes as are introduced by irrigation schemes have tended to increase the incidence of blood fluke disease (often also called Bilharziasis) to alarming proportions. The debilitating nature of this disease and its occupational hazards place it at the heart of many economic and social problems of countries in which it is prevalent. Since Pharonic time Egypt has been known to have an unusually high incidence among the villagers in the farm communities; in the Sudan this disease and cattle liver fluke increased as agricultural schemes were introduced.

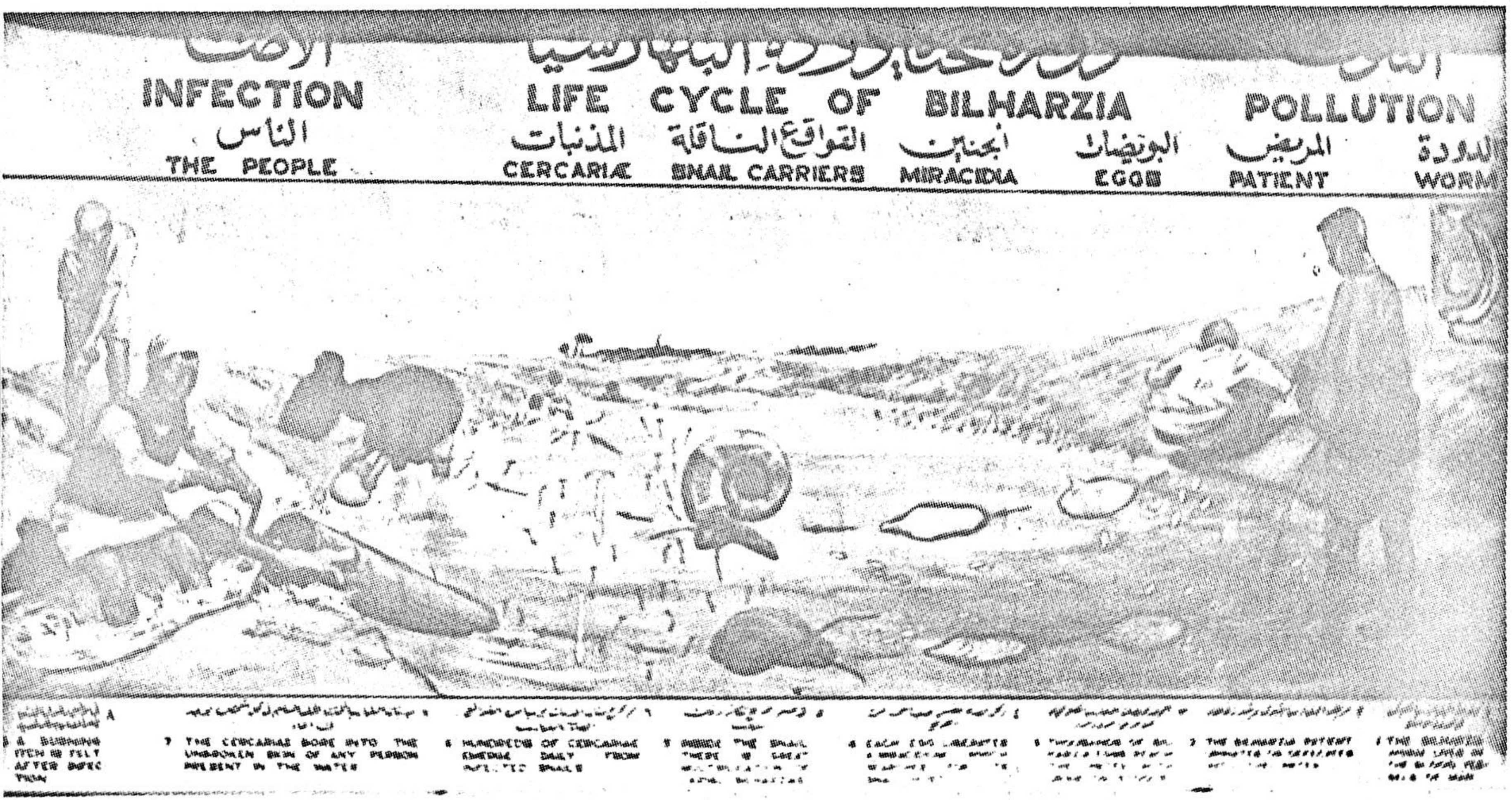
Blood fluke as it relates to humans has a cycle in which the adult worms live in the mesenteric veins surrounding the intestine (in *Schistosoma mansoni*) or in the blood vessels around the urinary bladder (in *Schistosoma haematobium*). The sexes of this trematode worm are separate with the slender and longer female carried in a special groove in the body of the male. The female is a virtual egg-laying machine producing eggs by the thousands. Many of the chitonous and spined eggs find their way out of the human body with the feces or with the urine; too many others fail to leave the human and are the cause of most of the pathology associated with the disease. Those eggs that do reach the water of a canal or a drain, often during a normal course of human elimination, hatch and must find a suitable snail to continue the life cycle. In the intestinal variety (*Schistosoma mansoni*) the snail host is a planorbid form called *Biomphalaria* while the bladder parasite (*S. haematobium*) must enter a spired *Bulinus* snail. The parasites in the snail develop bag-like reproductive structures nourished with the snails' digestive gland. After about a month under normal regional temperatures the infective larvae of the parasite, called cercariae, emerge from the snails; cercariae are often "shed" in prodigious numbers. Humans become infected when their skin is placed in contact with water contaminated with the cercariae (see Figure 1). Once infected, a human may pass eggs of this schistosome parasite for many years.

The suffering caused by blood flukes (schistosomiasis) has been known and recorded since ancient times. An excellent description and a good historic account of the disease is given by Leonard Greenbaum (1961) in his article titled Bilharziasis/Schistosomiasis, in which he traces the problems in Egypt as chronicled from the ancient (Pharonic) period to the time when the French expeditionary force was in Egypt and Syria; he also indicates the role of the pioneers in blood fluke studies such as Drs. Theodore Bilharz, Leiper and Barlow. It was the latter who, as a medical doctor, infected himself and carefully described the symptoms of the disease (Barlow and Meleney, 1949). In the early stages the patient experiences irritation of the skin which is later followed by a cough, headaches, loss of appetite, various aches and pains, and often difficulty in breathing. When the disease reaches a more advanced stage nausea is common, accompanied by dysentery, with bloody stools in intestinal schistosomiasis, or by bloody urine (haematuria) in the urinary variety. The liver becomes enlarged, as does the spleen, and the abdomen often becomes bloated, while the body is emaciated. It is in the advanced stages that the patients often develop cancerous growths. The intense suffering and the difficulty involved in bringing about a cure is well domented by Dr. Barlow, who clearly indicated that the cure involves suffering more intense at times than that caused by the disease.

2. Egypt 10 Program

The World Health Organization program (documented as "Egypt 10") was designed essentially to carry out four phases of schistosomiasis control in one area (The Qaliub tract, see Fig. 8). These programs were previously carried out by different agencies in the country, in different places and at different times. The plan of operations took into account that half of the population and most of the people

Figure 1. Schistosomiasis life cycles of the two common human schistosomes in Egypt; Schistosoma mansoni shown brought to canal during defecation. Note lateral spined egg, miracidia going to a Biomphalaria snail, and cercariae entering humans during daily water contact activities. The lower cycle is that of Schistosoma haematobium with eggs usually entering canal during urination, egg terminally spined, miracidia entering a Bulinus snail, which after about a month sheds cercariae that can infect humans. Chart is a photograph of a painting by Lucy Reiner.



INFECTION
LIFE CYCLE OF BILHARZIA
POLLUTION
الناس
THE PEOPLE
المذنبات
CERCARIÆ
القواقع الناقلة
SNAIL CARRIERS
أجنة
MIRACIDIA
البويضات
EGGS
المريض
PATIENT
الدودة
WORM
7 THE CERCARIAE BORE INTO THE UNBROKEN SKIN OF ANY PERSON PRESENT IN THE WATER
6 HUNDREDS OF CERCARIAE EMERGE DAILY FROM INFECTED SNAILS

in rural Egypt were afflicted with human blood fluke, and involved the following measures: After determining the incidence of schistosomiasis among the 32,000 people living in the six villages of the 5,000 acre tract, by a house-to-house survey establishing that at least half the population was infected in most of the villages (in one, Barada'a, the incidence was 70%), the project undertook: (1) a sanitation program designed to provide potable water by building 150 wells and pumps; 5,000 bore-hole latrines were to be built to assist in preventing eggs of the schistosomes from getting to the canals and drains; (2) a medical program was carried out by the government in which the patients found to be positive were given Fouadin intramuscularly, and 70,000 shots were given; (3) a program of health education was undertaken in an effort to appraise the people of the nature of the disease and what they would need to do to prevent becoming infected; (4) a snail control program was initiated since it was well established that a preventive campaign would constitute the best possible defense. This latter phase of the program best displays some of the ecological consequences and reveals the need for better coordination and cooperation.

3. General Problem

It has long been known that a direct correlation exists between the kind of irrigation practised by people in endemic areas and the incidence of human blood fluke (schistosomiasis). The Delta with its perennial irrigation has a fabulously high incidence of both *Schistosoma mansoni* and *S. haematobium*. In contrast, the Nile above Cairo has basin irrigation, and there the incidence of *Schistosoma mansoni* (Scott, 1937) is very spotty and low (imported from the Delta), while *S. haematobium* was estimated at only 5%. The change now projected for the Upper Nile when the new High Dam project is completed warrants some real concern (van der Schalie, 1960). An effort was made to obtain some basic information before the change, so that appraisals could be made subsequently, as the new system of perennial irrigation becomes established, but the recent war in the Middle East prevented the development of an evaluation program. Too little assessment has been made of the effect of the building of large dams, the attendant irrigation schemes that they promote, and the slow and steady rise in Schistosomiasis that usually follows such developments (Abdel Azim, 1948; Wright, 1951; and others). One such case is the development of the Gezira "Scheme" in the Sudan; and one of the best exposes of the relation of perennial irrigation to the increased incidence of schistosomiasis is given by W. H. Greany (1952). That region was a vast savannah in the Sudan until the Sennar dam was built, transforming some 900,000 acres into a large agriculture scheme, the Gezira Irrigated Area - an irrigation system running parallel to the Blue Nile south of Khartoum. Three years after irrigation was introduced, both S. mansoni and S. haematobium were well established and on the ascendence among the population.

4. Comparison between Egypt and the Sudan

In his study Greany verified (as was previously discovered in Egypt) that the density of the pulmonate snail hosts usually was correlated with the growth of aquatic vegetation. Since copper sulphate was used as the molluscicide, it was necessary to remove the aquatic vegetation before the chemical was applied. Copper ions are adsorbed by both vegetation and mud. Hence, in any such venture herbiciding and mollusciciding should be carried out jointly and the costs should then be shared by both public health and agriculture. In 1954 Dr. Naguib Ayad and the author surveyed a program to reduce the snail populations in the canals of the Gezira tract. The program was designed to apply 30 ppm of copper sulphate and to maintain a concentration of .125 ppm by keeping bags with copper sulphate immersed in the canals. It was evident that this program not only eliminated the snails but where the copper ions were held in solution there was an equally beneficial reduction of aquatic vegetation which served to augment the flow of water in the canals. This program was to cost a quarter of a million dollars and there was naturally some concern since that project would cost more than malaria control. In any case, the program seems to have produced some beneficial results as a method for controlling schistosomiasis.

If one compares the Sudan to Egypt in terms of possible methods of control, some interesting differences appear. Perhaps it should first be stressed that there are also some very important similarities in the two regions. Among them are: (1) the people are culturally alike in that they are mainly Islamic and practice the rites of their religion (ablutions, wadu or washing before prayers, etc.); (2) they often use canal water for bathing, washing clothes, tending the gamoosa (water buffalo) which youngsters almost daily take into the canals, etc., and (3) they work in the fields in similar irrigation systems designed to grow cotton and other staple crops. However, in several ways the areas are so strikingly different, that there appears more hope for protecting the health of the people in the Sudan than in Egypt. The Sudanese have room to build homes and sanitary facilities; they enjoy a higher standard of living and with the comparatively much lower incidence of blood fluke are more vigorous in coming to grips with their problems.

In Egypt the country over hundreds of years has become unbelievably infested with blood fluke. The seriousness of the health conditions in rural Egypt was documented in the Delta region by the study of John Weir and his associates in 1952 at Sindbis (near the Qaliub Egypt 10 tract). They provided the first meaningful mortality and morbidity data; they also showed that the life expectancy of women in that region was 27 years and that of men was 25.

It is interesting to compare the Sudan with Egypt in the functional aspects of blood fluke control. The Sudan in many ways typifies the emergent countries of Africa where schistosomiasis remains at a low ebb until irrigation is developed and then snail hosts and aquatic vegetation flourish. Migrant labor carrying blood fluke infections move to the area, and the habits of the people encourage a steady rise in the incidence of schistosomiasis. In Egypt this process has gone to a stage where in the countryside of the Delta the region is virtually rotten with the disease. The overpopulated condition of the area with its farm population in horribly crowded villages, the lack of sanitation and the near impossibility of building proper facilities for potable water and waste disposal, the many unfortunate daily practices that allow for an amazing exposure to infection - all contribute to make the conditions in the areas where perennial irrigation exists almost impossible to control. The amazing ramifications as they relate to politics, economics, education, agricultural practices, etc. compound the problems. In the Sudan the problem of control is also serious and difficult but there the prospects look brighter. Just in the fact that there is room not only for people to live, but also to provide the facilities (wells, latrines, etc.) makes control easier. The Gezira scheme has proven to be a very successful venture economically, not only providing most of the funds used for operating the government but also raising living standards for the tenant farmers sufficiently to enable them to procure in part the facilities needed to cope with the problems on their own. While roughly a million acres are now cultivated, the area between the White and Blue Nile will allow for the development of two million more acres.

The potentials in the Gezira of the Sudan are good for several reasons. The disease has not spread as widely as it has in the lower Nile or Delta of Egypt. People are apt to be more vigorous with a consequently more positive attitude towards initiating constructive reforms. The programs relating to key aspects such as education, medication, sanitation and potential snail control, etc. seem to be kept more in focus in the areas where support for collateral and integrated activity is needed.

5. Methods for Schistosomiasis Control

a. Health education undoubtedly serves as one of the best ways to inform the people of the endemic area about the nature of the disease and the conditions that lay them open to infection. In the Sudan, in 1954, there were some excellent village councils made up of people active in the community. The village council at Hassa Hessa in the Sudan was most impressive; the paucity of leaders available in the Egyptian villages (usually only the Mayor (the Sheik), the Imam (religious leader), the school teacher, and an occasional person from another profession) made work in the community very difficult. Yet, the adults and children were aware of the program, and what means were available were mustered for the benefit of the protective aspects of the work.

b. Sanitation

In an Egyptian village it is almost impossible to provide sanitary facilities. In Egypt 10, bore-hole latrines were installed. They became open cesspools because the water table was so high. People were obviously not able to cope with them even in the few houses where they could be installed. Few seemed to realize that those latrines can serve only about 9 months, that they become frightfully putrid where the temperatures in summer go so high, and it is well nigh impossible to reestablish the latrine once it has filled up. Again, coordination between the several aspects of the project failed and this project could have profited from assistance available in parallel programs, such as are now sponsored by AID. The evidence, then, indicates that bore-hole latrines are not the answer to sanitation in rural Egypt, especially when they are placed within the limited confines of already too substandard housing units. One must bear in mind that the people and their animals all remain in the house together at night. The gamoosa (a water buffalo) are apt to step too close to the walls of the latrine causing it to crumble away at the edges; other inconveniences arise simply because there is just no room for such a latrine. It was not until the second year of the project that the WHO was able to recruit a capable sanitary engineer (Mr. Max Aroaz) who later developed some good models of pit latrines that were used in the outdoors and showed promise for better disposal of human wastes. Obviously the great difficulty of coping with a rapidly filling bore-hole latrine placed within a house during a summer with high temperatures drove the people back to their usual haunts and elimination at the edge of the canal (or drain) where conditions were far more tolerable although fraught with great danger of infection.

C. Medical aspects

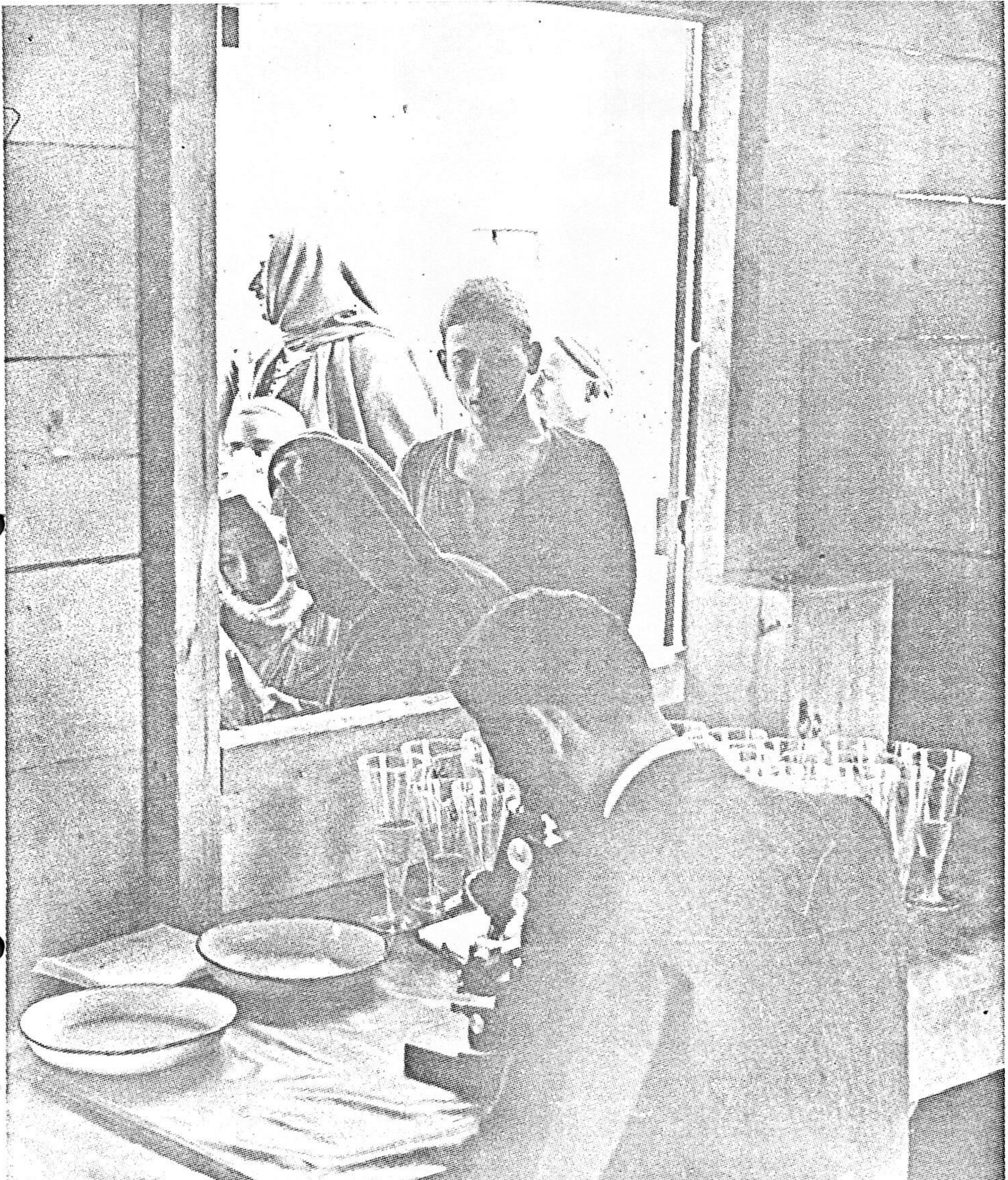
In terms of the medical aspects, the control of schistosomiasis is proving very difficult for several reasons. Many drug houses have been working for a number of years to find a suitable drug for treatment. Most drugs currently used today have serious side effects and it is generally conceded that attaining a cure is often questionable. The disease is debilitating. The suffering caused has been well described by C. H. Barlow (1949) who discusses his voluntary, heavy infection with Schistosoma haematobium. Two major obstacles appear in the medical approach to control: (1) the eggs in failing to find their way out of the body cause serious pathological changes in liver, spleen, colon, etc.; drugs are of little help to those with heavy and advanced cases; (2) in endemic regions poverty is so great that few can obtain medication unless the government is prepared to provide such help. The government provides, but it is too onerous an experience for the people to go, wait and lose 15 whole days of the month and be sick the intervening days, i.e., they lose about 20 days. While the programs are usually administered by medical personnel, the first line of defense obviously is not within that field. Since well-meaning but uninformed doctors often are also in charge of all phases of the control programs, errors are often made when their faulty judgments are applied often without consultation, in fields other than their own.

Figure 2
WHO 503

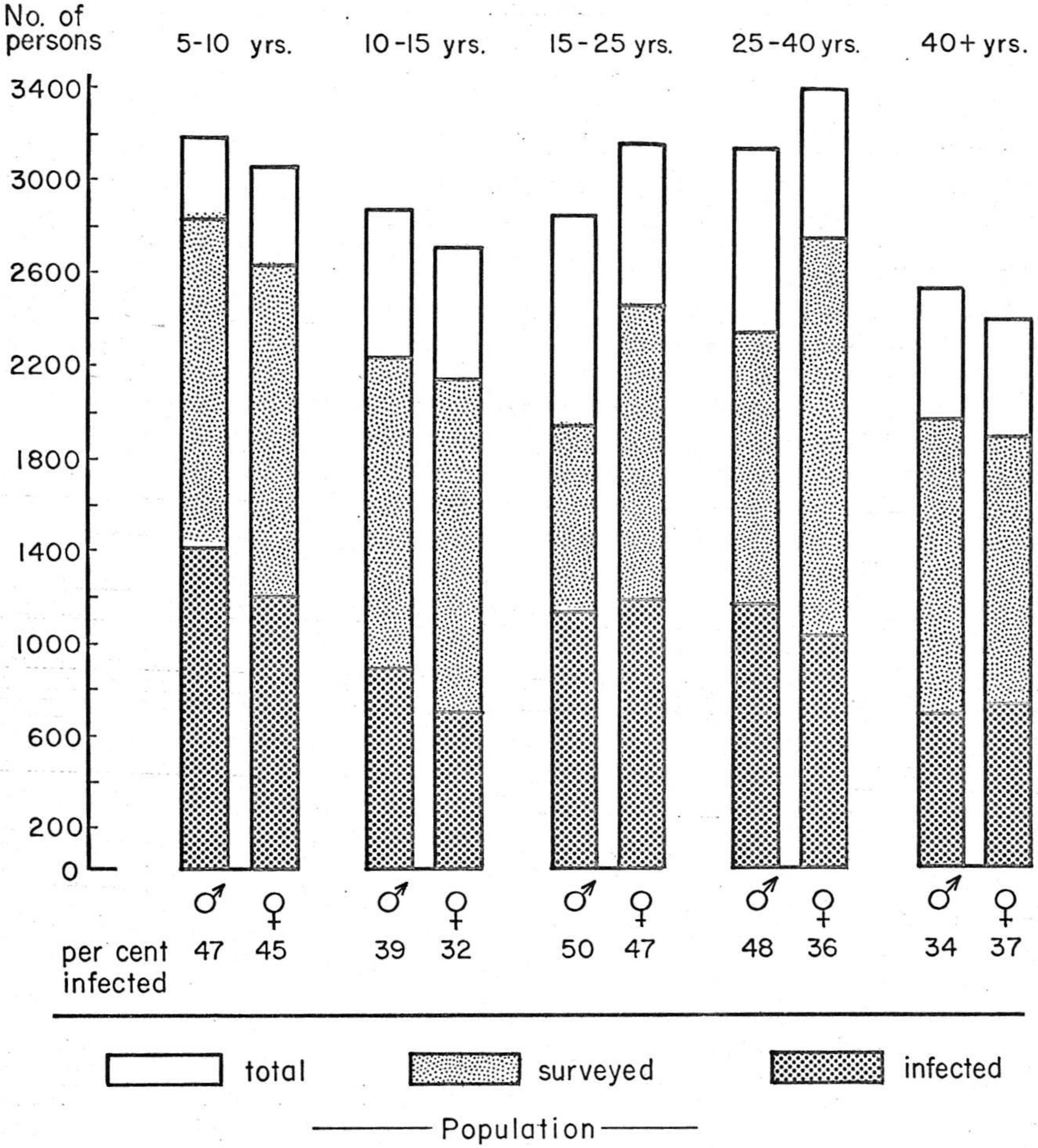
When one of the health teams on the Qaliub project visits a village in the Demonstration Area all the inhabitants are sent to the latrines with a pot and a glass labelled with his or her number. Analyses of excrement and urine are then made at the team's laboratory.

Fig. 3.

When the data on incidence for the major affliction (Schistosoma haematobium) are plotted by age groups (as shown in the grpph) it is evident that at least half the population has Bilharziasis.



Human survey for *Bilharzia haematobia* according to Age and Sex in Qaliub Area



When the data (see picture at medical center with sedimentation flasks) obtained from people registered and called to the medical centers after the house-to-house survey are considered (Fig. 2), the incidence of blood fluke in the villages is alarmingly high. The survey area will be shown later to harbor largely Bulinus snails with a relatively small sector in the northern part of the tract harboring Biomphalaria, usually in terminal canals or drains in association with water hyacinth. However, as shown in Fig. 3 attached, the villages did have a wide range of difference in the incidence of the two species of schistosomes carried by the inhabitants. As for the most prevalent blood fluke, Schistosoma haematobium, Qanater Town was relatively light with 19%, but many of the people in that village travelled to Cairo to work so that they were not as likely to be engaged in farming with its high potential for occupational hazard. On the other hand, Barada'a had 72% infection and most of the other villages showed at least half (Fig. 4) of the population as carrying blood flukes. As is generally known, one does not always get positives on a single urine examination. Consequently, those previously negative were recalled for additional testing. As shown in Fig. 5, one is likely to find between 20 and 30 percent of those supposedly negative turning positive. One has the feeling that with more precise tests over more extended periods, the chances would be good that it would show that the whole population in most of those villages had active cases or were harboring blood fluke as a chronic condition.

In the medical phase of the work some 70,000 injections of Fouadin were given to almost nine thousand patients (see Fig. 6). These treatments were given by a special medical team supplied by the Egyptian government. The treatment is drastic and with its serious side effects (so ably described by Dr. Barlow) many patients fail to complete the course of treatment. It has been indicated by medical authorities that the relapse rate is very high and relatively few people are cured in such courses of treatment. More serious is the fact that the patients in their daily activities are bound to become reinfected within a short time even though they may have had some relief from the medication.

Fig. 4.
Human Survey for Bilharziasis in the Towns, Villages and Farms of the Project Area (Figures from March 15, 1953 to June 25, 1954)*

Locality	URINES			STOOLS		
	Persons examined**	Schistosoma haematobium	Inf. %	Persons examined	Schistosoma mansoni	Inf. %
Qanater Town	7,862	1,356	17	7,643	1	0.01
Shalaqan, Kafr el Harith and farms	6,944	2,918	42	4,935	6	0.12
Hallaba and farms	1,993	1,164	58	1,261	1	0.08
Sanafir and farms	3,807	1,939	51	2,713	4	0.15
Barada'a and farms	4,734	3,429	72	3,711	317	8.54
Total	25,340	10,806	43	20,263	329	1.62

*S. mansoni eggs were not found in the urines but S. haematobium were found in the stools on 19 occasions.

**The urines of 1,440 negative persons were examined twice; the distribution by age groups is shown in Fig. 3.

Fig. 5.

Re-examination of Urines for Schistosoma haematobium in Persons found Negative in the First Examination, from September 1, 1953 to June 25, 1954.

Locality	Examined	Positive	%
Shalaqan, Kafr el Harith and farms	859	171	20
Hallaba and farms	298	38	13
Sanafir and farms	194	37	19
Barada'a and farms	89	25	28
Total	1,440	271	19

Fig. 6.

Human Treatment of Bilharziasis Cases with Fouadin in the Qaliub Project Area from September, 1953 to June 25, 1954.

Locality	Calls Sent	Patients Beginning Treatment	Patients Ending Treatment*	Number of Injections Recorded
Qanater	1,356	622	596	6,342
Shalaqan, Kafr el Harith & farms	2,914	2,909	1,898	22, 137
Hallaba & farms	1,389	993	745	7,967
Sanafir & farms	1,997	1,632	1,161	13,275
Barada'a & farms	3,698	2,839	2,169	20,861
Total	11,354	8,995	6,569	70,582

*A course of nine injections of Fouadin given on alternate days.

Sanitary engineering has held a high place in the control programs and properly so. When one realizes that in the winter practically all of the snails in Egypt lose their schistosome infections, it would obviously be a great boon if the canals and drains were not polluted as soon as the winter period of closure ends. In two consecutive years of observations, for which there are good data, the team in Egypt 10 found that there were practically no snails shedding cercariae until the middle of May (see Fig. 7)! This observation obviously has great significance in all planning in epidemiology. Yet, in an excellent series of reports by the teams in Egypt 49 (near Alexandria) there is virtually no mention of this very important functional relationship in the epidemiology of this disease. Perhaps drains near Alexandria do have a little overwintering of infection since they probably never dry out.

Fig. 7. VECTOR SNAIL CONTROL IN QALYUB, EGYPT 277

H. van der Schalie - Bull.Wld.Hlth.Org., 19: 277, 1958.

TABLE VIII. MONTHLY EXAMINATIONS OF *BULINUS TRUNCATUS* FOR CERCARIAE OF *SCHISTOSOMA HAEMATOBIUM* : 8 AUGUST 1953 TO 6 JULY 1954

Year and month	Samples			*Bulinus*		
	number examined	number infected	percentage infected	number examined	number infected	percentage infected
1953						
August	22	0	0	49	0	0
September	65	1	1.6	106	1	1.0
October	265	1	0.4	488	1	0.2
November	104	2	2.0	259	2	0.8
December	5	0	0	9	0	0
1954						
January	14	0	0	39	0	0
February	99	1	1.0	466	1*	0.2
March	89	0	0	204	0	0
April	164	0	0	394	0	0
May	645	6	0.9	3 421	9	0.3
June	1 111	21	1.8	7 648	27	0.3
July	226	25	11.0	1 206	30	2.4
Total . .	2 809	57	2.0	14 289	71	0.4

* This infected snail was found in a drain not subject to closure of water.

d. Snail control

The 5,000 acre Qaliub tract (Figure 8) was surveyed by the WHO Egypt 10 team to determine the distribution of the host snails. Even in this relatively small area there were in this system of perennial irrigation more than 450 kilometers of canals and drains. The collection of snails when plotted (see Fig. 8) show that Biomphalaria snails with the possible Schistosoma mansoni infections occurred only in the northern sector of this tract and mostly above a line shown in the snail distribution map. It should be emphasized that the Bulinus snails, which carry S. haematobium, were widely distributed throughout the sample area. While this limited distribution of Biomphalaria was fortuitous, it is interesting to note (as will be emphasized later in connection with the High Dam at Aswan) that this demarcation line actually extends across the whole Delta area. Schistosoma mansoni, as a correlary of perennial irrigation, should become common

-16-

Fig 8

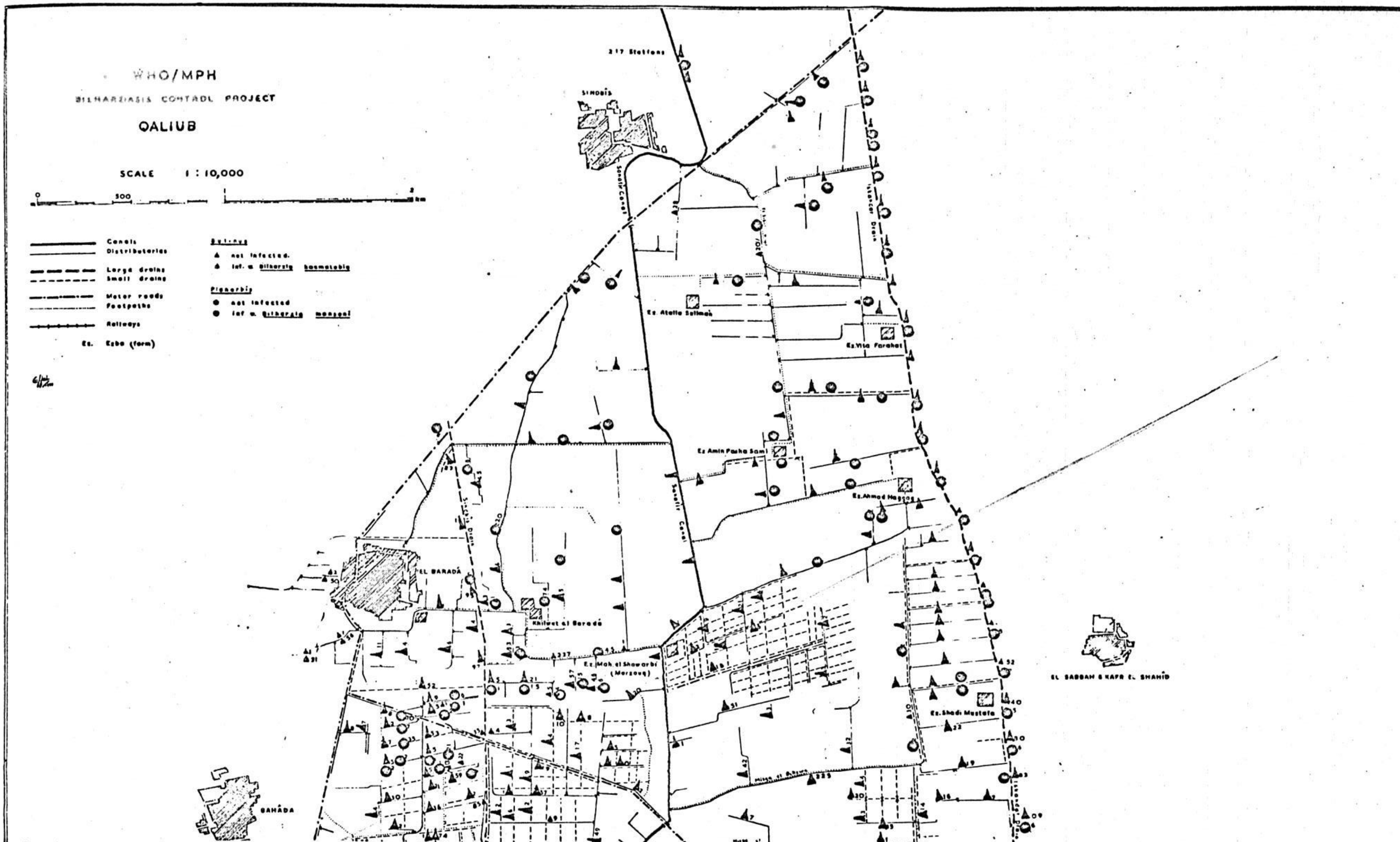

WHO/MPH
BILHARZIASIS CONTROL PROJECT
QALIUB
SCALE 1 : 10,000
0
500
Canals
Distributaries
Large drains
Small drains
Motor roads
Footpaths
Railways
Ez. Ezba (farm)
Bulinus
not infected.
inf. w. Bilharzia haematobia
Planorbis
not infected
inf. w. Bilharzia mansoni
217 Stations
SINDBIS
Sanafir Canal
Ez. Atalla Soliman
Ez. Yisa Farahat
Ez. Amin Pasha Sami
EL BARADA
Khilwet el Barada
Ez. Mah. el Shawarbi (Marzouq)
Ez. Shadi Mustafa
BAHADA
EL SABBAH & KAFR EL SHAHID

Fig. 8. Map represents the whole tract with circles showing distribution of Biomphalaria snails; and triangles showing distribution of Bulinus.

throughout the whole length of the Nile in Egypt when the pattern of irrigation is changed from basin, as it now exists throughout Upper Egypt, to perennial when the High Dam is completed.

It should be noted that the onset of infective cercariae shed by the snails takes place largely in late May. Also, agencies often fail to realize that the actual number of snails infected in nature is surprisingly low. In the studies of the Egypt 10 project (van der Schalie, 1958: 277), the highest rate of infection among snails infected with the Schistosoma haematobium brought in from the field was 0.4%!. This low incidence appeared in a sample of more than 14,000 snails collected from many stations in the 5,000 acre tract. Yet, the incidence among humans in the six villages ran over 50% for most of them and that in Barada'a was at least 70%. Evidently a few widely scattered infected snails (not necessarily located near the villages) produce enough cercariae sometime after the middle of May to infect almost the whole population because of the tremendous amount of contact people in the countryside have with infested water. If these facts were mentioned in later reports they seem somehow hard to uncover!

278 -12-- H. VAN DER SCHALIE

Fig. 9. Bull. Wld,Hlth.Org., 19: 278, 1958

TABLE IX. MONTHLY EXAMINATIONS OF *BIOMPHALARIA BOISSYI* * FOR CERCARIAE OF *SCHISTOSOMA MANSONI* : 8 AUGUST 1953 TO 6 JULY 1954

Year and month	Samples			*Biomphalaria*		
	number examined	number infected	percentage infected	number examined	number infected	percentage infected
1953						
August	1	0	0	1	0	0
September	4	0	0	7	0	0
October	59	2	3	126	3	2.3
November	11	0	0	24	0	0
December	0	0	0	0	0	0
1954						
January	4	1	25.0	78	1 **	1.2
February	22	0	0	26	0	0
March	49	0	0	482	0	0
April	0	0	0	0	0	0
May	7	0	0	45	0	0
June	147	3	2.0	1 944	3	0.2
July	89	11	12.0	530	12	2.3
Total . .	393	17	4.0	3 263	19	0.6

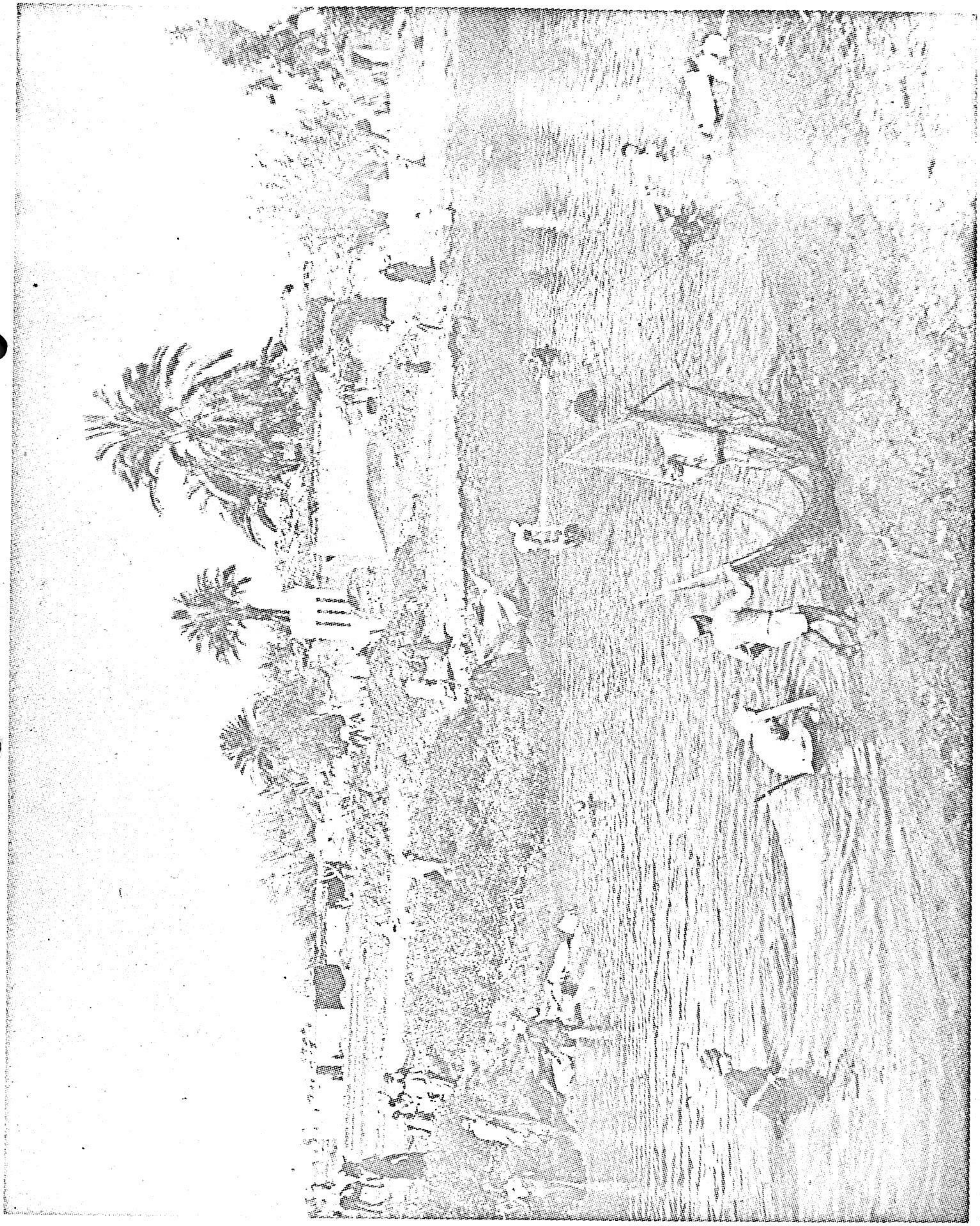
* now called B. alexandrina

** This infected snail was found in a drain not subject to closure of water.

The loss of infection among the snail hosts between December and May of each year has been attested to both in Egypt and the Sudan. The work of the Snail Control Section of the Ministry of Health and especially the studies of Dr. C. W. Barlow (1939) and his associates indicated that few infected snails could be found in the Delta of Egypt in the cold period during and following winter closure. The significance and regularity in the appearance of infected snails as they are found in nature was clearly shown in the two years of observations obtained in the Egypt 10 project. In our survey of the Qaliub tract (H. van der Schalie, 1958) the effects of cold weather and aestivating conditions on the infections in the snails are evident as shown in Figs. 7 and 9. Most of the infected snails are found in May, June and July, whether they are infected with S. mansoni in Biomphalaria boissyi (now called B. alexandrina) or with S. haematobium in Bulinus truncatus. It is just this lateness in the appearance of cercariae in Egypt that led Dr. Barlow to emphasize that he was not concerned about getting infected if exposed to canal water prior to May since the emergence,or shed,of cercariae usually comes about the middle of May, as is clearly shown in the number of infected snails that appear seasonally by months in these tables. Another striking and important bit of evidence in these tables is the low incidence one finds in the snails even during the seasons of highest infection. Yet, the populations in the villages have such a tremendous amount of exposure to natural and infested waters that the incidence in humans involves almost all the people of some villages (Fig. 10). The failure to find infected snails which shed cercariae before the climate turns quite hot in May also has historic significance. Dr. Looss in 1910 decided that the human schistosomes in Egypt completed their life history without passing through snails. Dr. Leiper, in 1915, after two years without finding infected snails, discovered infected ones only after he remained longer in Egypt (because of illness) than usual and was able in the late spring to find the infections.

Fig. 10.

Seining fish at edge of an Egyptian village in the Qaliub Egypt 10 WHO tract. Note the sharp line as between village and countryside and the congested nature of the houses of a village. Seining is at a time of approaching winter closure and this contact represents a usual way of contracting Bilharziasis; this situation is one where Schistosoma haematobium is often contracted.



In a recent WHO Expert Report (1965) insufficient stress was given a paper by C. H. Barlow (1939) in which he stated: "...For 5 years the writer and his men have worked barehanded in the El Marg area during January, February and March without becoming infected. Constant crushing and dissecting of snails have presented a picture of such inactivity of whatever cercariae exist that an assumption of security seems warranted." This loss of infection at low temperatures in the maintenance of infection in snails that are cold stressed has been proven experimentally by Stirewalt (1954). Evidently most snails in Egypt lose their infections in the winter. This fact has been confirmed in the laboratory at Ann Arbor when loss of infection occurred after snails in the aquaria were chilled when windows of an aquarium room was accidentally left open in the fall of the year.

In the last analysis snail control has been considered by most authorities as the most promising method for reducing the incidence of schistosomiasis in the populations exposed to infection. Both in Egypt (van der Schalie, 1958) and in the Sudan (Greany, 1952) copper sulphate has been used as a molluscicide for many years. More recently some of the newer chemicals have been tested, and among them Sodium Pentachlorophenate and Bayluscide appear most promising (I. K. Dawood, B. C. Dazo and M. Farooq, 1966). Bayluscide seems to be preferred because not only is NaPCP (Sodium pentachlorophenate) more expensive, but it is a dangerous chemical to handle. The recent surveys by the WHO team working with the Egypt 49 project near Alexandria, and specifically the studies of M. Farooq and his associates (1966), provide a wide variety of detailed data on prevalence, relation of schistosomiasis to personal habits, environmental factors, incidence, etc. of this disease. In that same project information is given bearing on methods for the control of snails and the lowering of the incidence in the populations in areas where control was maintained with molluscicides (Bayluscide and Sodium pentachlorophenate). Similar work was previously done by E. G. Berry working nearer Cairo, and more recently M. Farooq et al. (1966), working near Alexandria, also showed that

Fig. 11a Prevalence of *Schistosoma haematobium* — Kom Ishu and Kom el Birka combined

Age at Time of Survey	1962		1963		1964		1965		%	%	%	%
	No. Examined	No. Positive	No. Examined	No. Positive	No. Examined	No. Positive	No. Examined	No. Positive	1962	1963	1964	1965
1	14	0	29	0	57	0	35	0	0	0	0	0
1—2	9	1	58	7	34	0	54	0	11.1	12.1	0	0
2—3	24	5	40	2	54	4	23	0	20.8	5.0	7.4	0
3—4	29	5	59	11	34	1	62	2	17.2	18.6	2.9	2.9
4—5	28	10	64	10	59	4	33	0	35.7	15.6	6.8	0
5—6	29	15	52	19	60	9	55	9	51.7	36.5	15.0	16.4
6—7	35	14	70	30	51	21	61	18	40.0	42.9	43.1	29.5
Prevalence of *Schistosoma haematobium* in Akrisha Section (Control Division)												
1	31	3	No Survey		34	0	46	0	9.7	No Survey	0	0
1—2	28	1			25	2	29	2	3.6		8.0	6.9
2—3	33	4			29	3	28	7	12.1		10.3	25.0
3—4	41	5			28	8	28	5	12.2		28.6	17.5
4—5	32	8			35	7	28	7	25.0		20.0	25.0
5—6	42	13			31	15	35	12	31.0		48.4	34.3
6—7	35	17			42	19	31	18	48.6		45.2	58.1

Fig. 11b

Prevalence of *Schistosoma mansoni* — Kom Ishu and Kom el Birka combined Part 2.

Age at Time of Survey	1962		1963		1964		1965		%	%	%	%
	No. Examined	No. Positive	No. Examined	No. Positive	No. Examined	No. Positive	No. Examined	No. Positive	1962	1963	1964	1965
1	14	0	29	3	57	0	35	0	0	10.3	0	0
1—2	9	0	58	6	27	2	54	0	0	10.3	7.4	0
2—3	24	7	40	4	54	3	23	0	29.2	10.0	5.6	0
3—4	29	8	59	8	34	2	62	0	27.6	13.6	5.9	0
4—5	27	4	64	8	59	4	33	0	14.8	12.5	6.8	0
5—6	29	11	52	8	60	10	55	4	37.9	15.4	16.7	7.3
6—7	35	16	70	27	51	10	61	3	45.7	33.6	19.6	4.9
Prevalence of *Schistosoma mansoni* in Akrisha Section (Control Division)												
1	31	1	No Survey		34	0	46	0	3.2	No Survey	0	0
1—2	28	1			25	2	29	0	3.6		8.0	0
2—3	33	1			29	1	28	3	3.0		3.4	10.7
3—4	41	6			28	3	28	4	14.6		10.7	14.3
4—5	32	8			35	3	28	6	25.0		8.6	21.4
5—6	42	9			31	6	35	3	21.4		19.4	8.6
6—7	35	9			42	5	31	9	25.7		11.9	29.0

incidence in children was reduced (Fig. 11, a, b) when a molluscicide was applied in an experimental area to eliminate the snail hosts.

The data in Fig. 11 indicate that molluscicides when applied for an extended period to an area where schistosomiasis is prevalent will bring about a reduction in the transmission of the disease. For the villages of Kom Ishu and Kom el Birka, M. Farooq et al. (1966: 43) reported on this, and in referring to their graphs stated:

> "The evidence is very strong, particularly when it is realized that no one born in the two years since the start of molluscicidìng operations has become positive for either parasite."

The work on which this assessment was based is of a high order of excellence, but one wonders what is gained by the statement at the end of this article, as follows:

> "The authors believe this to be the first scientifically acceptable demonstration of the interruption of transmission of bilharziasis in the Nile Valley or Delta."

They evidently did not bother to take into account work published by their sponsor, the World Health Organization, done a decade earlier and appearing under the title "Field Trials of Various Molluscicides (chiefly Sodium pentachlorophenate) for the Control of Aquatic Intermediate Hosts of Human Bilharziasis." This study was reported by Wright, Dobrovolny and Berry (1958). While the work was done mainly in an area near the Pyramids southwest of Cairo where Schistosoma haematobium predominates, graphs are here presented (through the courtesy of Dr. Elmer G. Berry) clearly indicating that the incidence is reduced in areas where molluscicides can be applied for several years. In Fig. 12a the reduction of Schistosoma haematobium in school children in each of the age classes from 6 to 10 years old is clearly indicated; in Fig. 12b a similar and marked reduction is shown for Schistosoma mansoni in the same Warraq el Arab region even though the incidence of that parasite is usually comparatively low in that region. E. Lee Husting (1967: 195) in Gelfand's "A Clinical Study of Intestinal Bilharziasis in Africa" indicated that snail eradication "...is one fifteenth of its

Fig. 12 a

SCHISTOSOMA HAEMATOBIUM

COMPARATIVE INFECTION RATE FOUND IN WARRAQ EL ARAB SCHOOL CHILDREN AGE 6 TO 10 1954 and 1958

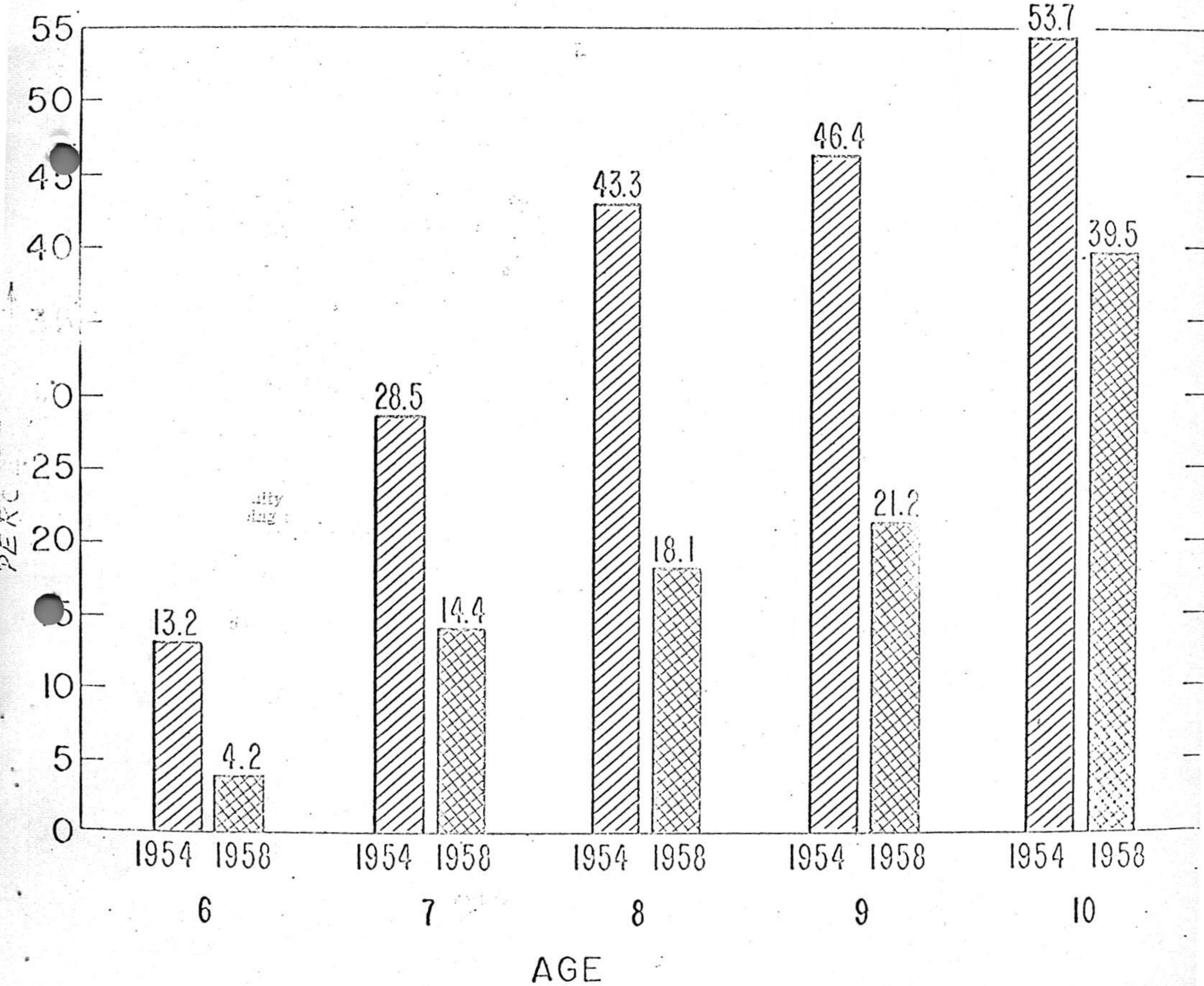
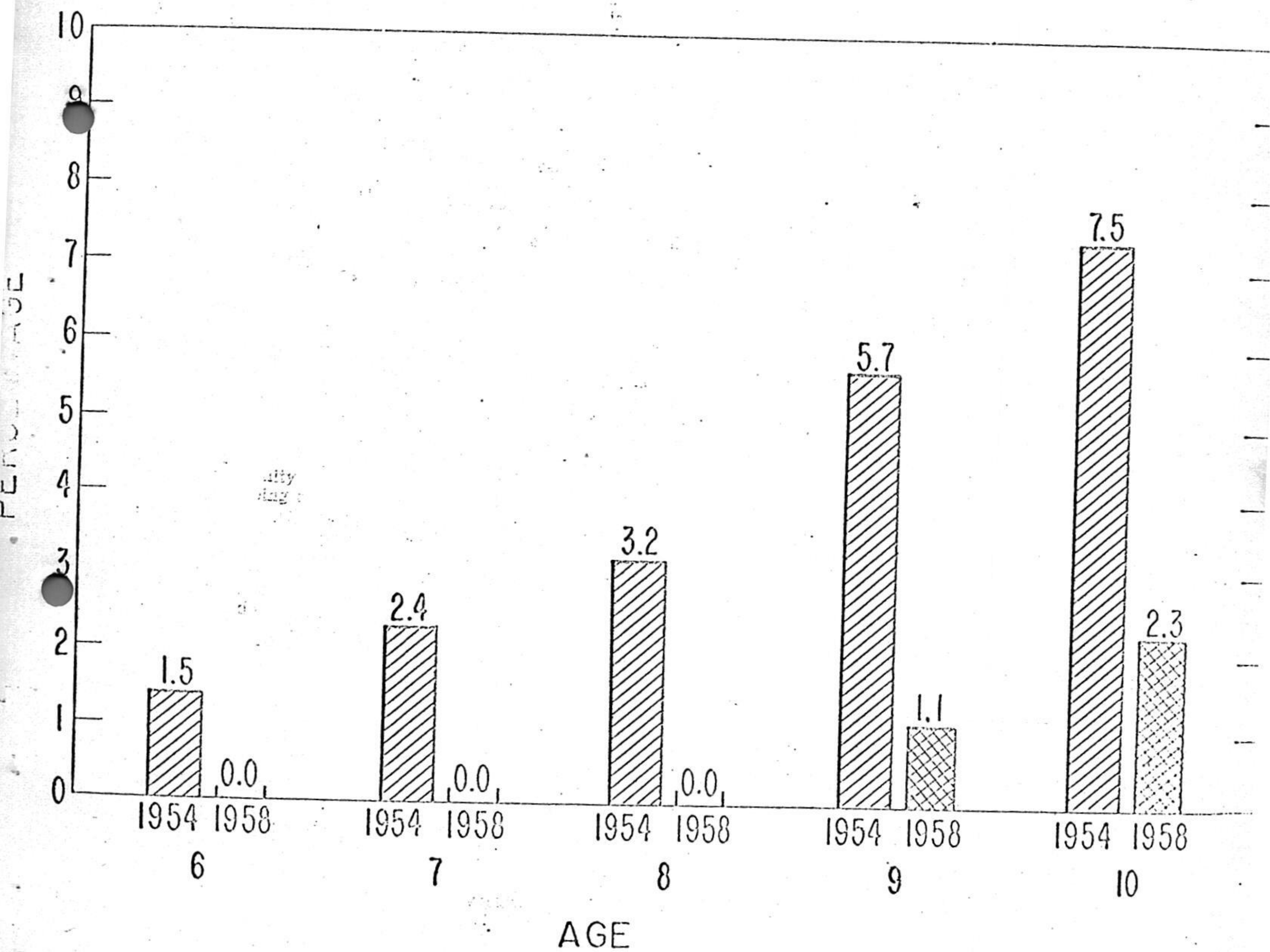


Fig. 12b

SCHISTOSOMA MANSONI

COMPARATIVE INFECTION RATE FOUND IN WARRAQ EL ARAB SCHOOL CHILDREN AGE 6 TO 10 1954 and 1958



original level, by molluscicidng or other means", it would "reduce the worm loss to zero in about twenty-three years, thus achieving eradication." In most regions where blood fluke is widespread and represents a serious problem, the prospects for using large quantities of a molluscicide over extended periods are not good. Consequently, it is almost certain that snail eradication with molluscicides alone will never be achieved and plans must be made for the use of chemicals with measures designed specifically for each situation.

The snail survey of the Qaliub tract was carried out by the WHO Egypt 10 team in a manner developed by previous investigators working with the Snail Control Section of the Ministry of Health. Small canals and drains were usually sampled with a dip net (see Figure 13), the snails were placed in marked containers for spot recording purposes and then brought to the field laboratory at Qaliub for study. The larger canals were surveyed with the use of palm leaf traps which were placed in the lower bank of the canal, left there for a week or ten days and then recovered (Figure 14) and examined (Figure 15) for snails (usually Bulinus) on the fronds. As many as 80 or 100 may be found on a single trap. The snails were placed in marked bags (Figure 16) and brought to the laboratory for the determination of the sites that produce infected (Figure 17) or uninfected snails. Those snails that did not show infection when placed in water for such observation were later crushed (Figure 18) to determine whether they were infected but not in the shedding state. The data accumulated from these field surveys and the laboratory examination was plotted on maps which not only showed an enormous amount of snail production, but also indicated that the two intermediate host snails, Biomphalaria and Bulinus, lived under different ecological conditions, shown by their patterns of distribution in the distribution map (Figure 8). It was surprising also to note that foci of infected snails in this tract were not nearly as numerous as one might expect. In keeping with the low incidence of infection within the host snails, the infested localities were relatively few and widely scattered. There was no evidence that infested areas were necessarily in the neighborhood of inhabited places.

When the distribution of the intermediate hosts snails was established and the infested areas had been determined, the tract was treated with copper sulphate. It had been established previously that vegetation in canals and drains tended to remove the copper ions by adsorption. Consequently, programs of removal of vegetation were undertaken prior to sulphation. This process is arduous and expensive as is shown in Fig. 19, which indicates that the labor required was close to 2400 mandays (see also Barlow, 1937). The amount of copper sulphate necessary for even so small a tract is shown (Table 20) to be 71 tons. Calculations made on the relative costs of just the chemical used indicates that more than thirteen thousand dollars was spent to complete one sulphation in an area with 450-kilometers of canals and drains. If one projects this cost to the area (roughly 5 million acres) to be treated in Egypt as a whole, the costs for the chemical alone would be prohibitive. As conditions developed it was not possible to maintain programs of sulphation in the tract in subsequent years. The following year there were about half the number of snails but as many foci of infestation; by the third year the tract reverted to its original state of high infestation with infective snails. The population pressures of snails in surrounding regions are so great that reinfestation takes place very rapidly when eradication methods are discontinued.

However, there are conditions and methods for control that have been recommended by previous investigators in the WHO itself but which were not considered in subsequent programs. For example, infections occur in both Bulinus truncatus (carrying S. haematobium) and in Biomphalaria alexandrina (carrying the S. mansoni) usually after the middle of May, so that a single mollusciciding, taking into account not only the life cycle of the snails but also their time of infection, would seem most efficacious.

Fig. 13.

Collecting *Biomphalaria* snails in a small terminal ditch where these snails are common on the roots of water hyacinth. Note the sharp line of demarcation between the village of Barada'a and the countryside. Villagers in this area have both *Schistosoma mansoni* (associated with this type of ecological niche) and *S. haematobium* (more common in the flowing waters of the canals).

Fig. 14.

Collecting palm traps that had been set a week before to catch snails as part of the survey ~~being~~ carried out by the Bilharziasis team in Egypt. Only three tenths of a per cent of the snails caught have proved to be infected, yet in some villages of the experimental area as many as 95 per cent of the people have Bilharziasis, showing the high number of cercariae produced by the infected snails. In the background the fellah turning the tambour (also known as Achimedes' screw (because it represents an application of Archimedes' principle) to lift water from the canal to irrigate the land, is at the same time exposing himself to Bilharziasis by sitting with his feet in the water.

Fig. 5.

Snails caught in the palm traps are harvested by Egyptian workers attached to the Bilharziasis project. Looking on, right, is Dr. Henry van der Schalie, WHO team leader, a malacologist on loan from the University of Michigan to WHO for the project. Left rear, Egyptian fellah is raising water from the canal to irrigate his fields by turning the tambour - an application of Archimedes principle known as "Archimedes' screw", and has been employed in this form for at least two thousand years. Fellah operating the tambour is particularly liable to catch bilharziasis since water pours over his knees into a gutter and his feet are usually in water.

Fig. 16.

Snails caught in the palm traps are harvested by Egyptian workers in the Bilharziasis project. Looking on, left is Dr. Henry van der Schalie, WHO team leader and a malacologist on loan to the WHO for one year from the University of Michigan, Ann Arbor, Michigan, U.S.A.

-29-

Fig. 16.

Snails caught in the palm traps are harvested by Egyptian workers in the Bilharziasis project. Looking on, left is Dr. Henry van der Schalie, WHO team leader and a malacologist on loan to the WHO for one year from the University of Michigan, Ann Arbor, Michigan, U.S.A.

Fig. 17.

The Egyptian government, with the collaboration of the World Health Organization (WHO), is working to control bilharziasis, a disease that is responsible for one out of every five deaths in the country. (Bilharziasis is caused by a larva born in snails in the stagnant waters of the Nile, which penetrates into the human tissues and develops into worms, causing general bodily and mental deterioration). Efforts are being made in experimental controls on a special tract of land within the health demonstration area in Qaliub Province, approximately 20 miles north of Cairo, where the carrier snails will be destroyed and sanitary measures introduced to provide good water and proper disposal of sewage. Infected persons will be treated and health education will describe the value of treatment, in an effort to gain the cooperation of the people, the aim being, of course, to prevent people from polluting the canals.

Here, in a laboratory Egyptian Government health workers examine carrier snails to determine whether they have cast off (shed) cercariae. Such tests reveal what areas are infected.

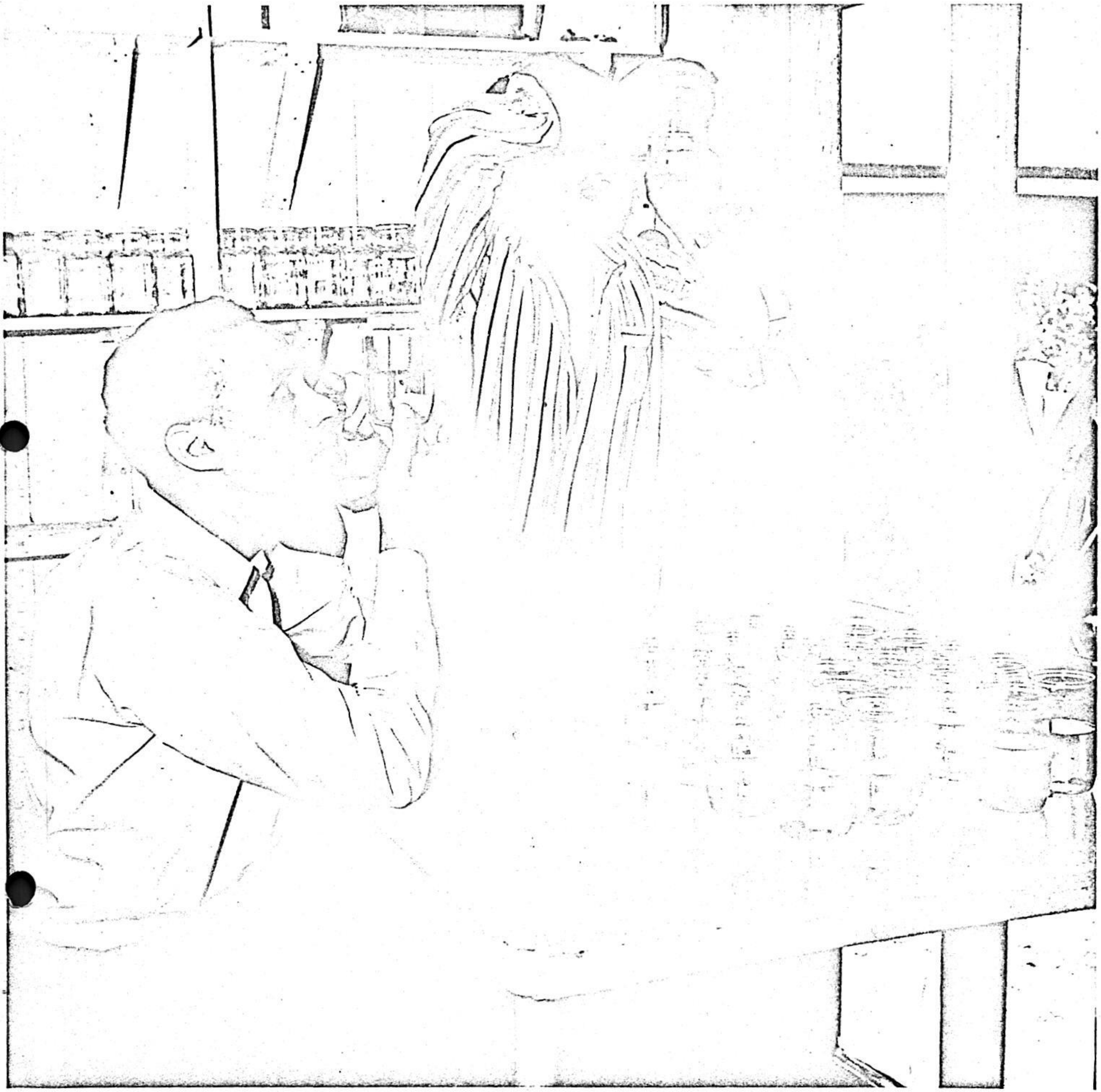


Fig. 18.

The late Edward Ahenius, chief laboratory technician (lfêt) and Dr. Emile A. Malek, matching member on the Bilharziasis team in Egypt (right), preparing snails to be microscopically examined for the bilharziasis parasite.

Fig. 19 ... LABOUR REQUIRED FOR CLEARANCE OF VEGETATION FROM CHANNELS IN PROJECT AREA PRIOR TO SULFATION: APRIL 1953 TO JUNE 1954

Sequence of clearances	Number of channels cleared	Length of channels (km)		Labour required (man-days)	Time spent (days)
		total	cleared portions		
Before first sulfation in 1953 (April-August)	8	29	12	302	16
Between first and second sulfations in 1953 (August-December)	82	53	39	1 400	47
Before third sulfation of area * (December 1953-June 1954)	50	25	23	688	36
Total	140	107	74	2 390	99

* This was the first sulfation in 1954.

H. van der Schalie - Bull.Wld.Hlth.Org., 19: 281, 1958

H. van der Schalie, Bull.Wld.Hlth.Org., 19: 281,1958

VECTOR SNAIL CONTROL IN QALYUB, EGYPT 281

Fig. 20. ... AMOUNT OF CHEMICAL AND LABOUR REQUIRED FOR SULFATION OF MAIN AND BRANCH CANALS AND DRAINS IN PROJECT AREA: JULY 1953 TO JUNE 1954 *

Type of channel	Number of channels treated	Length of channels (km)		Amount of $CuSO_4$ used (tons)**	Labour required (man-days)	Time spent (days)
		total	treated portions			
Main canals	21	106	72	15.1	414	18
Branch canals	754	355	349	13.3	636	34
Main drains	12	75	54	6.1	238	10
Branch drains	318	153	149	5.0	181	9
Total	1 105	689	624	39.5	1 469	71

* The figures are cumulative and represent the total amount of work done since the inception of the Project.

** Excluding 6.3 tons used in treatment of infested channels upstream of Project area.

Another observation that would warrant more attention than it has hitherto received concerns the possibility for the elimination of snails from the canals during the time of winter closure and cleaning of the canals (WHO Monograph 50: 94, 1965) to bring them back to a proper gradient by removing accumulations of silt and mud. It is specifically indicated that snails thrive in canals where silt accumulates. Silt removal improves both the flow of water in the channels as well as reduces the possible development of high snail populations.

During the Egypt 10 program it was observed that the snails do not burrow when the canal dries. The *Bulinus* remain exposed with epiphragms (a mucous membrane across aperature of shell) in place on the surface mud; the *Biomphalaria* secrete epiphragms and remain in the surface litter awaiting the return of water to their habitat. If a small mechanical scraper could be devised and used along with a conveyor belt, the mud (or bottom material) could then be dug in such a way as to take the soil and the snails away from the site they occupy during hibernation. With the small amount of rain (in some places less than an inch a year) the snails removed could be eliminated from the canal. While in places this process may not completely eliminate the snails from the canals, it would certainly greatly reduce the populations. A study using this technique has long been needed since it is another area in which agricultural practices and health programs could well be meshed. Time will not permit a review of a very informative paper by C. H. Barlow (1937) but essentially he has shown that: "The use of canal clearance is proposed as a prime factor in a scheme for the control of human schistosomiasis in Egypt because it is efficient, inexpensive, and requires no teaching of new methods for its execution."

One of the interesting recent developments relating to the probable increase in schistosomiasis is the building of the new High Dam at Aswan. The nature of this problem was previously discussed (van der Schalie, 1960) and an effort was made two years ago to obtain some support for a study to obtain field data necessary to show whether the prediction that the new dam might well prove to be a liability rather than an asset. It is quite certain that the incidence of urinary schistosomiasis (S. haematobium) would greatly increase and the intestinal form (S. mansoni, now not widespread) would eventually invade the 500 odd miles of river flood plain converted to perennial irrigation. Assistance was requested from three agencies: Ford Foundation since they were involved in improvement of fishing to provide protein in that region; the Rockefeller Foundation because they have had a long history of work designed to improve health there; and the PL 480 source for funding since it appears that those funds may eventually be used for ventures other than archeology. Progress in getting support was discouraging and slow. Most agencies were interested and saw the need for the study but there was a reluctance that discouraged work in what appeared to be an already difficult program. The matter was settled by the outbreak of war in the area.

The nature of the problem of high incidence of schistosomiasis is closely related to the distribution of the snails that serve as intermediate hosts. It has already been shown from the distribution patterns (Fig. 8) in the Qaliub tract that there is a definite break in the range of the Biomphalaria snails (carrying S. mansoni)and the Bulinus (hosts for S. haematobium), in such a way that the former are found only in the northern sector of this tract while the latter are distributed throughout the tract. From what is known of the ecology of Biomphalaria it is apt to become established in areas where the irrigation system is of the perennial type. In 1937 a map (Fig. 21) prepared by J. Allen Scott reveals that the high incidence of both Schistosoma mansoni and Schistosoma haematobium is correlated with the type of irrigation practiced in the area. In this case the two prevalent schistosomes are shown to have an incidence of at least 60% in the Delta with its perennial irrigation. The rest of the Nile upstream for approximately 500 miles has mostly the basin (or one crop) system of irrigation and in that region only Schistosoma haematobium is common and it is at a rather low incidence of about 5%.

The purpose of the new High Dam at Aswan, in addition to the power that it will supply, is to provide the water necessary to establish the perennial (or four-crop rotation system) throughout the 500 miles of flood plain along the Nile from Cairo to Aswan. Actually little additional land will be provided but on the basis of increased land potential it will add the equivalent of another two million acres to the approximate six million now available for agriculture. On the basis of what is known about the snail hosts, their ecology, and the relation of perennial irrigation to human blood fluke in Egypt, the prospects are good that this new agricultural development will produce a tremendous increase in schistosomiasis.

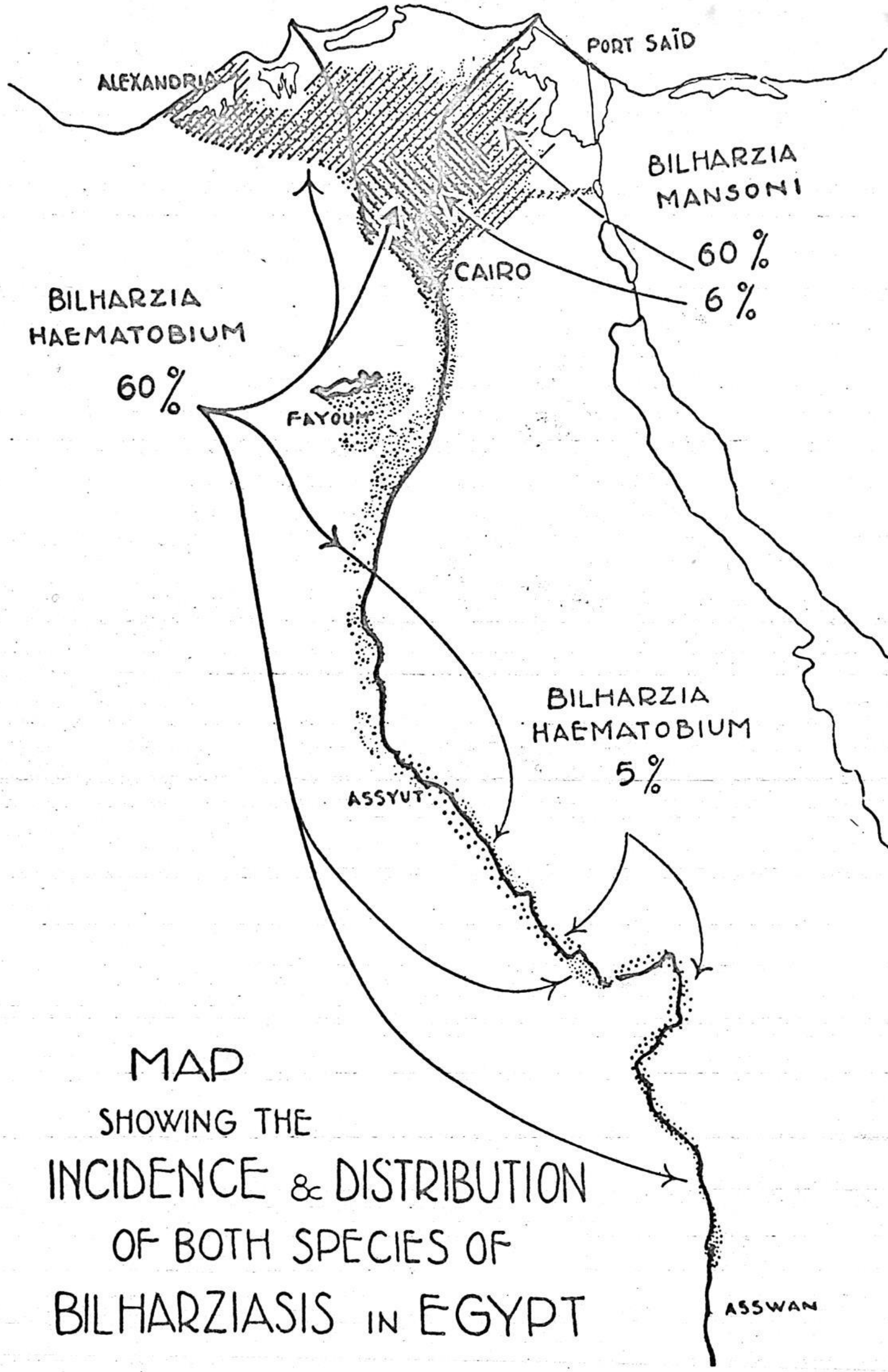


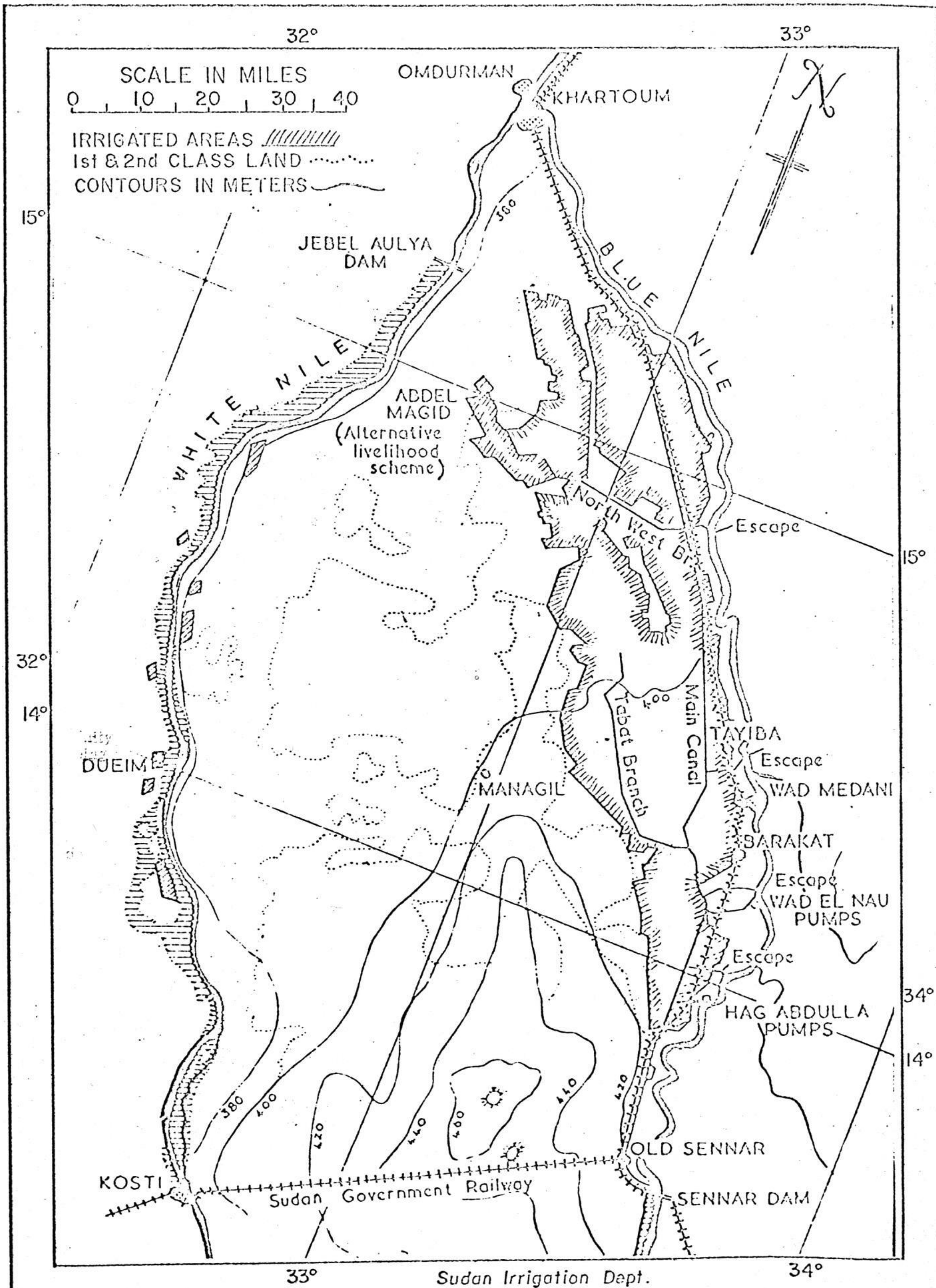
Fig. 21

Showing correlation of high incidence (60%) of both schistosomes (S. mansoni and S. haematobium) in Delta with perennial (4-crop) irrigation; from Cairo to Aswan irrigation is the basin (1 crop) type, incidence is low (5%) and limited to only one species (S. haematobium), (after J. Allen Scott, 1937).

Fig. 22.

The Gezira agriculture tract below Sennar Dam in the Sudan. obout one million acres are under cultivation; possibilities exist for developing two more million acres to the west. In this agricultural region snail control must be provided to keep both schistosomiasis and fascioliasis in check.

Fig 22


SCALE IN MILES
0 10 20 30 40
IRRIGATED AREAS
1st & 2nd CLASS LAND
CONTOURS IN METERS
OMDURMAN
KHARTOUM
JEBEL AULYA DAM
WHITE NILE
BLUE NILE
ADDEL MAGID (Alternative livelihood scheme)
North West Br.
Escape
Tabat Branch
Main Canal
TAYIBA
WAD MEDANI
MANAGIL
DUEIM
BARAKAT
WAD EL NAU PUMPS
HAG ABDULLA PUMPS
OLD SENNAR
SENNAR DAM
KOSTI
Sudan Government Railway
380
400
420
440
32°
33°
34°
15°
14°
Sudan Irrigation Dept.

7. Fascioliasis

In the realm of snail control, a key problem in the Sudan (and elsewhere in Africa) is the elimination of Lymnaeid snails that carry fascioliasis. The Gezira agricultural project (see Fig. 22) occupies about a million acres below the Sennar Dam along the west shore of the Blue Nile. It has been a very successful economic venture. But it also has some of the characteristic problems that are found in most such schemes in Africa. Reference should be made to the studies of Greany (1952) reporting essentially the same basic pattern of incidence of schistosomiasis as was shown for the Delta region by the Egypt 10 team. In Greany's study (Fig. 23) he reported only 0.06% of about 5,000 Bulinus snails carrying Schistosoma haematobium; among the 6,600 Planorbis (now called Biomphalaria) only 1.2% were positive.

Fig. 23 Showing the number of *Bulinus* and *Planorbis* snails collected at village watering-places situated near canals, and the proportion of those snails which were found infected with schistosome cercariae of the human type

Month	No. of canals from which snails were collected	*Bulinus*		*Planorbis*	
		No. examined	No. positive	No. examined	No. positive
Jan. ...	9	336	1	246	0
Feb. ...	13	936	0	841	3
March ...	17	697	1	606	2
Apr. ...	12	886	0	850	10
May ...	7	535	0	1,007	13
June ...	11	397	0	1,238	1
July, Aug., Sept. ...		No. observations*			
Oct. ...	10	480	1	637	5
Nov. ...	6	457	0	638	29
Dec. ...	10	397	0	538	17
Totals		5,121	3 (0·06%)	6,601	80 (1·2%)

* During the months of July, August and September, the writer was on leave and the work was carried on by an assistant, whose findings were as follows: in July two *Bulinus* and four *Planorbis* were found positive; in August one *Bulinus* and five *Planorbis*; in September no *Bulinus* were found positive, but two *Planorbis* discharged schistosome cercariae.

From: W.H.Greany - Schistosomiasis in the Gezira Irrigated Area
Ann. Trop.Med. and Parasit., 46: 257, 1952

In addition to the increase in the trend of schistosomiasis, the problem of controlling fascioliasis has also assumed crucial proportions. The tremendous growth of lush aquatic vegetation (Figure 24) supports many Lymnaea natalensis. Rich silty soils and the great quantities of strong sunlight tend to build sufficient aquatic vegetation to choke many of the distributaries. In the process of canal clearance by hand picking, humans are subjected to infection with schistosomiasis. At the same time cattle and sheep are put to pasture on the lush grass along the edge of these vegetation-choked canals (Figure 25). This arrangement is ideally suited for promoting a high incidence of fascioliasis. When one finds cattle as emaciated as those observed in a village in the Gezira (Figure 26) the danger of cattle liver fluke is not difficult to surmise. While serving as a professor in the University of Khartoum at Shambat, Dr. Emile A. Malek studied fascioliasis in the Sudan. He can report on these problems far more authentically than others less acquainted with the region. However, it is necessary here to stress that the abundance of snails found in such a habitat is related to the abundance of the aquatic vegetation in such distributaries. The elimination of the vegetation and the eradication of the snail intermediate hosts then becomes the concern of agriculture as well as of the health authorities.

Since humans are directly affected, the snail control program has been carried largely by the Health Department. They followed a program developed originally in Egypt which consists of removing the aquatic vegetation, applying an initial dose of 30 ppm of copper sulphate to kill most of the snails. To keep the canals free of reinvasion by snails a small residual (0.125 ppm) of copper ions are maintained in the canals by placing bags with copper sulphate suspended in the water (Figure 27).

Figure 24 . A distributary in the Gezira tract of the Sudan showing aquatic weed control by hand picking; also a source of schistosome infection.

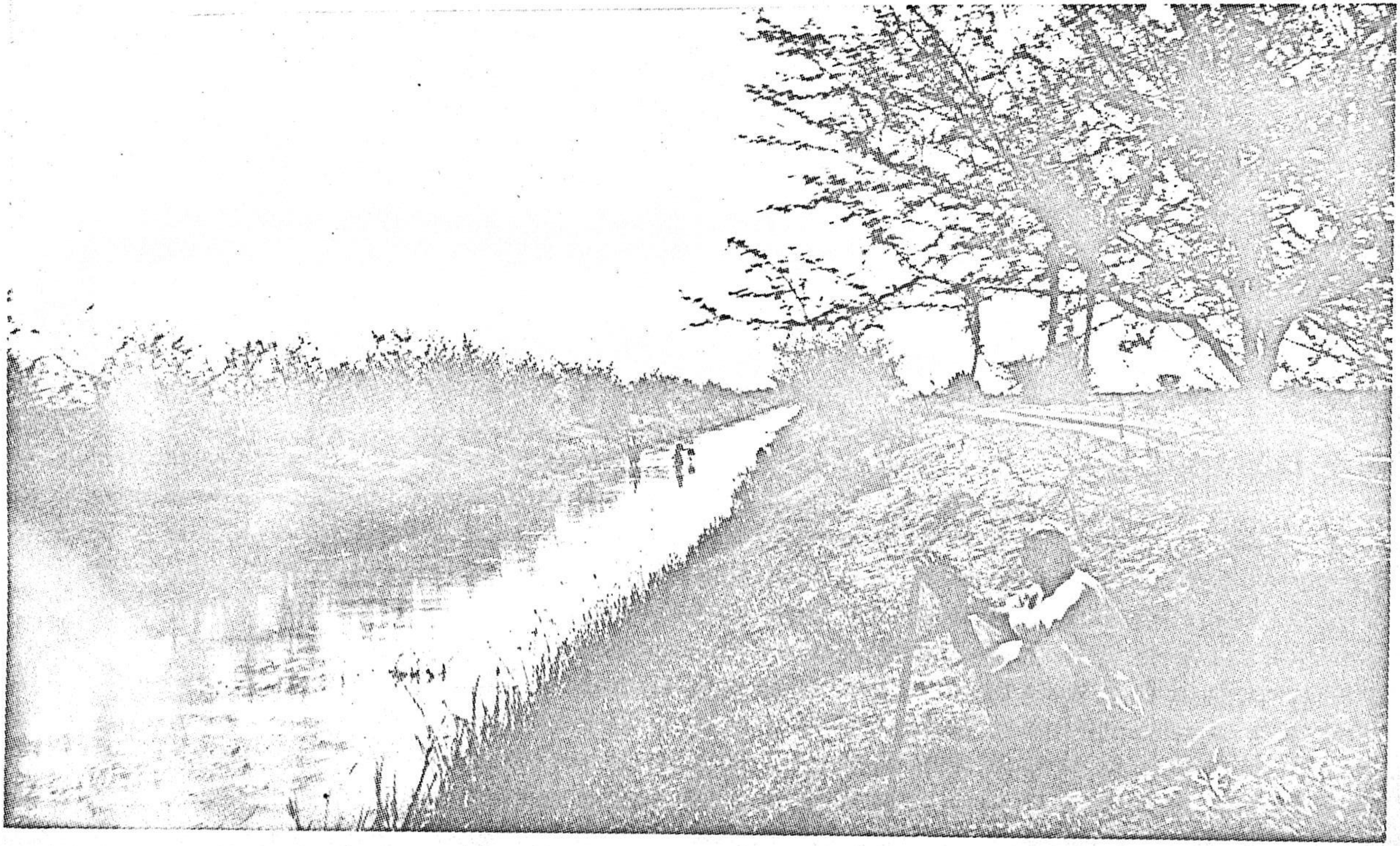


Figure 25. Cattle and sheep grazing along a canal heavily choked with aquatic vegetation; Lymnaea natalensis, the snail host for fascioliasis, as well as schistosome snail hosts abound in such habitats.

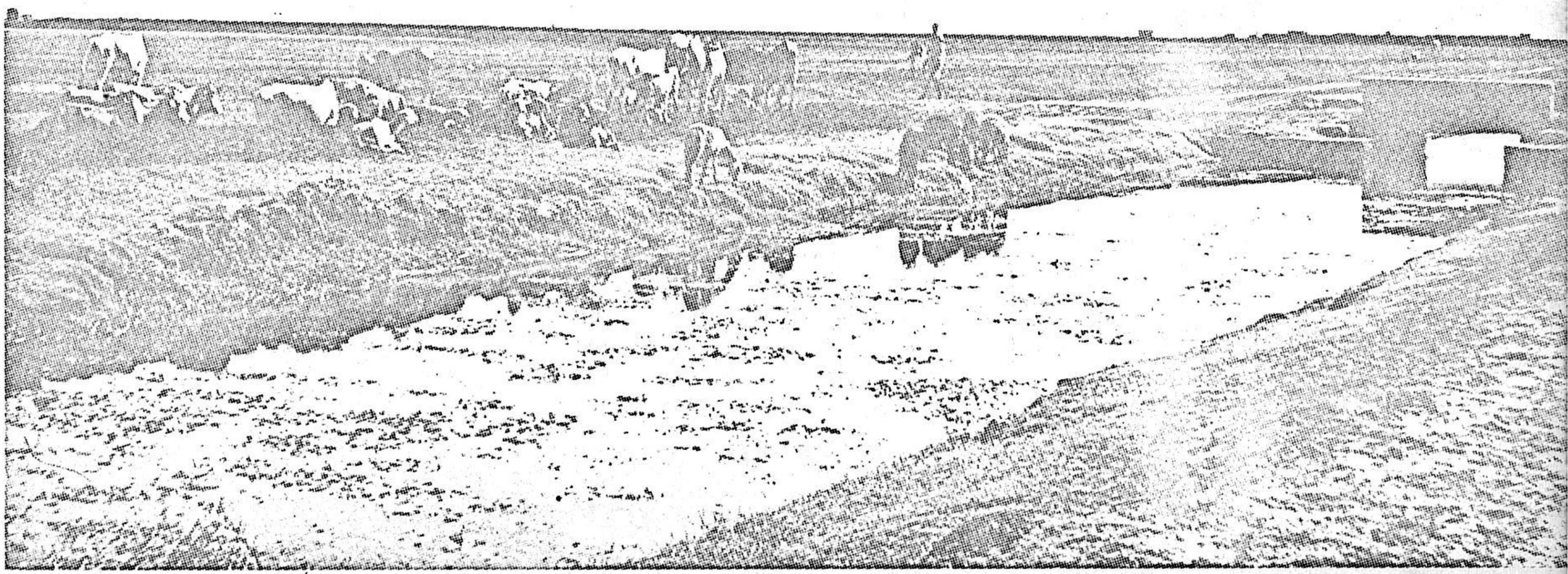


Figure 26. Village in the Gezira of the Sudan showing emaciated cattle in an area with a high endemicity of fascioliasis.

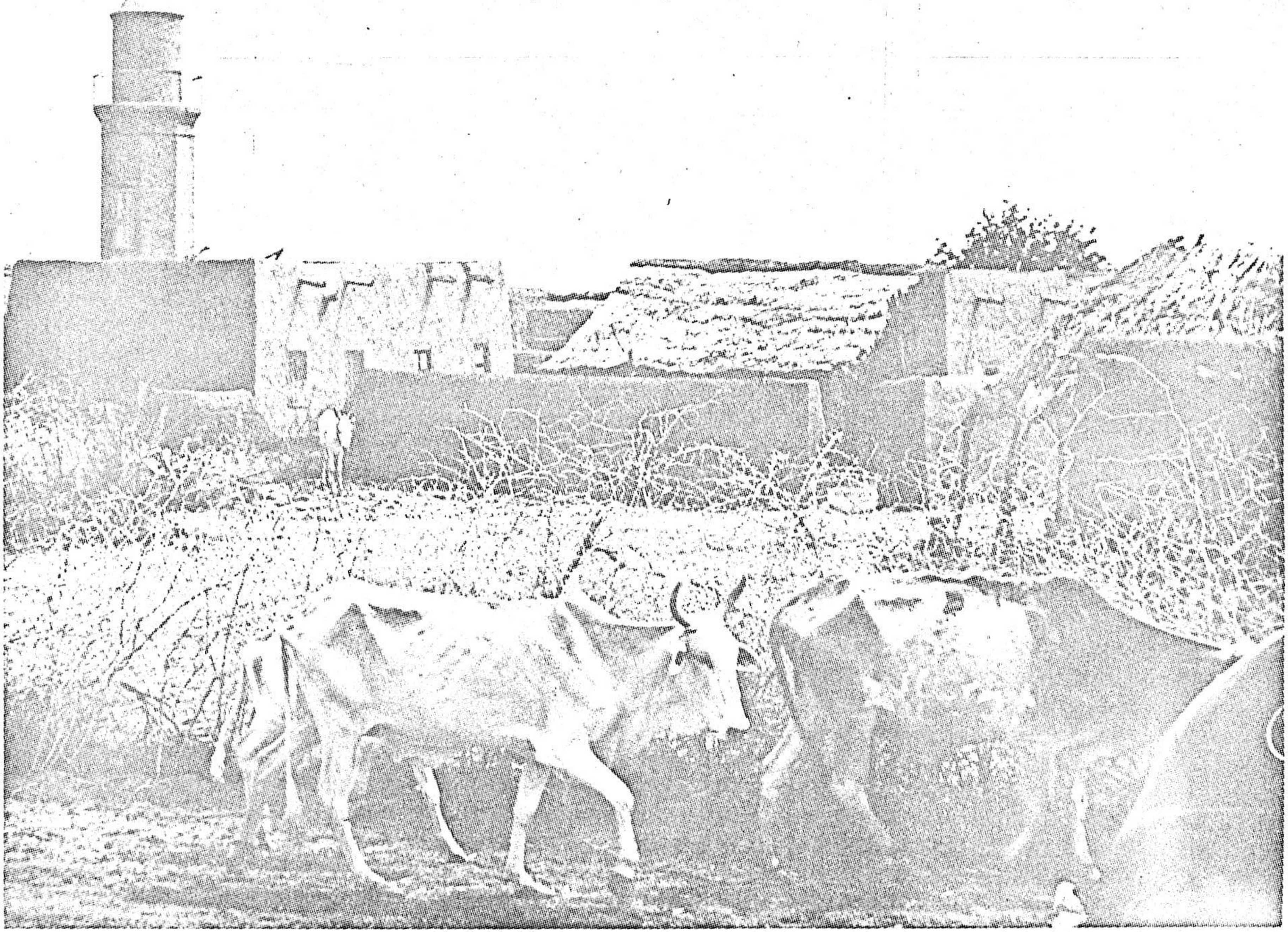
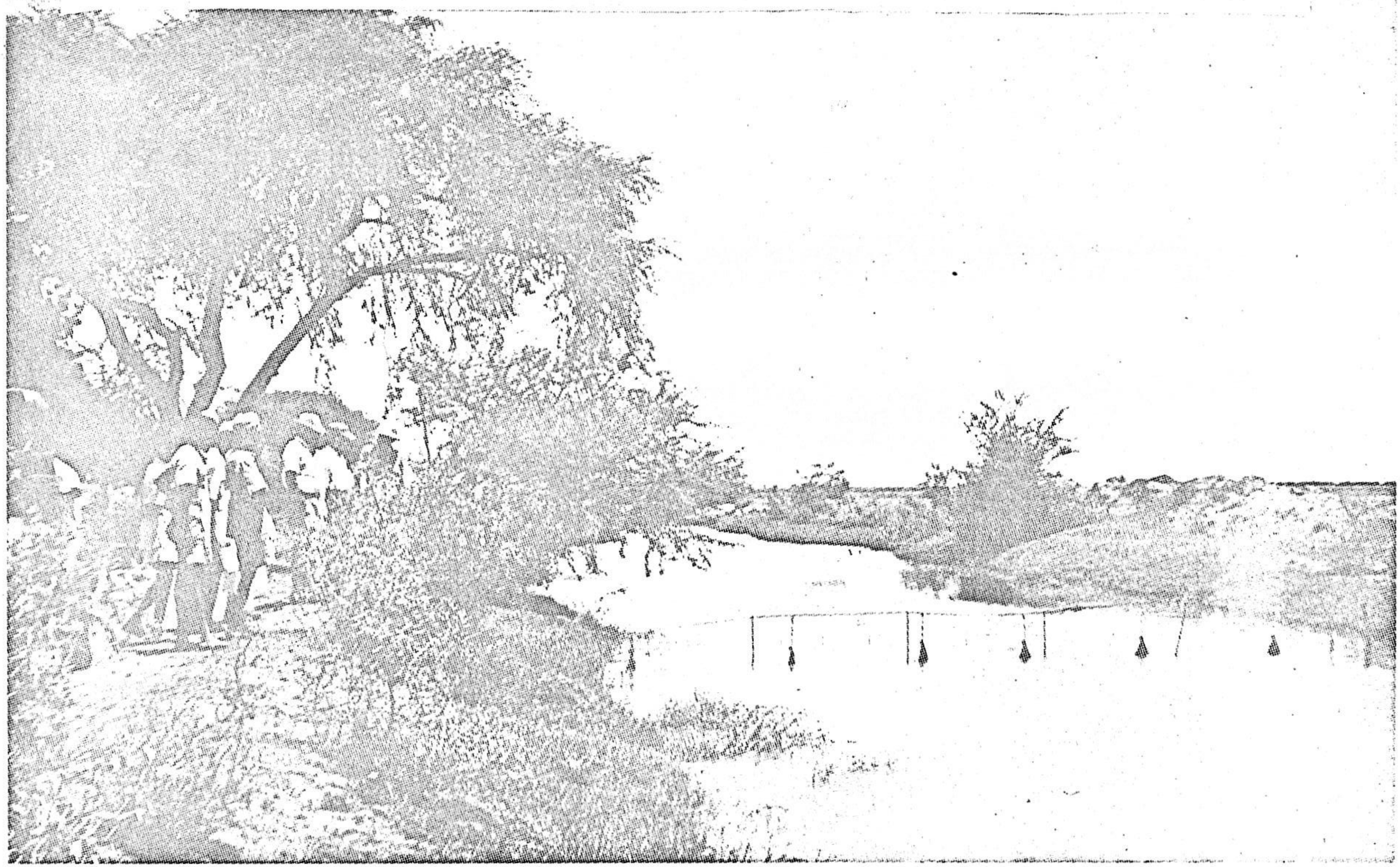


Figure 27. Bags of copper sulphate hung in a canal of the Gezira tract in the Sudan. a 0.125 ppm of copper ions are maintained after initial treatment with 30 ppm. Snails were absent in these canals and the aquatic vegetation also disappears.



8. Summary

To summarize, schistosomiasis, or bilharziasis, poses a very serious problem both in Egypt and the Sudan. While both regions share many ecological relationships, the areas are also strikingly different in the position they hold with respect to the stage in the development of the disease and its implications. A number of studies and programs have been initated and some good basic information is available. Few diseases demand more collaboration in more fields and at every level. International programs fail to include the areas where their programs mesh with blood fluke control. Within the country involved the scourge of this disease enters practically every field of human endeavor. Programs within an agency such as the WHO concentrate on the immediate aspects (usually Medical, Sanitary, Education and Snail Control) but many important other fields must of necessity be involved. Only when this work can receive total commitment will there be any hope for alleviating suffering and improving economy.

In the Egypt 10 project interest was focused on educating the people, improving sanitary conditions, providing some drug therapy (in this case Fouadin), and attempting snail control with the use of copper sulphate. But these measures become ineffective as a result of religious practices such as ablution, the lack of available facilities due to extreme poverty within rural communities, the impossibility of enforcing helpful legislation, and the unconcern of government agents whose lot is not in the filthy villages but largely in the metropolitan areas of Cairo and Alexandria.

In conclusion, it is clear that the <u>perennial</u> system of irrigation is most explosive in producing a high incidence of blood flukes - as is well exemplified in the Sudan. Problems become difficult because in the conditions of rural Egypt; all facets of living have their own special relation to the control problem. Although the need for integration and planning is overwhelming, the prospects for obtaining relief are dim. In the meantime the emerging countries in Africa face frightening increases in the incidence of blood fluke.

REFERENCES

Abdel Azim, M. 1948 Problems in the Control of Schistosomiasis (Bilharziasis) in Egypt. Proc. 4th Int. Cong. Trop. Med. and Malaria, Washington, D. C. May 10-18: 1013-1021

Abdel Malek, Emile 1958a Distribution of the Intermediate Hosts of Bilharziasis in relation to Hydrography with special reference to the Nile Basin and the Sudan. Bull. Wld. Hlth. Org., 18: 691-734.

1958b. Factors Conditioning the Habitat of Bilharziasis Intermediate Hosts of the Family Planorbidae. Bull. Wld. Hlth. Org., 18: 785-818.

Barlow, C. H. 1937 The Value of Canal Clearance in the Control of Schistosomiasis in Egypt. Amer. J. Hygiene, 25: 327-348.

1939 Seasonal Incidence of Infestation of the Snail Hosts with Larval Human Schistosomes. Ibid.: 30: 73-81.

Barlow, C. H. and H. E. Meleney 1949 A voluntary infection with *Schistosoma haematobium*. Amer. J. Trop. Med., 29: 79-87.

Chandler, A. C. 1954 A Comparison of Helminthic and Protozoan Infections in Two Egyptian Villages Two Years after the Installation of Sanitary Improvements in one of them. Amer. J. Trop.Med.Hug., 3: 59-73.

Dazo, B. C., N. G. Hairston and I. K. Dawood 1966 The Ecology of *Bulinus truncatus* and *Biomphalaria alexandrina* and its Implications for the Control of Bilharziasis in the Egypt-49 Project Area. Bull. Wld.Hlth.Org., 35: 339-356.

Farooq, M.,N. G. Hairston and S. A. Samaan 1966 Preliminary Report on the Effect of Area-Wide Snail Control on the Incidence of Bilharziasis in Egypt. Pflanzenschutz-Nachrichten, 19: 41-48.

Gelfand, Michael 1967 A Clinical Study of Intestinal Bilharziasis, (*Schistosoma mansoni*) in Africa
Edward Arnold, Ltd., London, 230 pp.

Greany, W. H. 1952 Schistosomiasis in the Gezira Irrigated Area of the Anglo-Egyptian Sudan.

I. Public Health and Field Aspects. Ann.Trop.Med.&Parasit., 46: 250-267.

II. Clinical Study of *Schistomiasis mansoni*. Ibid. 298-310.

McMullen, D. B. and H. W. Harry 1958 Comments on the Epidemiology and Control of Bilharziasis. Bull.Wld.Hlth.Org., 18: 1037-1047.

Scott, J. Allen 1937 The incidence and distribution of human schistosomes in Egypt. A. J. Hyg., 25: 566-614.

Stirewalt, M. A. 1954 Effect of Snail Maintenance Temperatures on Development of *Schistosoma mansoni*. J. Parasit., 40: 35.

van der Schalie, Henry 1958 Vector Snail Control in Qaliub, Egypt. Bull. Wld. Hlth.Org., 19: 263-283.

1960 Egypt's New High Dam - Asset or Liability. The Biologist, 42: 63-70.

1963 People and Their Snail-Borne Diseases. Mich. Quart. Rev., 2: 106-114.

Weir, John 1952 An Evaluation of Health and Sanitation in Egyptian Villages. J. Egyptian Publ. Hlth. Ass., 27: 55-114.

1959 World Health Organization Chronicle, 13:19

World Health Organization 1961 Molluscicides. Wld. Hlth. Tech. Rpt. Ser., 214: 1-50.

1965 Snail Control in the Prevention of Bilharziasis. Wld. Hlth.Org. Mono.Ser. 50: 1-255.

Wright, W. H. 1951 Medical parasitology in a changing world. What of the future? J. Parasit., 37: 1-12.

Wright, W. H., C. G. Dobrovolny and E. G. Berry 1958 Field Trials of Certain Molluscicides (chiefly Sodium Pentachlorophenate) Bull. Wld.Hlth.Org., 18: 963-283.