AD-A093 062   AKRON UNIV OH ENGINEERING AND SCIENCE DIV   F/G 6/5
THE SCOURGE OF TROPICAL WATER RESOURCES. SCHISTOSOMIASIS.(U)
DEC 80   E O GANGSTAD   DACW73-70-C-0042
UNCLASSIFIED   NL

1 of 1
AD
A093062

END
DATE
FILMED
1 81
DTIC

LEVEL II

③

SECURITY CLASSIFICATION OF THIS PAGE (When Data

AD A093062

## REPORT DOCUMENTATION

READ INSTRUCTIONS BEFORE COMPLETING FORM

|  |  |  |
|---|---|---|
| 1. REPORT NUMBER<br>N/A | 2. GOVT ACCESSION NO.<br>AD-A093 062 | 3. RECIPIENT'S CATALOG NUMBER<br>N/A |
| 4. TITLE (and Subtitle)<br>The Scourge of Tropical Water Resources, Schistosomiasis |  | 5. TYPE OF REPORT & PERIOD COVERED<br>N/A<br>6. PERFORMING ORG. REPORT NUMBER<br>N/A |
| 7. AUTHOR(s)<br>Gangstad, E. O. |  | 8. CONTRACT OR GRANT NUMBER(s)<br>DACW-73-70-C-0042 |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS<br>Engineering and Science Division<br>University of Akron<br>Akron, Ohio |  | 10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS<br>N/A |
| 11. CONTROLLING OFFICE NAME AND ADDRESS<br>Office, Chief of Engineers |  | 12. REPORT DATE<br>13 December 1980<br>13. NUMBER OF PAGES<br>19 |
| 14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office) |  | 15. SECURITY CLASS. (of this report)<br>Unclassified<br>15a. DECLASSIFICATION/DOWNGRADING SCHEDULE |

16. DISTRIBUTION STATEMENT (of this Report)

Distribution Unlimited

DTIC
ELECTE
DEC 17 1980
E

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

None

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Schistosomiasis
Tropical Water Resources

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Schistosomiasis is the scourge of tropical and sub-tropical water resources, it is more than a medical or public health problem. It is a political, sociological and economic problem as well. The effectiveness of a health care program depends on the cultural setting. Our Western approach is clearly not the best for all cultures. Traditional methods are, for most people, more accessible, more effective, and far cheaper than the urban hospitals and health care centers we often support or the complex and costly techniques we (over)

DDC FILE COPY

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

80 12 17 010

412 1

introduce. A new medical school based on Western medicine can absorb 50 percent or more of the entire health-care budget of a country like Ethiopia. And in countries unable to spend more than five dollars per person per year for all health expenses, an urban medical center can consume the budget of a health-care system for years and paralyze the functioning of rural practitioners, who provide the only health care available to most rural people in Third World countries.

Accession For
NTIS GRA&I ☒
DDC TAB ☐
Unannounced ☐
Justification______

By______
Distribution/
Availability Codes

| Dist | Avail and/or special |
|---|---|
| A | |

B

# THE SCOURGE OF TROPICAL WATER RESOURCES/
# SCHISTOSOMIASIS

## Introduction

It has become apparent that man's triumph over disease has attained what might be considered a high level of success. This, however, does not mean that infectious diseases are no longer a threat. To the contrary, a major infectious disease of man, schistosomiasis, still remains as a terrible scourge to mankind in many parts of the world, specifically the water resources of the tropics and subtropics. It has been estimated that the number of persons afflicted by schistosomiasis throughout the world ranges between 200 and 300 million. (1).

This is not an acute disease. Rather, it is a chronic one which saps energy, and as a consequence is a major deterrent of the technological advancement of under developed countries. Consequently, the prevention as well as cure of schistosomiasis is of paramount importance. Unfortunately, this has not been the case in developing nations with limited economic resources. The control and cure of schistosomiasis are long-range programs that require professional planning, continuous research, and financial commitment.

Schistosomiasis is more than a medical or public health problem. It is a political, sociological, and economic problem as well. Unfortunately, although there is considerable biomedical information on the transmission, pathology, epidemiology, immunology, and other aspects of the pathobiology of schistosomiasis, there are essentially no hard facts on the economic, political and sociological implications of the disease, or very successful programs of control.

# Epidemiology

When we speak of human schistosomiasis, we are actually referring to three distinct diseases caused by three different species to helminth parasites: Schistosoma mansoni, S. Haemotobium, and S. japonicum. Although the distribution of S. mansoni and S. haemotobia geographically overlap each other, especially in Africa, each disease can be recognized by its distinctive symptoms and resulting pathology. Schistosomiasis japonica is an oriental disease with its major foci being in the People's Republic of China and the Philippines.

The adults of S. mansoni, S. haematobium, and S. japonicum are dioecious. The males and females of S. mansoni occur in more or less permanent copula in the host's portal circulation, usulally in the smaller branches of the inferior mesenteric vein the the region of the lower colon. The fully formed eggs laid by the fertilized female each measures 117-175 by 45-68 um, and bears a large posterolateral spine. Such eggs become free in the mesenteries and are carried by the blood to the proximity of the large intestine, where they gradually penetrate the intestinal wall and some are passed out in feces.

In the case of S. haematobium, after starting to mature in the host's liver, the majority of the adult worms reach the vesical, prostatic, and uterine plexuses by way of the inferior haemorrhoidal veins. The eggs laid by the fertilized females measure 112-170 by 40-70 um and are characterized by a distinct terminal spine. These penetrate into the wall of the urinary bladder, with some passing through and are expelled from the body in urine.

The adults of S. japonicum inhabit the branches of the superior mesenteric vein in the proximity of the small intestine. In addition, the inferior mesenterics and caval system may also be invaded, for the worms tend to migrate away from the liver as they become older. The eggs of S. japonicum characteristically bear a very small lateral spine on the shell. The entire egg measures 70-100 by 50-64 um. Like those of S. mansoni, these penetrate the intestinal wall and are eventually voided to the exterior in feces.

Not all of the eggs produced by the females of all three species are voided from the human hosts. Many remain embedded in the hosts' tissues and serve as foci for the development of granulomatous lesions. It follows that the intensity of the pathological changes due to schistosomiasis is directly correlated with the number of eggs lodged in tissues, which, in turn, is correlated with the adult worm burden. In addition, such factors as the age of the infection, and the immunologic state of the victim, and important roles in determining the seriousness of the disease and the intensity of the resulting pathology.

If eggs of all three species of the human-infecting schistosomes passed out of the hosts should come in contact with water, the enclosed ciliated larvae, known as miracidia, break out and are free-swimming. Their life span as free-living organisms, however, is limited. They may remain active for as little as 6 hours or as long as 72 hours. During this period they must find and penetrate into a suitable gastropod host. The miracidia locate their molluscan hosts by first being brought into range as a result natural taxes and subsequently make contact with the host by chemotaxis.

Each miracidium generally penetrates the snail intermediate host through the surface epithelium of the tentacles or the headfoot. If it should enter an imcompatible species or strain of snail, cellular reactions lead to the encapsulation and destruction of the parasite (1). The miracidial penetration process is reportedly made possible by the secretion of a lytic enzyme from two large, unicellular, glands situated one on each side of the terebratorium. Between 25 and 30% of <u>S</u>. <u>mansoni</u> miracidia are incapable of penetrating compatible snail hosts (2). In the case of S. mansoni, the principal intermediate hosts are Biomphalaria glabrata, B. straminea, and B. pfeifferi. For S. haematobium, the principal hosts are Bulinus truncatus and B. globosus. For S. japonicum, the principal hosts are Oncomelania nosophora and O. humensis (3).

Upon entering a compatible gastropod host, the ciliated epithelium of the miracidium is sloughed and the parasite metamorphoses into a first generation or mother sporocyst. This is essentially anon-motile, opaque, elongate, somewhat convoluted sac measuring several hundred um in length. Within the brood chamber of a mother sporocyst are found germinal cells which eventually develop into second generation or daughter sporocysts. A larval stage known as a cercaria eventually develops from each germinal cell in the brood chambers of post-first generation sporocysts. Daughter and subsequent generations of sporocysts are elongate, opaque, motile sacs with a snout-like anterior end covered with spines. Daughter sporocysts, as stated, develop with mother sporocysts. These escape when the mother sporocyst wall ruptures and the yound daughter sporocysts migrate to the interacinar spaces of the molluscan host's digestive gland where they attain maximal growth and development.

Fully developed cercariae emerge from sporocysts when the walls of the latter rupture. These cercariae start migrating through the snail's tissues and accumulate in the hemolymph sinuses and dilated veins at as early as 20 days post-infection. They eventually migrate from the sinuses and veins to the mantle collar and from there escape to the exterior to become free-living organisms. The time required for intramolluscan asexual reproduction and development varies, depending on several ambient factors, especially temperature. The shortest time occurs when the temperature in between 26-28°C and longer periods are required as the temperature decreases. Cercarial emergency occurs daily. In the case of S. mansoni and S. haematobium, most of the cercariae emerge between 9:30 a.m. and 2:00 p.m. and in the case of S. japonicum, between 10:30 p.m. and 2:00 a.m.

The most important structures in the body of a cercariae relative to penetration and establishment in the human host are the pre- and post-acetabular glands (4). The post-acetabular glands, which occur in three (some claim four) pairs, are smaller. They contain finely granular, periodic acid-Schiff-positive material. Each time the cercaria's oral sucker is attached to the host's skin, some of this material is secreted. These deposits swell in water and result in a sticky mucus which allows the cercaria to become attached by its suckers while commencing to penetrate. (5, 6, 7).

There are two pairs of pre-acetabular glands. They contain alkaline, macrogranular, alizarin-staining material as well as calcium. Most of this material is secreted when the anterior end of the cercaria penetrates the horny layer of the host's skin and reaches the keratogenous layer. The secretion permeates the keratogenous and other layers and facilitates further penetration and migration by softening the keratin in the horny layers because of its alkalinity and by hydrolyzing the ground substance of the epidermis and dermis. It is also noted that penetration into mammalian skin is also facilitated by muscular action of the cercarial body.

The post-penetration form of schistosomes is known as a schistosomule. Those that are to survive in the definitive host enter peripheral venous or lymphatic vessels within one to several days, reach the lungs by way of the right side of the heart, and from the lungs enter the portal system. There is little question that the route taken by schistosomules from skin to lungs is via blood vessels; however, there is some question whether the avenue taken from lungs to the portal circulation is also the circulatory system.

In view of the brief review presented above, it should be obvious that the suppression of the incidence of human schistosomiasis can be approached in several ways. Traditionally, research and the application of results with this objective have been directed along three approaches: chemotherapy, vaccination, and mollusc control. The last mentioned includes several subapproaches, namely chemical, biological, genetic, and engineering control methods. (7).

## The Problem of Large Dams

Of all the ecological repercussions modern man has initiated, the most widespread have followed the construction of giant hydroelectric irrigation dams. Until recent years these dams were universally admired products of the Western tradition of environmental conquest and domination.

As each project begins, its planners speak glibly of the need of information from many disciplines, but once the dams are authorized, they are viewed largely as problems in engineering. Construction is justified on the basis of economics, and considerations of public health or social and cultural change are often sacrificed in the course of dealing with other problems.

One deleterious outcome of this emphasis on engineering has been the creation of conditions that allow parasitic organisms that have afflicted human beings since antiquity to increase their levels of infection beyond their normal intensity or range. The result is disease of unprecedented severity or extent. Most people infected with parasitic worms show mild symptoms or even none at all. But increase the number of invaders or their virulence, or reduce the human host's resistance, and infection becomes disease. The measure of infection is the presence of the agent; the measure of disease is damage to the host. In parasitic infections, environmental conditions- host, parasite, and surroundings- determine whether their interaction will develop into disease.

Anything that interferes with the host's resistance or encourage parasites to multiply shifts the balance between host and parasite, and disease follows. The young, who have an undeveloped immunologic system, and the aged, whose response to parasites is dulled, are usually the first struck down by disease. Malnutrition, especially protein deprivation, reduces the body's capacity to maintain high levels of antibodies, those critical elements in the immunologic arsenal. Too many infective agents, too frequent exposure, and the presence of other infections may also overwhelm the host's ability to form antibodies. And anxiety, trauma, and social upheaval can further depress immunologic responses. War, mass migration, crop failure, floods, poverty, crowding, or sudden changes in ancient social habits render the human population vulnerable to plagues of parasites and to epidemics of other diseases (7) 8, 9).

The high dams of Africa are paradoxical examples of the widespread changes wrought by technology and of the environmental interaction that frequently results in outbreaks of parasitic disease. The three principal African rivers-the Volta in Ghana; the Zambesi between Zambia and Rhodesia, and the Nile of East Africa, Sudan, and Egypt-have been controlled and domesticated through the greatest building efforts since the construction of the pyramids. The Aswan High Dam on the Nile is 17 times the mass of the gaint Cheops pyramid, which for over 5,000 years had been the largest structure ever built. The new dams have created the largest man-made bodies of water in the world: The shoreline of Lake Nasser behind the Aswan High Dam is longer than that of the Mediterranean and of the Red Sea combined.

The Nile was dammed to check its annual flood, which for millennia regularly deposited some 130 million tons of silt along the narrow river-carved valley that forms the heart of Egypt. Instead of annual flooding, the great delta fan of lower Egypt has had perennial irrigation for over half a century, so the mixed blessings of a permanent water supply (expanded agriculture and the spread of parasitic disease) have been known in Egypt for several generations. (10).

Perennial irrigation permits crops to be harvested two and sometimes even three times a year. The impounding of the Nile at Lake Nasser was to have placed under irrigation two million acreas of desert, equal to one third of all of Egypt's currently arable land. Another objective of the dam was to produce hugh amounts of power, over 10 billion kilowatts from 12 giant turbines. Planners expected the dam to yield a return on its $600 million cost in two years, double Egypt's national income in 10, and provide a beacon of progress for the Arab world.

But the real world seldom operates according to such grand plans. Much of the water meant to be conserved has been lost to evaporation by the hot desert winds, a backflow of lake water into adjacent underground pools in the desert, and the growth of large masses of aquatic weeds in

Lake Nasser. Only about half of the million acreas of desert have received water because the lake has filled more slowly than was expected and the need for water has increased greatly in the cities and on land already under cultivation.

Egypt's power supply has doubled- but a single huge aluminum plant producing 300 tons of metal a day, now uses one fourth of that power. Only three of the dam's 12 turbines are in operation, because the waterhead has been reduced by increased water requirements for agriculture.

One positive result of the Aswan High Dam is that the danger of drought is apparently past in Egypt. But the water, though controlled, still possesses erosive power. The Nile has altered its course and eroded the bases of nearly all the bridges along the riverbed.

Elminating the annual flood has created its own problems. Nitrates and phosphates the fertilized the land every year when the Nile deposited its silt need to be replaced. Phosphates are abundant and can be mined from the desert with energy generated by the dam, but nitrates must be imported.

The end to the yearly supply of soil that rebuilt and held the shoreline of the delta fan seems already to have altered the ecology of the eastern Mediterranean. Margins of the delta are receding. The

Mediterranean is apparently eroding the shoreline at nearly the same rate that new lands are being wrested from the desert of Upper Egypt. Crustaceans formely supported by rich depositions of soil and soil-drevied nutrients in the delta are also gone. And so are the shrimp boats that tapped this resource, and the entire sardine fleet from the coasts of Egypt and Libya, which supported a number of coastal communities by taking 18,000 tons a year of fish protein from the eastern Mediterranean.

Permanent irrigation provides water year-round, but it fails to provide the leaching effect of flooding followed by rapid drainage. Irrigation has raised the water table in the Nile delta and Egypt's age-old agricultural wealth: waterlogging and salt. In these immensely productive lands formerly flooded and washed clean each year by the Nile, salt-saturated water levels in the soil are rising and may soon reach the roots of food and export crops, especially the economically irreplaceable cotton.

These problems belong to the engineers; they are technological errors that technologists must solve. To assess the cost of the African dams in human terms, we need to consider the communities of people and animals that had to be resettled to make way for them: 75,000 people in the Kariba Basin in the Zambesti; 150,000 in Upper Egypt and the Sudan; 85,000 from the Volta, and many thousands from similar projects elsewhere in Africa (11).

For many of these people in different parts of the continent, ill-planned resettlement has meant changed diet and customs and loss of autonomy and traditional ways of life. Frequent consequences of resettlement are crowding and filth, which promote contact disease and extensive breeding of the flies and mosquitoes that spread parasitic infections. Moved into new areas, people and their animals have been exposed to local disease-causing organisms for the first time. Lacking resistance to these new infections, the uprooted people contract disease with tragic rapidity.

The human results of this and other projects in Africa appear in World Health Organization reports on tropical diseases spread by water: thousands of children with livers swollen by schistosomiasis; Nigerians and Ghanians blinded by onchocerciasis, a parasitic-worm disease carried by blackflies, which breed in fast-flowing water; Sudanese with visceral leishmaniasis, a frequently fatal disease carried by sand flies; and outbreaks of tsetse fly-borne sleeping sickness among people and domestic animals. We can trace the rapid spread of schistosomiasis in Upper Egypt directly to the ditching of Nile waters through a web of new irrigation canals that are filled year-round, an ideal environment for the snail hosts of the schistosome blood flukes.

Snails that spread schistosomiasis were already present in most of the major river tributaries of Africa; they merely needed to float on aquatic vegetation to reach the dam and find their way into the new desert irrigation networks. The snails often arrived before the first farmers did. Snail eggs also may have been carried on the feet of water birds or in soil transported to build sluices that control water flow from primary to sudsidiary canals. As each canal system is usually part of a single interconnected network, all suitable snail-breeding areas were soon occupied. Thus the essential element for crops and human survival-water-becomes equally available to man and the disease-bearing snail. (12,13,14).

The eggs of these blood flukes hatch instantly when deposited with infected feces or urine in water. Each egg releases a larva that, propelled by hairlike cilia, seeks out and penetrates the particular strain of snail to which the worm is adapted. Soon the infected snail swarms with progeny of the single larva that entered it; in a few weeks several hundred to a thousand larvae emerge each day from the snail, thrash about in the water with their forked tails, and spend their one to two days of nonparasitic life in search of human skin to penetrate. A single infected snail, shedding 100,000 schistosome larvae in its six-month life span, could infect an entire village.

Formerly, the land of Upper Egypt was cultivated only after the annual flood. The land dried out between the floods, killing most of the snails. Rarely did more than 5 percent of the population shown evidence of schistosomiasis.

As permanet irrigation canals were built and people were consinuously exposed to infected snails, infection rates in some areas soared to about 85 percent in less than a year after people moved into the new villages. In villages farther away from irrigated areas and receiving piped water, few people-20 to 25 percent-become infected.

## Summary and Conclusions

Sanitary control in settled areas might help if people were given sufficient time to alter their old habits and customs. Privies, for example, are often unsuited to the tropics. They become fouled, unmaintained, and abandoned. Each of the many groups concerned-Arab, nomad, settled agriculturalist, cattle-keeping agriculturalist, hunter-gatherer, urban worker-must be considered and assisted in term of specific habits and needs so that preventive measures will not simply trade off one disease for another.

Control of snails by chemicals has been tried for years. Available poisions are costly, toxic to fish, and require constant reapplication by trained personnel. A special disease-control spection of the Egyptian Ministry of Public Health devotes itself entirely to the destruction of snails. Thousands of tons of various chemicals have been dipped, sprayed, scattered, pelleted, and implanted inslow-release formulations in snail-bearing waters. Yet 60 to 80 percent of rural villagers in Egypt still harbor the worms.

People kill snails and then bring them back by constructing new canals and ditches, or by refilling treated canals with water from snail-bearing canals. They try to eliminate the snails using engineering methods: weirs, sluice gates, concrete-lined canals, periodic clearing of vegetation, and fences to keep children from the water. Then they reintroduce more snails, perhaps in a load of mud brought in to repair a dike or to line a feeder ditch to convey a share of precious water. Because the web of canals is a single system, a control project is never finished. Anywhere control is lax or stopped, snails are reintroduced and schistosomiasis returns.

Community involvement based on local recognition of the problem and local responsibility and pride in its solution seems to be the key. In Ethiopia, Aklilu Lemman of the University of Addis Ababa discovered that the berries of a local plant would kill snails with nearly the sam efficacy as costly imported drugs.

He then organized a research program to develop procedures for mass cultivation of the plant, improved by artificial selection of more vigorous or resistant strains. Members of his institute at the university-an Ethiopian staff assisted by foreign technical consultants-worked out various methods of processing the berries and preparing the snail-killing product. They discovered an astonishing variety of applications for the endod berries, raising the interest of researchers elsewhere. Althrough foreign funding has supported the project, its promise and its chief advantage are the development of a local product, locally made and administered. The intention is to initiate a self-sustained village-level approach to ongoing snail control.

The effectiveness of health care in general depends on the cultural setting. Our Western approach is clearly not the best for all cultures. Traditional methods are, for most peopole, more accessible, more effective, and far cheaper than the urban hospitals and health-care centers we often support or the complex and costly techniques we introduce. A new medical school based on Western medicine can absorb 50 percent or more of the entire health-care budget of a country like Ethiopi. And in countries unable to spend more than five dollars per person per year for all health expenses, an urban medical center can consume the budget of a health-care system for years and paralyze the functioning of rural practitioners, who provide the only health care available to most rural people in Third World countries.

# REFERENCES

1. Ansari, N. (ed.) Epidemiology and Control of Schistosomias (Bilharziasis). Unviersity Park Press, Baltimore, Maryland. 1973.

2. Chernin, E. and Antolics, V.M. Penetrative capacity of Schistosoma mansoni miracidia. J. Parasitol., 63, 560-561. 1975.

3. Malek, E.A. and Cheng, T.C. Medical and Economic Malacology. Academic Press, New York. 1974.

4. Stirewalt, M.A. Skin penetration mechanisms of helminths. In "Biology of Parasites". (E.J.L. Soulsby, ed.). pp. 41-59. Academic Press, New York. 1966.

5. Lewert, R.M. and Lee, C.L. Studies on the passage of helminth larvae through host tissues. II. Enzymatic activity of larvae in vitro and in vivo. J. Infect. Dis., 95, 35-51. 1959.

6. Cheng T.C. Schistosomiasis: The Wulks Magin/Medical Problem. Proceedings 1975 International Cujtural Release Pesticide Symposium. College J. Science and Engineering, Wright State University, Dayton, Ohio 1975.

7. Jordan, Peter, and Gerald Webbe. Human Schistosomiasis. Charles C. Thomas, 1969.

8. Scuder, T. "Ecological Bottlenecks in the Development of the Kariba Dam." The Careless Technology, ed. by M.T. FArver and J.P. Milton. Natural History Press, 1972.

9. Stanley. N.F., and M. Alpers, eds. Man Made Lakes and Human Health. Academic Press, 1975.

10. Van der Schalie, H. "Aswan Dam Revisited-The Blood Fluke Thrives." Environment, Vol. 16, pp. 18-26 1979.

11 Waddy, B.B. "Research into the Heath Problems of Man-made Lakes with Special Reference ot Africa." Transactions of the Royal Society of Tropical Medicine and Hygiene. Vol 69, pp. 39-50 1975.

12. Heyneman D. Dams and Disease. Human Nature. Vol. 2, No. 2, pp 50-57, 1979.

13. Ferguson, F.F. Aquatic weeds and mans well being, in Weed Control Methods for Public Health Applications. Gangstad, E.O. Ed. CRC Press, Boca Rato, Fla. 1980.

14. Cardarelli, N.F. Control of snail-borne parasitic diseases. in Weed Control Methods for public Health Applications. Gangstad. E.O. Ed. CRC Press, Boca Raton, Fla. 1980.