INVITED CONTRIBUTION

Intramural Aspects of Schistosomiasis Control

DONALD B. McMULLEN[1]

INTRODUCTION

Work in different parts of the world has tended to solidify a "one world" concept of disease control. The fact that this paper would be presented at the annual meeting of the Oklahoma State Academy of Science, and that schistosomiasis (bilharziasis) control is not entirely a medical-science problem, led to the choice of the word "intramural" in the title. This was done in order to emphasize some of the problems that face us "within the walls" of Science.

The human schistosomes and schistosomiasis mean little or nothing to the average American. By a quirk of Nature the species of snails that serve as intermediate hosts for the three parasites, *Schistosoma mansoni*, *S. haematobium* and *S. japonicum*, are not found in continental United States. The first two of these parasites were introduced into the Western Hemisphere when slaves were brought from Africa and persons infected with *S. japonicum* have come from the Orient. It was only in Puerto Rico, some of the other Caribbean islands, and countries in the northern part of South America where suitable snail hosts for *S. mansoni* were present. As a result, this parasite did become established and it continues to be a public health problem in those areas.

In the Eastern Hemisphere the disease is found from the southern tip of Portugal to the Union of South Africa, and from a few areas in Japan to the Celebes. It is estimated that there are 150 million cases in the world today and of the parasitic diseases of man it is considered second only in importance to malaria.

The trematodes that cause schistosomiasis live in the branches of the hepatic portal system and related veins. Adults of *S. mansoni* and *S. japonicum* lay eggs in the wall of the intestine and these pass out with the feces. In the case of *S. haematobium*, the worms prefer the wall of the urinary bladder and the eggs pass out in the urine. In water the eggs hatch and the larvae (miracidia) must find a suitable snail host within a few hours. Asexual reproduction takes place within the snail and the production of another type of larva (cercaria) begins in about six weeks. Each infected snail may produce 1000 cercariae or more daily for many weeks. Cercariae coming in contact with the human skin penetrate and enter the blood stream, become established in the liver, and finally migrate against the flow of blood to their favorite egg-depositing sites within 4-6 weeks.

EPIDEMIOLOGY AND IMPORTANCE OF SCHISTOSOMIASIS

Effects of schistosomiasis on the individual

The infection is usually acquired during childhood or by teenagers. The course of the disease depends on the amount and pattern of exposure and various other factors. A few worms may cause serious damage but

[1] Leader, World Health Organization Bilharziasis Advisory Team, on leave from Department of Medical Zoology, Walter Reed Army Institute of Research, Washington, D.C.

they are usually tolerated and eventually a person appears to develop some resistance to further infections. When the number of worms from early infections is larger and proper treatment is not administered, irreversible changes take place and the young adult either dies of complications or, because of the residual effects caused by the worms and eggs in the tissues, the person is unable to do his share of work in the family and the community.

Effects of schistosomiasis on the economy

The effects of schistosomiasis on the economy of an area have not been fully assessed but it is possible to cite a few examples. As a part of the WHO-supported Schistosomiasis Pilot Control Project in the Philippines, it was calculated that the annual loss of wages alone was $1.35 million. In Egypt it has been estimated that economic productivity is reduced 30 per cent, with an annual loss of $57 million. In that country they spend more than $3 million annually in attempts to control the disease but 12 million out of a population of 22 million continue to have the infection. The 1700 American soldiers who acquired an infection of *S. japonicum* in the Philippines during World War II, cost the United States about $3 million in man-days lost and medical care (WHO, 1959).

Types of areas where schistosomiasis is found

Wet areas. In 1952 I participated in a WHO-sponsored survey of the schistosomiasis problem in the Philippines. The endemic foci there are located in low-lying areas where there is often too much water. Because of the extent of the infested areas and the lush vegetation, the annual cost of control by the use of molluscicides would have been more than the total public health budget for the entire country. For this reason it was proposed that the pilot control project mentioned above be set up in Leyte (McMullen et al, 1954). This was primarily a research project to study the bionomics and the effect of various engineering and agricultural procedures on the population dynamics of the snail intermediate host, *Oncomelania quadrasi.* The results that have been obtained show that engineering and improved agricultural methods can be used to eliminate many colonies and reduce the total snail population by more than 95 per cent. They have been able to treble the crops obtained from formerly poorly farmed fields and waste land has become productive (Pesigan et al, 1958a, 1958b, 1958c).

Dry areas. Ironically, in the arid and semi-arid areas, where surveys have been made by the WHO Bilharziasis Advisory Team in the past two years, the development of water and soil resources tends to spread the disease and increase its intensity. In four provinces of Egypt, where basin irrigation has been converted to perennial irrigation, the prevalence of the disease has increased from between 2-11 per cent to between 44-75 per cent and a much higher percentage of the people are critically ill. In one area of the Congo, the prevalence jumped from about 4 to 34 per cent within a year after an irrigation system was installed. Flood control, water conservation, fish pond, hydro-electric and water supply projects, quite similar to those seen in Oklahoma, also often increase the amount of schistosomiasis. In any endemic area, unless the economists and planners, the agricultural experts, the irrigation and water management engineers, and the public health authorities co-operate, the benefits derived from the development of water resources may be counterbalanced by an increase in the prevalence of disease. It is rare indeed that the planners of such schemes include disease control as a part of their development program. In the name of economic advancement they can get funds and produce health problems more rapidly than public health budgets and personnel can take care of them. The impasse that often results from this lack of mutual understanding of the problems involved leads to the impression that the planners are unrealistic visionaries and that the public health authorities are stubborn obstructionists.

In the first six countries surveyed by the team in the Middle East and Africa in 1958, it was found that within the next 10-15 years they expect to convert 8.9 million acres from partial to perennial irrigation, and 11.2 million acres are to be completely reclaimed. This total acreage is about five times that now under perennial irrigation in Egypt. Such an area may eventually support about 50 million people. The same changes in the environment that will make such areas habitable by people will encourage the spread of various kinds of invertebrate hosts for human diseases. The economic, sociological, and medical aspects of such developments are staggering, and it is time that plans were made to meet these problems.

THE CONTROL OF SCHISTOSOMIASIS

The life cycle of the parasites and the epidemiological factors that have been discussed above indicate that there are four points where schistosomiasis control may be initiated: (1) prevention of contact with infested water; (2) mass treatment; (3) environmental sanitation; and (4) snail control. The first of these is difficult or impractical in most areas. In the case of the second, the lack of a truly efficacious drug mitigates against the effective elimination of the parasites from all of the definitive hosts. Environmental sanitation should be a part of any disease control program but human habits and economic considerations make it unlikely that such steps will be effective in less than a generation. For these reasons it has been concluded that the control of the snail intermediate hosts offers the most rapid and effective means of reducing schistosomiasis transmission. The relationships between the life cycles of the parasites and of the snail intermediate hosts to the theory of schistosomiasis control have been reviewed by McMullen and Harry (1958). The three different known types of snail control measures are outlined below.

Biological control. All of the evidence available indicates that the intermediate hosts are very well adjusted to their ecological niche. Investigations on the effect of parasites and predators have not been encouraging (Michelson, 1957). The only hopeful results obtained with biological control have been those observed in the laboratory and after the introduction of *Marisa cornuarietis* into *Australorbis glabratus* habitats in Puerto Rico (Olivier-Gonzales et al, 1956; Chernin et al, 1956; Michelson and Augustine, 1957; Olivier-Gonzalez and Ferguson, 1959). In this case the voracious feeding habits of the first snail apparently result in the elimination of the intermediate host's food.

Reduction and control of snail habitats. As has been shown above, this method of schistosomiasis control has been effective in the Philippines. The advantages and limitations of such measures can be outlined as follows:

1. Advantages
   - a) They increase production by utilization of waste land.
   - b) Improved irrigation and agricultural methods reduce the number of snails and increase production.
   - c) They reduce the areas where it is necessary to use phytotoxic and zootoxic molluscicides on residual colonies.

2. Limitations

   a) Wet areas

      (1) They usually leave a few colonies in unmanageable areas and ditches.

      (2) They are expensive unless they are a part of a land reclamation scheme.

   b) Dry areas

      (1) Water is essential to their development and there is always the danger that its introduction or storage will encourage snails and a concentration of human populations.

      (2) Water introduction and/or storage tends to extend the transmission period.

      (3) In many areas water use and agricultural measures are primitive and this encourages the spread of snails.

The control of snails by the use of molluscicides. It has been shown repeatedly in many parts of the world that copper sulfate, sodium pentachlorophenate, dinitro-o-cyclohexylphenol, and "Bayer 73" are very effective molluscicides under certain conditions. It has been shown in Warraq El-Arab (Egypt) that the application of a molluscicide in the irrigation canals two or three times per year will eliminate schistosomiasis transmission (Wright et al, 1958). In other areas the use of molluscicides is sometimes impractical until the number of snail habitats have been reduced by engineering and agricultural methods. The advantages and limitations of the use of molluscicides can be outlined as follows:

1. Advantages

   a) Rapid cessation of transmission.
   b) The administration of such a program is in the hands of trained personnel.
   c) Eradication is possible under certain circumstances, e.g., oases and limited watershed units.

2. Limitations

   a) This method is only a snail control measure.
   b) Usually it must be repetitive and, therefore, expensive.
   c) Compounds now in use tend to be biocidal.

CONCLUSIONS

The evidence available leads one to conclude that at present we do not have a simple answer to the problem of schistosomiasis control. Each situation requires careful study and then judgements must be made regarding the measures that should be taken to give the best cost-efficiency ratio. The problem is so broad that it requires serious consideration by scientists in many fields. Any assistance that experts in any science can give will be more than welcome.

REFERENCES

Chernin, E., Michelson, E. H., and D. L. Augustine. 1956. Studies on the biological control of schistosome-bearing snails. 1. The control of *Australorbis glabratus* populations by the snail, *Marisa cornuarietis*, under laboratory conditions. Am. J. Trop. Med. Hyg. 5: 297-307

McMullen, D. B., and H. W. Harry. 1958. Comments on the epidemiology and control of bilharziasis. Bull. Wld. Hlth. Org. 18: 1037-1047

McMullen, D. B., B. Hubendick, T. P. Pesigan, and P. Bierstein. 1954. Observations made by the World Health Organization Schistosomiasis Team in the Philippines. J. Philip. Med. Assoc. 30: 615-627

Michelson, E. H. 1957. Studies on the biological control of schistosome-bearing snails. Predators and parasites of fresh-water mollusca: A review of the literature. Parasit. 47: 413-426

Michelson, E. H., and D. L. Augustine. 1957. Studies on the biological control of schistosome-bearing snails. 5. The control of *Biomphalaria pfeifferi* by the snail, *Marisa cornuarietis,* under laboratory conditions. J. Parasit. 43: 135

Olivier-Gonzalez, J., P. M. Bauman, and A. S. Benenson. 1956. Effect of the snail *Marisa cornuarietis* on *Australorbis glabratus* in natural bodies of water in Puerto Rico. Am. J. Trop. Med. Hyg. 5: 290-296

Olivier-Gonzalez, J., and F. F. Ferguson. 1959. Probable biological control of *schistosomiasis mansoni* in a Puerto Rican watershed. Am. J. Trop. Med. Hyg. 8: 56-59.

Pesigan, T. P., M. Farooq, N. G. Hairston, J. J. Jauregui, E. G. Garcia, A. T. Santos, B. C. Santos, and A. A. Besa. 1958. Studies on *Schistosoma japonicum* infection in the Philippines. 1. General considerations and epidemiology. Bull. Wld. Hlth. Org. 18: 345-455.

.... 1958. Studies on *Schistosoma japonicum* infection in the Philippines. 2. The molluscan host. Bull. Wld. Hlth. Org. 18: 481-578

.... 1958. Studies on *Schistosoma japonicum* infection in the Philippines. 3. Preliminary control experiments. Bull. Wld. Hlth. Org., 19: 223-261.

World Health Organization. 1959. WHO Chronicle, 13: 2-56

Wright, W. H., C. G. Dobrovolny, and E. G. Berry. 1958. Field trials of various molluscicides (chiefly sodium pentachlorophenate) for the control of aquatic intermediate hosts of human bilharziasis. Bull. Wld. Hlth. Org., 18: 963-974