# Bilharzia in Lake Malaŵi - What are the facts?

Henry Madsen, Jay R. Stauffer Jr., Peter Makaula,
Paul Bloch, Adrianus Konings & Jeremy Likongwe
2006

Funding for this brochure was provided by the NSF/NIH joint program in Ecology of Infectious Diseases (DEB-0224958) and the work is conducted in collaboration with University of Malaŵi, Malaŵi Fisheries Department, and Malaŵi National Parks and Wildlife.

# Bilharzia in Lake Malaŵi
# What are the facts?

Madsen, H.[1], Stauffer, J.R. Jr.[2], Makaula, P.[3], Bloch, P.[1],
Konings, A.[4] & Likongwe, J.S.[5]

[1]) DBL Institute for Health Research and Development , Jaegersborg Allé 1D, DK2920 Charlottenlund, Denmark

[2]) School of Forest Resources, Penn State University, University Park, PA 16802, USA

[3]) Department of Community Health, Mangochi, Malaŵi, Africa

[4]) Cichlid Press, P.O. Box 13608, El Paso, TX 79913, USA

[5]) Bunda College of Agriculture, Aquaculture and Fisheries Science Department, University of Malaŵi, P.O. Box 219, Lilongwe, Malaŵi

## Summary

*The open shores (Fig. 1) of Lake Malaŵi were considered free from schistosomiasis (=bilharzia, bilharziasis, or snail fever) transmission until the mid-1980's, but transmission is now occurring along shores in the southern part of the lake (Nankumba Peninsula), and this may be related in part to over-fishing. Several fish species including those that primarily feed on freshwater snails have declined in abundance. In addition to constituting a major health problem for people along the lakeshore, the increased transmission also affects tourism in Malaŵi. This brochure is meant to summarize current knowledge about bilharzia transmission in Lake Malaŵi so as to enable visitors and inhabitants to better judge the risks without creating unnecessary concern. Focus is on Nankumba Peninula, which has been most intensively studied but there are many other important foci around the Lake. There is a risk of infection but by following simple guidelines the risk can be minimized. Views expressed in the document are those of the authors entirely.*

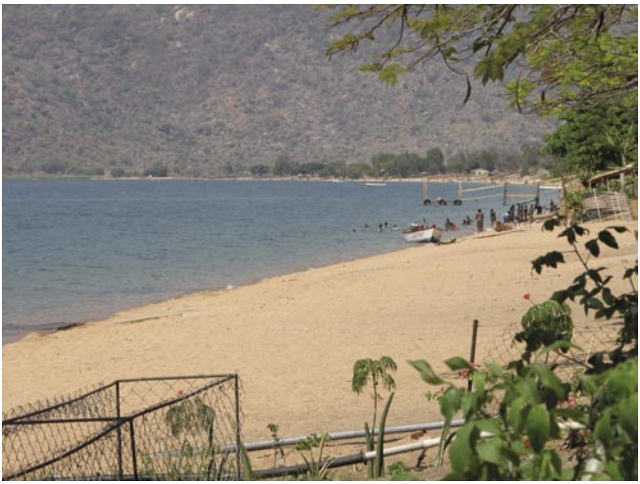

Fig. 1. Open beach at Chembe where transmission occurs.

## Introduction

Schistosomiasis (for further details see page 12) is a disease caused by parasites (flukes of the genus *Schistosoma*) and is widely spread in many tropical and subtropical parts of the world. The parasite requires two hosts during the course of its life cycle. In the intermediate host (certain species of freshwater snails), it undergoes asexual reproduction and the infective larval stage (cercariae) are released from the freshwater snail into the water; cercariae penetrate the skin of the final host (humans) with water contact, and sexual reproduction occurs.

Although bilharzia or schistosomiasis, primarily the urinary form (caused by *S. haematobium*), has been a major public health problem for many years in many lakeshore communities all around Lake Malaŵi, there is evidence that transmission has increased in certain areas within the last 20 years. Investigations in Chembe in 1999 showed that 87.5% of school children and 57.7% of the entire population was infected by the parasite. Previously, the Lake's open shores (Fig. 1) were considered free from schistosome transmission and only within relatively protected areas of the lake with presence of aquatic plants and areas around inflowing rivers would transmission take place. The intermediate host snail, *Bulinus globosus*, primarily is found in such habitats. During the mid-1980's, reports that transmission took place in the lake started to appear. In fact one of the authors (JRS) became heavily infected in 1987 by SCUBA diving in

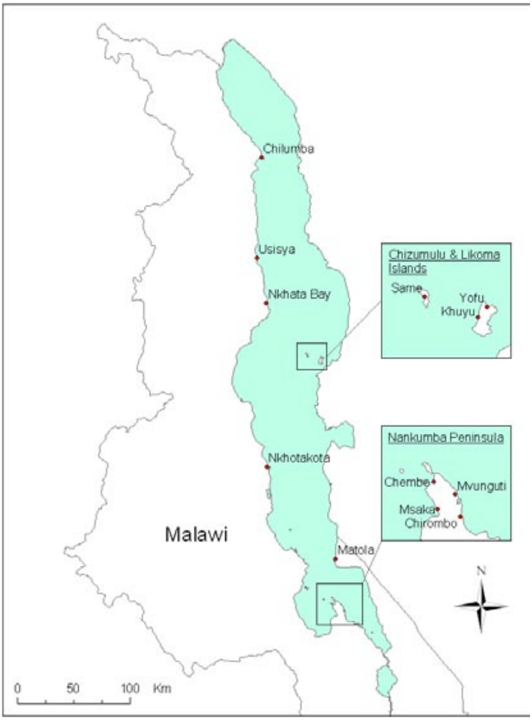


Fig. 2. Map of Lake Malawi showing stations mentioned in this report.

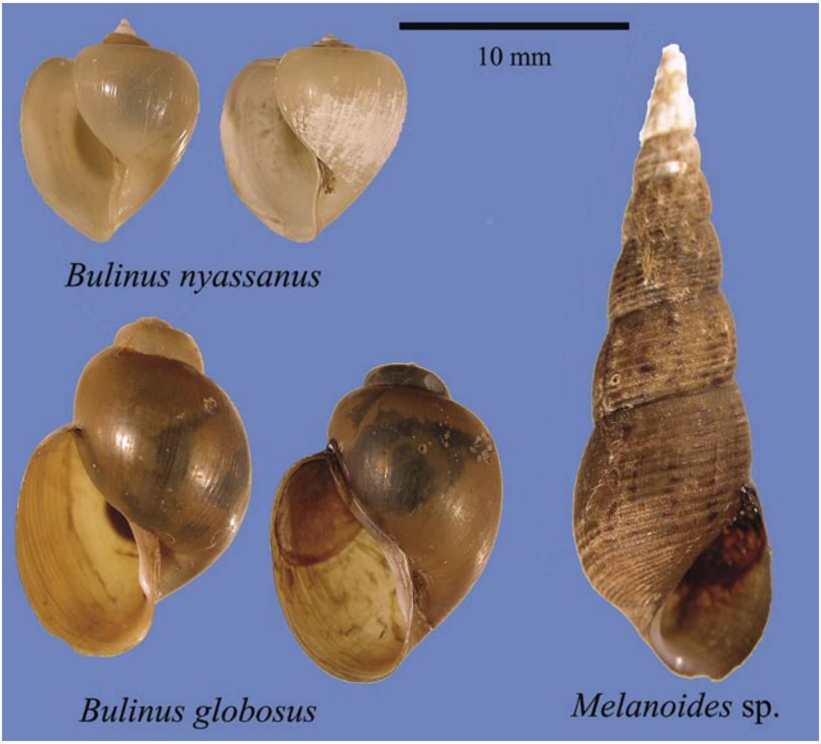


Fig. 3. Shells of the two intermediate host species for *Schistosoma haematobium* at Nankumba Peninsula, *Bulinus globosus* and *B. nyassanus*, and shell of *Melanoides* species which is the most common snail in the lake.

the Lake and it is now evident that at least in the southern part of the Lake (Nankumba Peninsula, Fig. 2) transmission also takes place along open shorelines with a sandy bottom (Fig. 1). In this habitat, one of the authors (HM) discovered that another snail species, *Bulinus nyassanus* (Fig. 3), is the intermediate host. In addition to causing a major health problem for local people, the disease also affects an important source of income for the country, namely tourism. The area around Cape Maclear is a World Heritage Site and is visited by many tourists every year. Unfortunately, many visitors become infected with schistosomes and some health organizations such the American Centers for Disease Control and Prevention (CDC) warn against visiting Lake Malaŵi. The cause of the changed transmission pattern probably may be found in the increased fishing pressure resulting from the increased population density around Chembe Village. It is well documented that a number of cichlid species, including those that prey on freshwater snails, have declined in population density

Fig. 4. Sheltered bay at Same Bay (Chizumulu) where transmission takes place through *Bulinus globosus*, which is common among the stones and in other parts with vegetation.

due to over-fishing. Apparently this has allowed the intermediate host snails to increase in density, thereby creating the basis for increased disease transmission. We will try to further elucidate the relationship between over-fishing, snail population density, and schistosome transmission.

Fig. 5. Bernard searches for *Bulinus globosus* in habitat at Chembe Village.

Fig. 6. *Bulinus globosus* habitat at Msaka.

## Schistosomiasis in Lake Malaŵi

There are two species of *Bulinus* that are documented to be intermediate hosts for *Schistosoma haematobium* in Lake Malaŵi, *B. globosus* and *B. nyassanus*. *Bulinus globosus* is the most important intermediate host for *S. haematobium* in Africa south of the Sahara and its role in the area around Lake Malaŵi has been known for a long time. The role of *B. nyassanus* as intermediate host, however, is a rather new discovery. In Lake Malaŵi, *B. globosus* is primarily found in protected areas with aquatic plants or stones that can function as shelter against wave action and possibly predators. *Bulinus nyassanus*, which is endemic to Lake Malaŵi, is found along open shores with sandy or gravel sediment. Transmission in the Lake occurs either in relatively well protected areas, harbors or protected bays (Fig. 4), where *B. globosus* is intermediate host or along open shorelines with sand or gravel bottoms (Fig. 1) with *B. nyassanus* as intermediate host. For transmission to occur, there must be considerable human water contact, such that schistosome eggs are introduced and miracidia can find an intermediate host and cercariae can find a final host. In addition, transmission can occur by cercariae that enter the lake via streams or rivers. This form of transmission occurs primarily during the rainy season and shortly after the rainy season most streams will

Fig. 7. Showing very high density of *B. globosus* in the stream shown in Fig. 6.

be isolated from the Lake and will form pools on the shore. These pools constitute important transmission sites as well, because they may contain water through a large part of the dry season and they constitute an important habitat for *B. globosus* (Figs. 5-7). This form of transmission may occur in many areas around the Lake. Furthermore, human water contact may be significant in these pools. In areas around the Lake, there may be other habitats that could constitute important transmission sites.

For tourism, transmission along the open shorelines is probably most important, because tourists primarily would have water contact in such sites (bathing, swimming and diving) and this is the form of transmission that is a new development in Lake Malaŵi. To date, this form of transmission has been documented only in the southern part of the Lake (Nankumba Peninsula). In this part of the Lake, *B. nyassanus* (Fig. 8) occurs in relatively shallow water (from about 0.5 m deep). In spite of the transmission, one should not desist from visiting Lake Malaŵi. Transmission is mainly restricted to areas with considerable human water contact and therefore, if water contact in areas close to villages, protected areas with aquatic plants and areas around stream or river inflows is avoided, the risk of infection is considerably reduced although not eliminated. Swimming and diving at open rocky shores and around islands with little human water contact is associated with a minimal risk of infection. The risk of infection is probably also reduced if one avoids water contact between 11:00-14:00 hr, when most cercariae are shed.

The snail fauna in the Lake (Fig. 9) is composed of several species but is dominated by species of

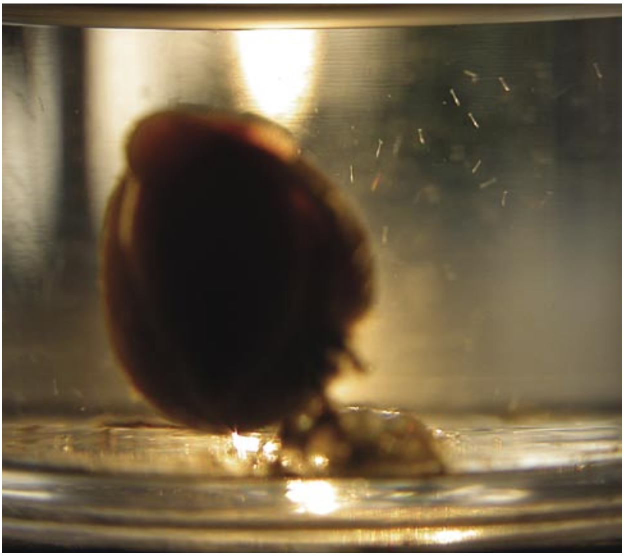

Fig. 8. *Bulinus nyassanus* shedding cercariae of *Schistosoma haematobium*.

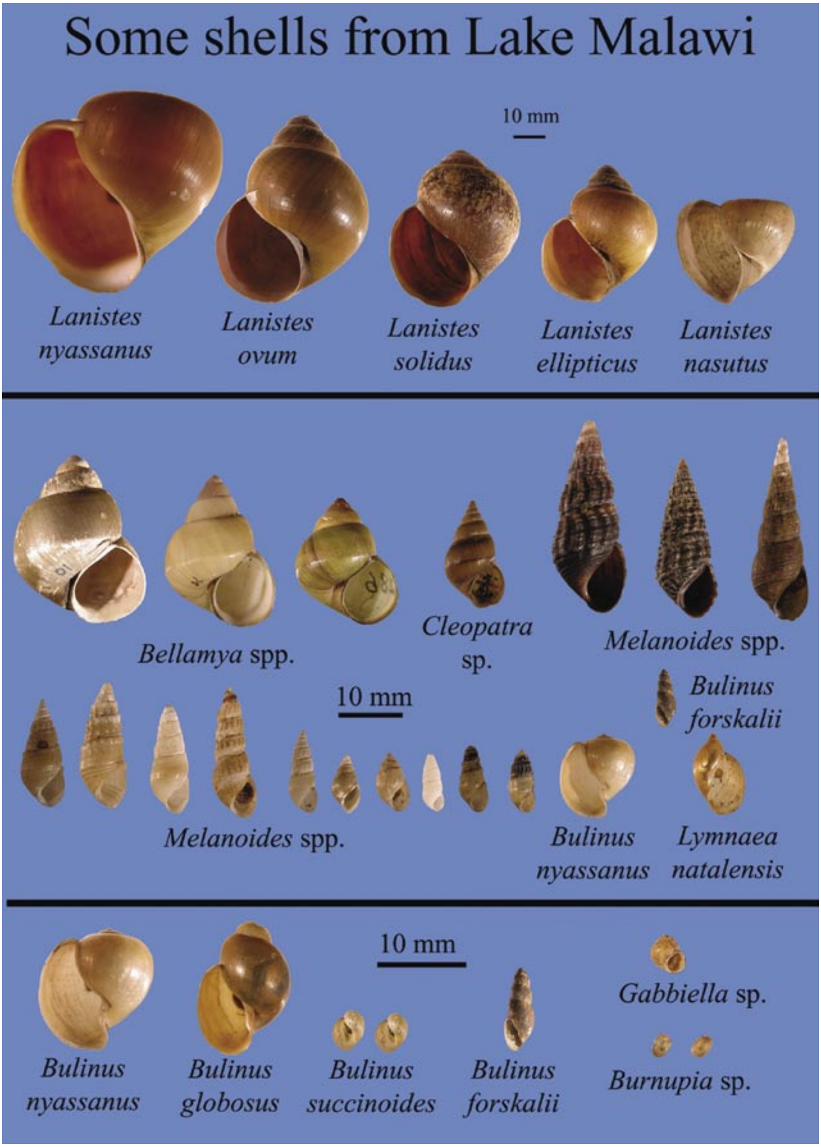


Fig. 9. Shells of Lake Malawi.

*Melanoides* (Figs. 3 & 9, 10) that in numbers constitute about 90% of the snail fauna. *Bulinus nyassanus* usually constitutes less than about 5%. These figures are obviously subject to a lot of variation from site to site. *Bulinus nyassanus* lives primarily on sand or gravel sediment and it usu-

Fig. 10. Live *Melanoides tuberculata*; very common in the Lake but has no importance for schistosome transmission.

Fig. 11. *Bulinus nyassanus* on sediment. Usually it will dig into the top sediment and is therefore often not seen.

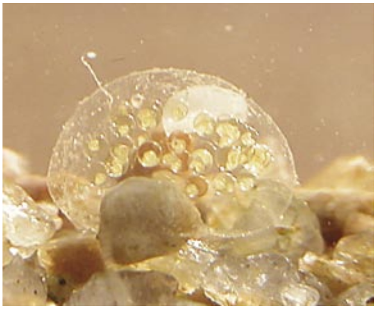

Fig. 12. Egg mass of *Bulinus nyassanus* on sediment.

ally digs slightly into the sediment (Fig. 11), where it feeds on various organic materials. The species has a very strong shell compared to other species of *Bulinus* and it probably functions as protection against the sediment and movements in the sediment during storms. The snail lays egg masses that are jelly-like (Fig. 12) so they can attach to loose sediment. The eggs will hatch after 6-8 days.

## Fish fauna in the near-shore areas of Lake Malaŵi

The fish fauna in Lake Malaŵi is unique with more than 850 species. Many cichlid species occur in the near-shore areas and most of these are endemic. As mentioned earlier, transmission occurs along open shorelines with sandy or gravel sediment. In this habitat, several species of snail eating cichlid fishes exist, one of the most important of these is

*Trematocranus placodon* (Fig. 13). Although *T. placodon* feeds on many different snail species, it prefers *B. nyassanus*. The species has highly specialized pharyngeal jaws that enable it to crush snail shells. Other species, for example *Metriaclima lanisticola,* that also feed on snails including *B. nyassanus*, do not crush the shells, but suck and pull out as much of the soft parts as possible.

Fig. 13. A male of the snail eating cichlid, *Trematocranus placodon*

Fig. 14. Stomach content of *Trematocranus placodon*. There are many shell fragments of *Melanoides* species and some almost intact shells of *Bulinus nyassanus.*

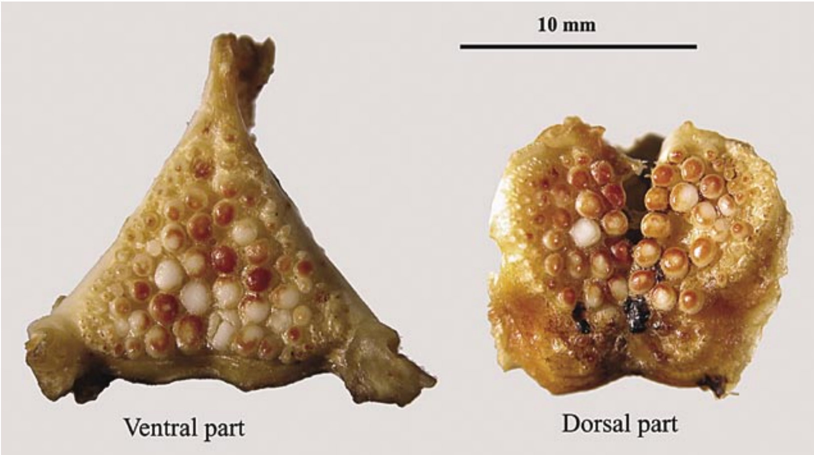

Fig. 15. *Trematocranus placodon* has special teeth on the pharyngeal bones that enable it to chrush snail shells.

## The problem to address

The near-shore areas of Lake Malaŵi are the areas where the juveniles of many fishes find refuge; thus, fishing within a zone less than 100 m from the shore is prohibited within Lake Malaŵi National Park. In fact, very fine-meshed (mosquito-net) seine nets are used directly from the shoreline. Clearly such practice will remove a large amount of juvenile fishes and therefore seriously affects recruitment into the fish population.

At the moment, we are conducting a research project (funded by the NSF/NIH program in Ecology of Infectious Diseases), where we have discovered that the reduction in fish populations is highly correlated with the increased schistosome infection in Lake Malaŵi and we predict that transmission can be reduced again if fish management is implemented.

There may be other factors involved and we are trying to address those as well. For example, why has *B. nyassanus* become important in the transmission in the southern part of Lake Malaŵi? Is it possible that the population density of *B. nyassanus* possibly because of over fishing or other environmental changes brought about by the increased human population, has reached a level where it effectively transmits *S. haematobium*? Or is it possible that visitors to the area have introduced another strain of the parasite that can utilize *B. nyassanus* as an intermediate host?

Since transmission along the open shorelines may be linked to reduced fish numbers, we should be able to reverse the situation by protecting the fish population. At the moment, we have been following fish and snail populations for 3 years and Chembe Village is now trying to ban fishing in the near-shore area. Activities required to mobilise people to implement the ban are coordinated by one of us (PM) with help of extension workers in the area.

Fig. 16. Beach seining at Msaka.

## Recommendations for visitors to Lake Malaŵi

Adhering to the following simple guidelines will minimise (but not necessarily eliminate) the risk of schistosome infection. Following visits to Lake Malaŵi, be aware of fatigue or flu-like symptoms, and consult a medical doctor for an examination.

Avoid water contact in harbour areas and other protected areas of the Lake where local people have water contact.

Avoid contact with water in streams and ponds behind the shoreline, as these habitats are potential high-risk transmission sites (as they are in most other African countries).

Avoid water contact close to inflowing streams. During the rainy season, avoid water contact close to villages, as most will have such streams in their vicinity.

Swimming and diving in the Lake 200 m (and probably even 100 m) away from the shore would result in minimal risk of attracting schistosome infection, even outside village areas where transmission occurs. Along isolated shorelines, swimming and diving from the shore should not result in exposure to schistosome cercariae.

Have a medical examination for schistosome infection performed about 2 months after visiting Lake Malaŵi. A schistosome infection should not remain untreated.

# Appendix

## Human Schistosomiasis

### Life cycle and distribution

Schistosomiasis (=bilharziasis, =snail fever) is a disease caused by parasites of the genus *Schistosoma* and is widely spread in many countries in Southeast Asia, Middle East, Africa, and South America. The World Health Organization estimates that about 200 million people are infected worldwide.

The parasite changes hosts during the course of its life cycle, i.e. between the final host (humans), where the sexual reproduction occurs and the intermediate host (certain species of freshwater snails), where the asexual reproduction occurs. The adult parasites live in the blood vessels of the final host where they lay characteristic eggs (Fig. 18) which penetrate the wall of the blood vessels and make their way into either the intestine or the bladder depending on the schistosome species. If the egg enters freshwater they hatch to a miracidium which within a few hours should locate and infect a suitable intermediate host snail. Within the snail, it produces a mother sporocyst which in turn starts to produce daughter sporocysts and these will migrate to the digestive organ of the intermediate host, where they will start to produce the infective larval stage, cercariae (Fig. 17). Under optimal temperature conditions this process will take about 4-5 weeks. Cercariae are liberated from the snail and they should, within a few hours, find and infect a final host; otherwise they will die. Upon penetration of the final host the cercarium looses its tail and becomes a schistosomulum, which will find its way to the lymph system, lungs and its final position in the blood vessels around the intestine or urinary bladder (depending on species).

Fig. 17. Schistosome cercarium (about 0.4 mm long).

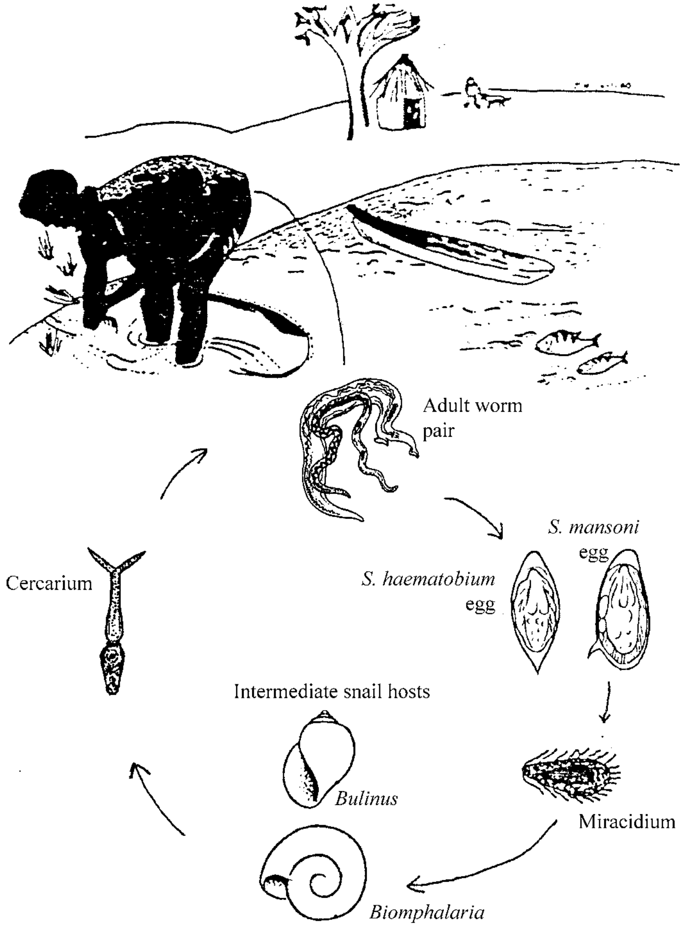


Fig. 18. Life cycle *Schistosoma haematobium* and *S. mansoni.*

There are five species that infect man and each uses certain species of freshwater snails as intermediate host. In Africa, the most widely distributed species are *Schistosoma mansoni* that causes intestinal schistosomiasis and *S. haematobium*, urinary schistosomiasis. *Schistosoma mansoni* utilizes different species of *Biomphalaria* as intermediate hosts and *S. haematobium* uses certain species of *Bulinus* as intermediate hosts. *Schistosoma mansoni* is found also in South America and some of the Caribbean islands. In Asia, *S. japonicum* is the most distributed species and it uses various subspecies of *Oncomelania hupensis* as intermediate hosts.

## Disease and symptoms

The disease (with clear morbidity) only develops in people that are heavily infected and is rarely seen in tourists or other short-term visitors to endemic areas. The clinical symptoms are related to the parasite life cycle. Within 24 h after the parasite's penetration of the skin, patients can develop rashes and itching which can last for 2-3 days. During parasite migration through the host tissue, symptoms such as fever, diarrhea, coughing and swollen lymph nodes often develop. These reactions are acute and often start 2-3 weeks after the initial infection and can last for 1-2 months. However, it it is the host's response against the schistosome eggs that causes the most serious complications, and these are directly related to the level of infection (number of worm pairs).

For infection with *S. mansoni*, bloody wounds in the stomach and intestinal system caused by histolytic enzymes liberated by the eggs, often develops. In the liver, eggs trapped in the capillaries will cause an inflammatory reaction due to the formation of blood cell containing tissue (granulomes) around individual eggs and the subsequent development of connective tissue, obstruction of the blood vessel and increase in blood pressure in the big liver blood vessel (vena portae). The body compensates for this by a gradual dilation of the minor blood vessels in the liver (collateral circulation). Similar changes will occur in the blood circulation of the spleen. The parasite's eggs can be carried by the blood stream to other organs such as the lungs and the central nervous system.

For infections with *S. haematobium,* accumulation of eggs in the wall of the ureter and the urinary bladder is often associated with inflammation, granuloma formation, fibrosis and loss of elasticity of the bladder wall and an increased pressure in the ureter and kidneys. Pain in connection with urination is common and cancer in the bladder wall can develop.

A common and clear symptom of infection with *S. haematobium* is bloody urine. Similarly, bloody stool is a common symptom of infection with *S. mansoni* and other intestinal schistosome species. Other symptoms may be an enlarged liver and spleen resulting from the increased blood pressure in these organs.

## Epidemiology

People become infected when in contact with water in which cercariae are found. Transmission is often very focal and primarily occurs in places with intense human water contact. In areas with an abundance of good snail habitats and high human population density, such as for example irrigation schemes, transmission can be very intense, but also natural habitats (streams, ponds, lakes) with intense human water contact can be important. The intermediate hosts are not normally found in fast flowing water but in areas with human water contact suitable microhabitats for the host snails may be found.

## Treatment

There is today an effective medical treatment for schistosomiasis. The treatment is by 40-60 mg praziquantel per kg body weight depending on age and species of the parasite and it is given either as a single dose or split into halves given 6 hours apart. Medical treatment not only reduces the worm load dramatically but also results in a significant reduction in morbidity suffered from the infection. In endemic areas, people quickly become re-infected, although morbidity takes longer to reappear, and therefore it is desirable to supplement with other means of reducing transmission such as control of the intermediate hosts, information campaigns, and improved water supply and sanitation.