Control of Schistosomiasis

A Practical Guide for Irrigation Development

(TDR Project R5837)

A J Thomson
M Chimbari, Dr S K Chandiwana, B Ndlela
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Report OD/TN 78
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HR Wallingford

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Summary

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Schistosomiasis is a parasitic disease and a major health problem in parts of Africa, South America and Asia where it is endemic in many countries.

Freshwater is required for several parts of the life cycle of the schistosome parasite and, as a consequence, this disease can be a major problem where freshwater resources are being developed. In particular, there is concern over the increased transmission of schistosomiasis linked to irrigation projects. This has led planners, design engineers and other decision makers involved in these projects, to seek guidance on how they can contribute to controlling this disease.

In a research project, based at the Mushandike irrigation scheme in Zimbabwe, an assessment was made of the extent to which engineers and planners, in cooperation with health professionals, could control the transmission of schistosomiasis through careful design and operation of the irrigation works and domestic facilities.

In the first section of this Technical Note, which follows from the assessment, each part of the Schistosome life cycle is illustrated and described. Where possible, simple terms have been used and jargon reduced to a minimum.

In the second section, the available control measures which can be targeted at each part of the schistosome life cycle, are explained. In particular, the control measures which design engineers and planners can incorporate into the basic design and operation of the irrigation system, are described in some detail.

Finally, recommendations are made to assist all those involved in irrigation projects to take actions for the control of this debilitating and widespread disease.

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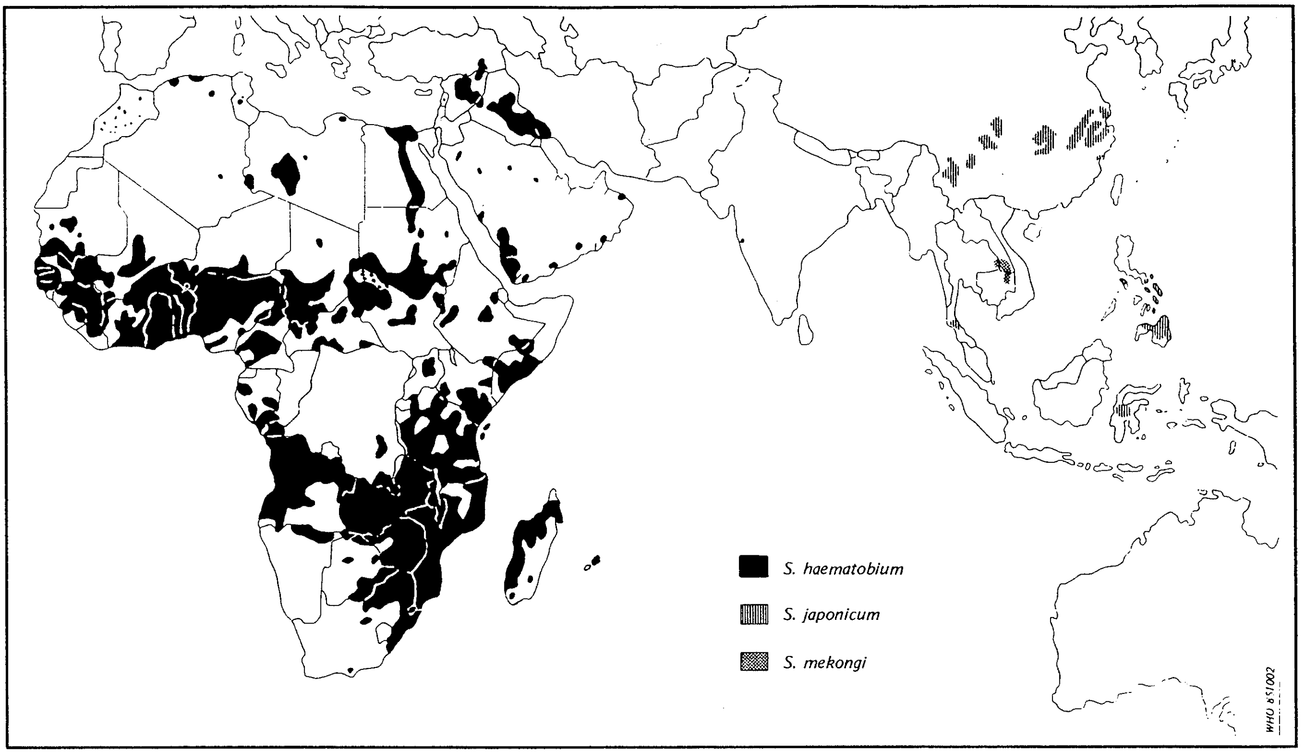


Figure 1 **Global distribution of schistosomiasis due to *Schistosoma haematobium*, *S. japonicum* and *S.mekongi***

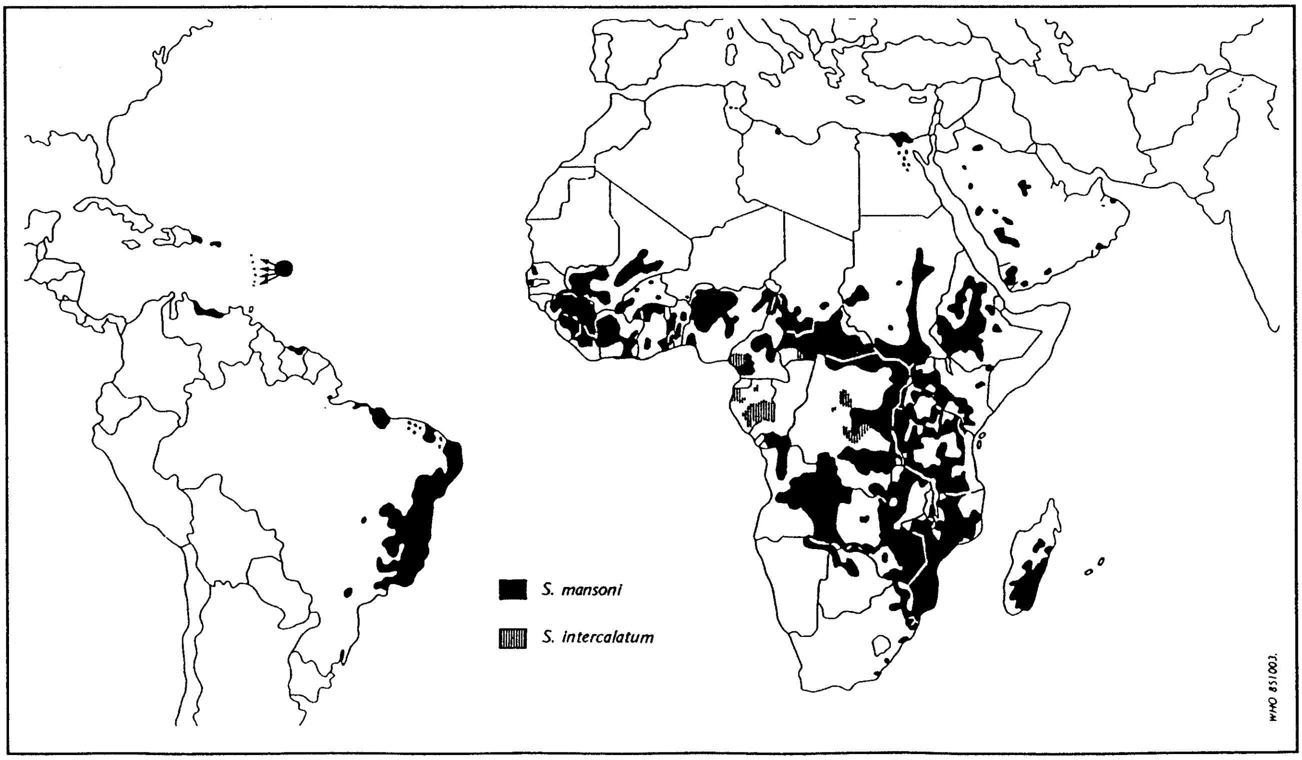


Figure 2 **Global distribution of schistosomiasis due to *Schistosoma mansoni* and *S.intercalatum***

1 Introduction

Schistosomiasis, commonly known as bilharzia, is a parasitic disease of man, other animals and birds caused by trematode worms of the genus *Schistosoma.*

There are eighteen species of *Schistosoma* known but only five are considered important parasites of man. *Schistosoma haematobium*, *S. mansoni* and *S. japonicum* are the most important and widespread, while *S. intercalatum* and *S. mekongi* have a more localised distribution. Other species such as *S. mattheei*, which are normally confined to domestic and wild animals, are known occasionally to infect man.

Schistosomiasis is currently endemic in 75 countries where it is estimated that 200 million people are infected. Figure 1 shows the global distribution of Schistosomiasis due to *S. haematobium, S.japonicum* and *S. mekongi*, while Figure 2 shows the distribution due to *S. mansoni* and *S. intercalatum.*

In the past decade, the problem of Schistosomiasis has been increased by water resources development projects in countries where Schistosomiasis is endemic. The projects, particularly those associated with irrigation, have created suitable habitats for snails and increased exposure of humans to potentially infected waters. This situation is likely to continue as more dams are constructed to store water, which is becoming a scarce resource.

From Figures 1 and 2, it can be seen that major concentrations of Schistosomiasis are to be found in Africa. These Guidelines follow from research work carried out in Zimbabwe. They are relevant, not only to other parts of Africa, but also to other parts of the world where Schistosomiasis is a problem.

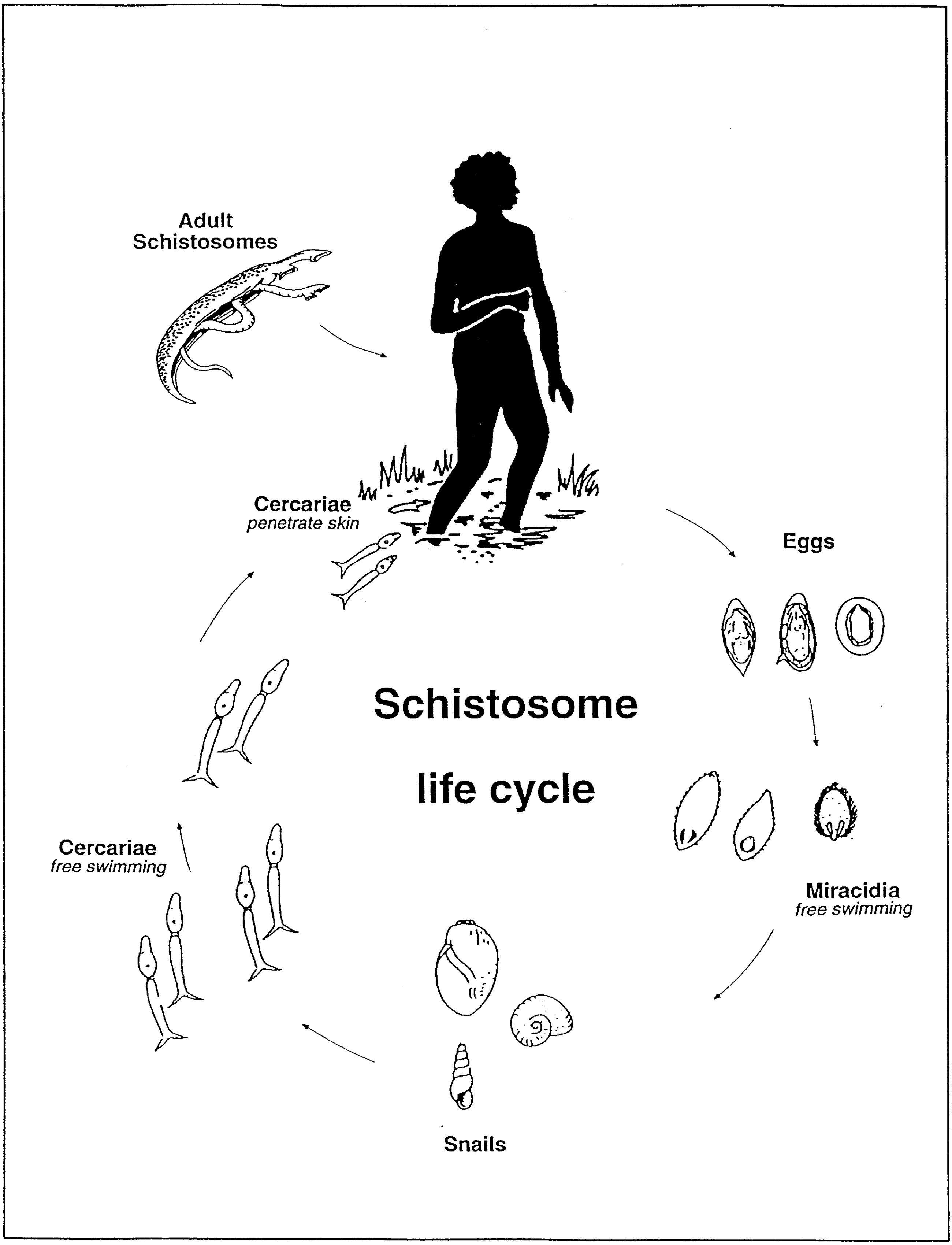


Figure 3 The Schistosome life cycle

2 Schistosome Life Cycle

2.1 Outline

- The adult schistosome worms pair off in the human host and the female produces many eggs.
- The eggs which are expelled in the urine and faeces hatch quickly if they reach fresh water.
- The early larvae which emerge from the eggs are called "miracidia".
- The miracidia swim about and seek out certain species of aquatic snails which they penetrate.
- After two stages of asexual development, within the body of the snails, another larval stage emerges. These second stage free-swimming larvae are called "cercariae".
- The cercariae swim around and seek out human hosts.
- They penetrate the skin and develop inside the body into adult schistosome worms, thus completing the life cycle.

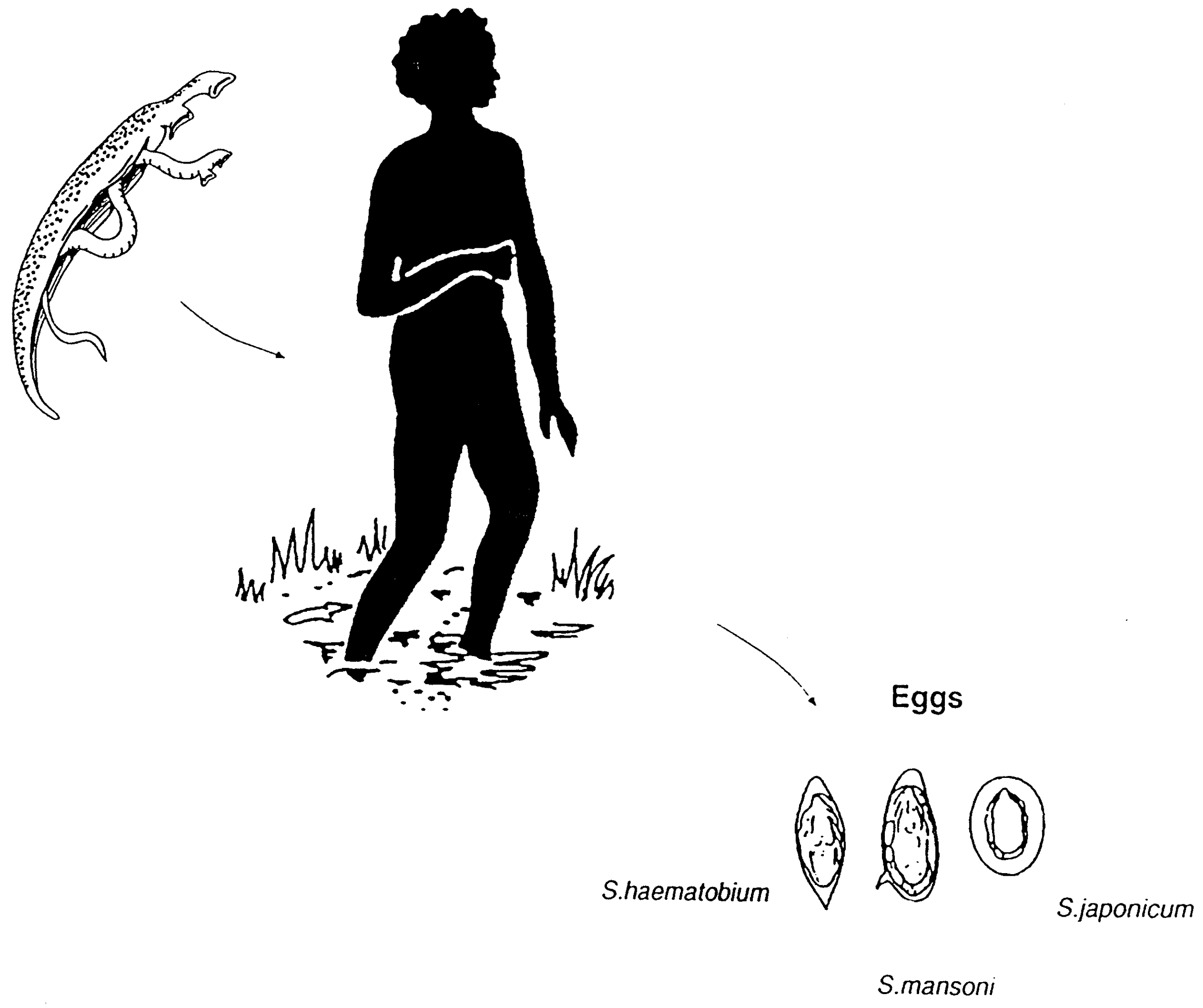


Figure 4 Adult worms to eggs part of schistosome life cycle

2.2 Adult worms → eggs

- Adult schistosome worms live in the blood vessels of man (the definitive host where sexual reproduction occurs).
- Worms that produce terminal spined eggs, e.g. *S. haematobium*, are usually found around the bladder while worms that produce lateral spined eggs e.g. *S. mansoni* are found around the rectal veins.
- Schistosome worms may live for 20 years but the average life span is 1-2 years for *S. haematobium* and 4-6 years for *S. mansoni*.
- A fully developed worm is 5-20mm long.
- The female schistosome worm produces 100-300 eggs per day throughout its life span.
- Less than half of the eggs produced by the female are excreted through urine (for *S. haematobium*) or through faeces (for *S. mansoni*).
- The remainder of the eggs stay in the body and become trapped in various organs.
- As the eggs die they calcify and damage the various organs leading to serious illness.
- Morbidity due to schistosomes is caused by eggs that fail to come out of the definitive host and not by adult worms.
- Eggs that are excreted hatch if they reach fresh water and so the life cycle continues.

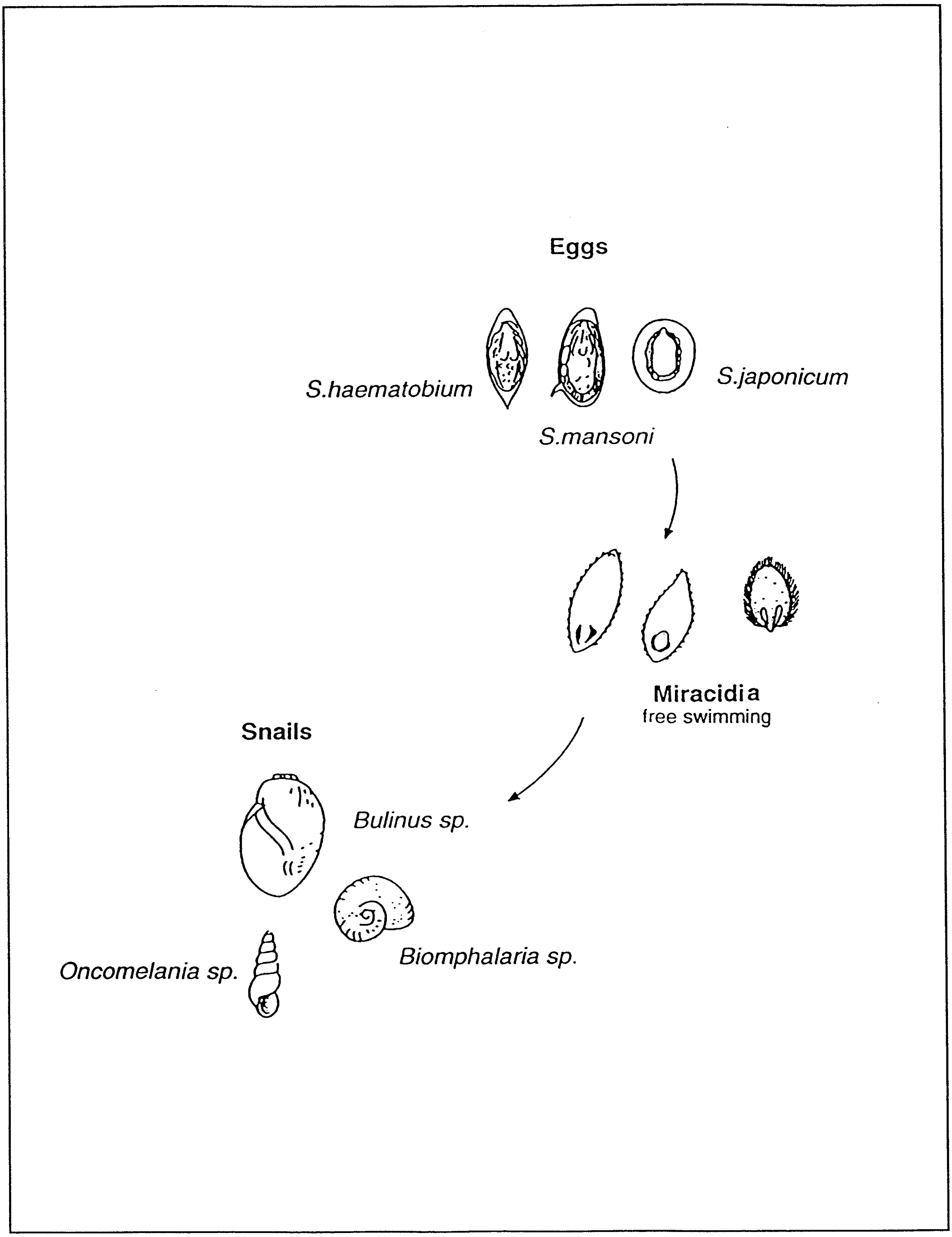


Figure 5 Eggs to miracidia to snails part of schistosome life cycle

2.3 Eggs → miracidia → snails

- Embryonic development within the eggs takes place in the human body before the eggs are expelled.

- This means the eggs are ready to hatch into miracidia, shortly after they reach fresh water.

- This first free-swimming larval stage, the miracidia, ensures transmission between humans and aquatic snails.

- Studies have shown that physical stimuli such as light and gravity cause the miracidia to move to parts of the habitat where suitable species of snails are likely to be found.

  For example, *Biomphalaria glabrata*, one of the snail hosts of *Schistosoma mansoni*, is often found close to the surface of the water, in floating vegetation or on the upper banks of canals and lakes. The behaviour of the miracidia of *S. mansoni*, in response to the physical stimuli of light and gravity, makes the larvae go to the surface where the snails prefer to be (Rollinson and Simpson, 1987).

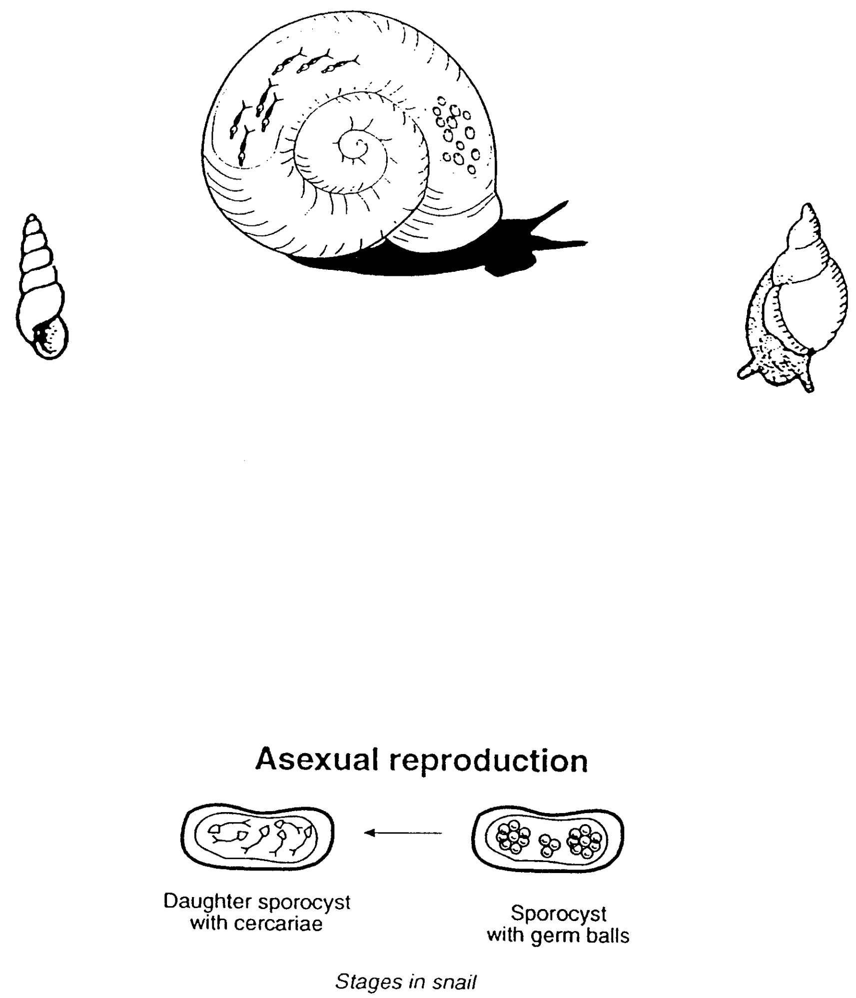


Figure 6 Development within snails part of schistosome life cycle

2.4 Development within snails

- Having found and penetrated the appropriate species of snail, the miracidia develop into mother sporocysts.

- Inside each of the mother sporocyst 'sacs', daughter sporocysts develop. Great multiplication takes place during this process. This means that for each mother sporocyst many daughter sporocysts are produced.

- After further development within the 'sacs', the daughter sporocysts become cercariae and emerge from the snail.

- The production and emergence (often called 'shedding') of cercariae in most species of schistosomes occurs daily and stops only when the host snail dies.

- Release of cercariae from snails depends on many factors such as temperature, light intensity etc. Studies have shown that for *S.haematobium*, the output for a single day can reach 2000 cercariae and for *S. mansoni* around 1500 cercariae per day.

- This means it only takes a few snails to be infected with a few miracidia for the water body to become a high risk source of disease transmission. Many cercariae will be swimming around looking for human hosts to penetrate in order to continue their life cycle.

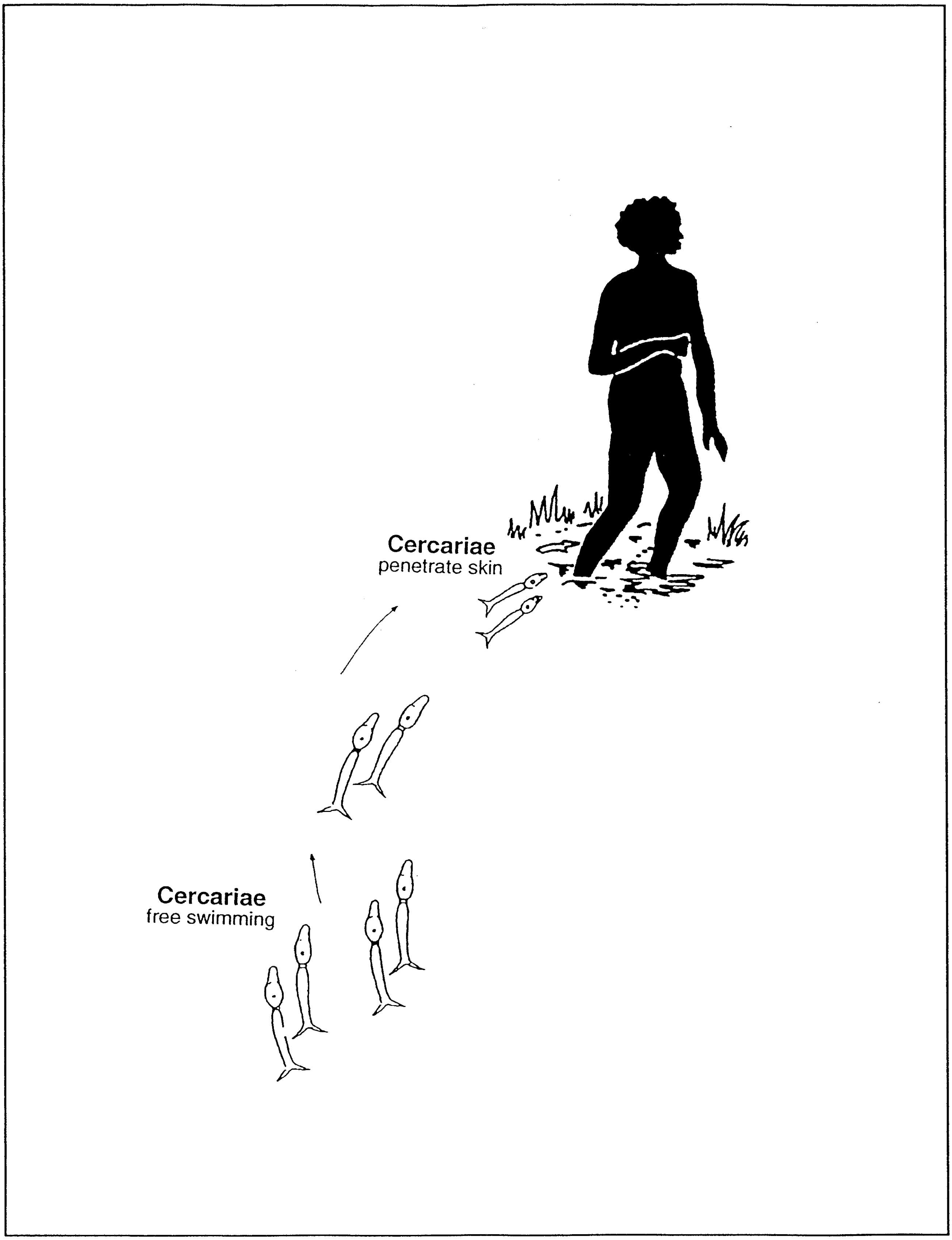


Figure 7 Cercariae part of schistosome life cycle

2.5 Cercariae

- After emerging ('shedding') from the snails, the cercariae have only a brief period in which to locate and penetrate a human host. The cercariae do not feed and live on their reserves of energy.

- The environmental stimuli to which cercariae respond by changing their activity pattern are precisely those which a human wading through water would generate, namely, turbulence, shadows and human skin substances.

- Cerariae move by vigorous wriggling of the tail, moving up and down near the water surface awaiting a host.

- If a host is encountered, penetration is effected through secretion of enzymes which are used to bore through the skin.

2.6 Migration of schistosomula in the body

- During skin penetration the cercariae shed their tails, become worm like morphologically and after this are known as schistosomula.

- They remain for around two days in the skin area. It is during this period that the schistosomula are believed to undergo a change necessary to avoid attack by the body's natural defence system.

- From the skin, the schistosomula are carried passively in the blood and lymphatic vessels via the heart to the lungs and finally to the liver.

- In the liver, worms grow and become sexually mature. The mature worms pair up and migrate to the veins around the bladder (*S.haematobium*) or intestine (*S. mansoni*).

3 Control Measures

3.1 Introduction

- Experience from a number of countries shows that the long term control of schistosomiasis is most effective when carried out within the primary health care system.

- However, schistosomiasis continues to be a major health problem where water resources are being developed, particularly those with small reservoirs and irrigation systems.

- With an understanding of the schistosome life cycle, all those involved in the planning and design of water resources projects, can incorporate measures into the basic scheme design which can have a significant effect on reducing and maintaining schistosomiasis at low levels.

- In the remainder of this publication, the current control measures available to interrupt the cycle at each vulnerable point are explained, and the parts where planners and design engineers can make a significant contribution highlighted.

- The examples given come mainly from the Mushandike Irrigation Scheme in Zimbabwe where the extent to which engineers and planners can help to control the transmission of schistosomiasis was assessed over a six year period (Chimbari et al, 1993).

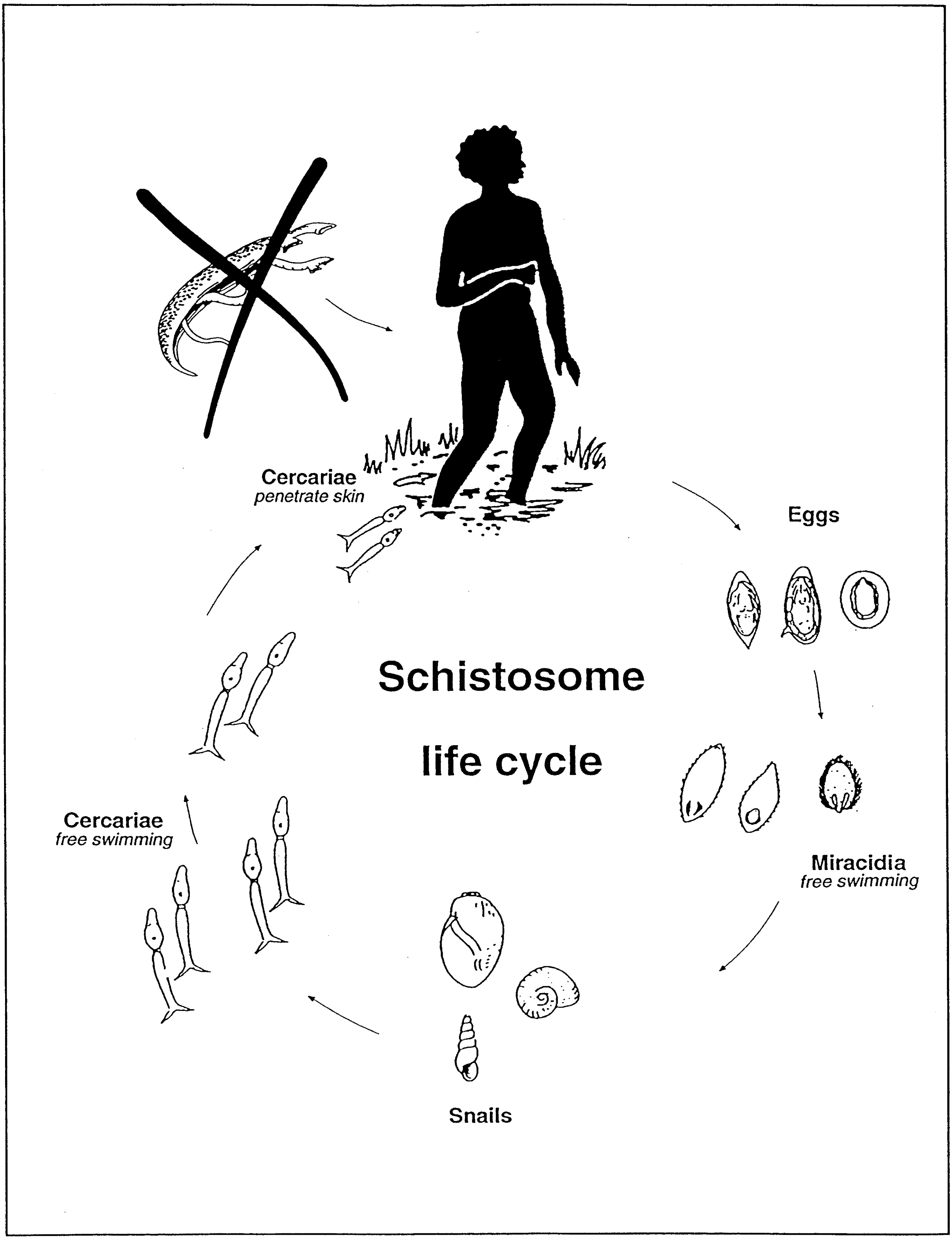


Figure 8 Part of schostosome life cycle targeted by chemotherapy -the adult worms

3.2 Adult worms and chemotherapy

- The chemotherapy of schistosomiasis, i.e. the use of antischistosomal drugs, has been transformed in recent years by the introduction of 'praziquantel'.

- This is effective in a single dose, and highly active against a wide range of trematode worms including all species of schistosomes pathogenic to humans. It is also effective in all forms of schistosomiasis, both in the acute stage and in individuals who have been exposed to heavy infection over a period of years.

- Immediately after exposure the worms contract, lose their anchorage on blood vessels, and gradually disintegrate.

- 'Praziquantel' is exceptionally well tolerated. However, in individuals with heavy worm loads, treatment may induce abdominal discomfort, blood diarrhoea, nausea, headache, dizziness and drowsiness.

- Other drugs currently in use include 'metrifonate', which is active against *S.haematobium* and 'oxamniquine', which is effective against *S.mansoni.* Other formerly used drugs have now become obsolete.

- Both 'metrifonate' and 'oxamniquine' require a course of treatment and effects, such as abdominal pain, vomiting and headache, can cause reluctance in individuals to complete the course of treatment. This is an important disadvantage compared with 'praziquantel', which is effective in a single dose.

- While chemotherapy treatment is effective at the time of administration, it has little residual effect. This means an individual can be successfully treated but if he or she comes into contact with cercariae infested water again then reinfection is likely to occur.

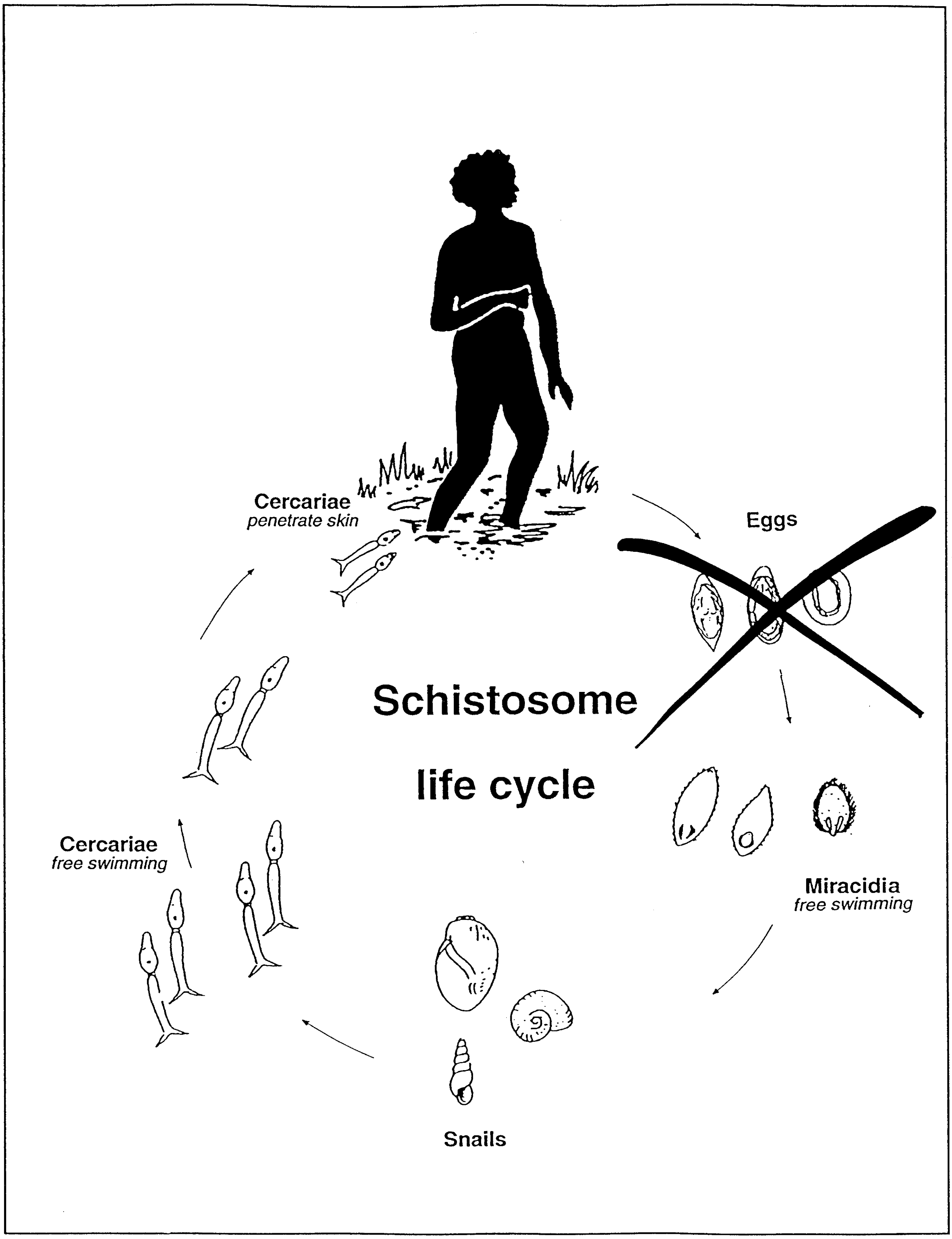


Figure 9 Part of schistosome life cycle targeted by improved sanitation - preventing eggs reaching water

3.3 Eggs and sanitation

- As schistosome eggs leave the human body in urine or faeces, good sanitation practices play a vital role in interrupting the cycles at this point.

- Many other important infectious diseases are also associated with human excreta. Some of these diseases rank among the chief causes of sickness and death. Therefore the disposal of human excreta is of the utmost importance in the protection of the health of any community. This is true in both developing and developed countries and across all climatic zones.

- In many rural areas of developing countries, where water is scarce, the method of disposal adopted is often pit latrines.

- Much developmental work has been carried out in recent years, especially in Zimbabwe by the Ministry of Health at its Blair Research Laboratory, in order to improve on the conventional pit latrines which can smell rather badly and are usually infested with flies and other insects.

- This developmental work has resulted in a type of latrine known as a VIP, a ventilated pit latrine, commonly known as a 'Blair Latrine'.

- Blair Latrines, when properly built, are odourless and the fly problem is reduced to a minimum. They do not require water to operate, although water is required for cleaning. They are simple, and may be more dependable than many waterborne units, and are therefore valuable even in areas where water may be available.

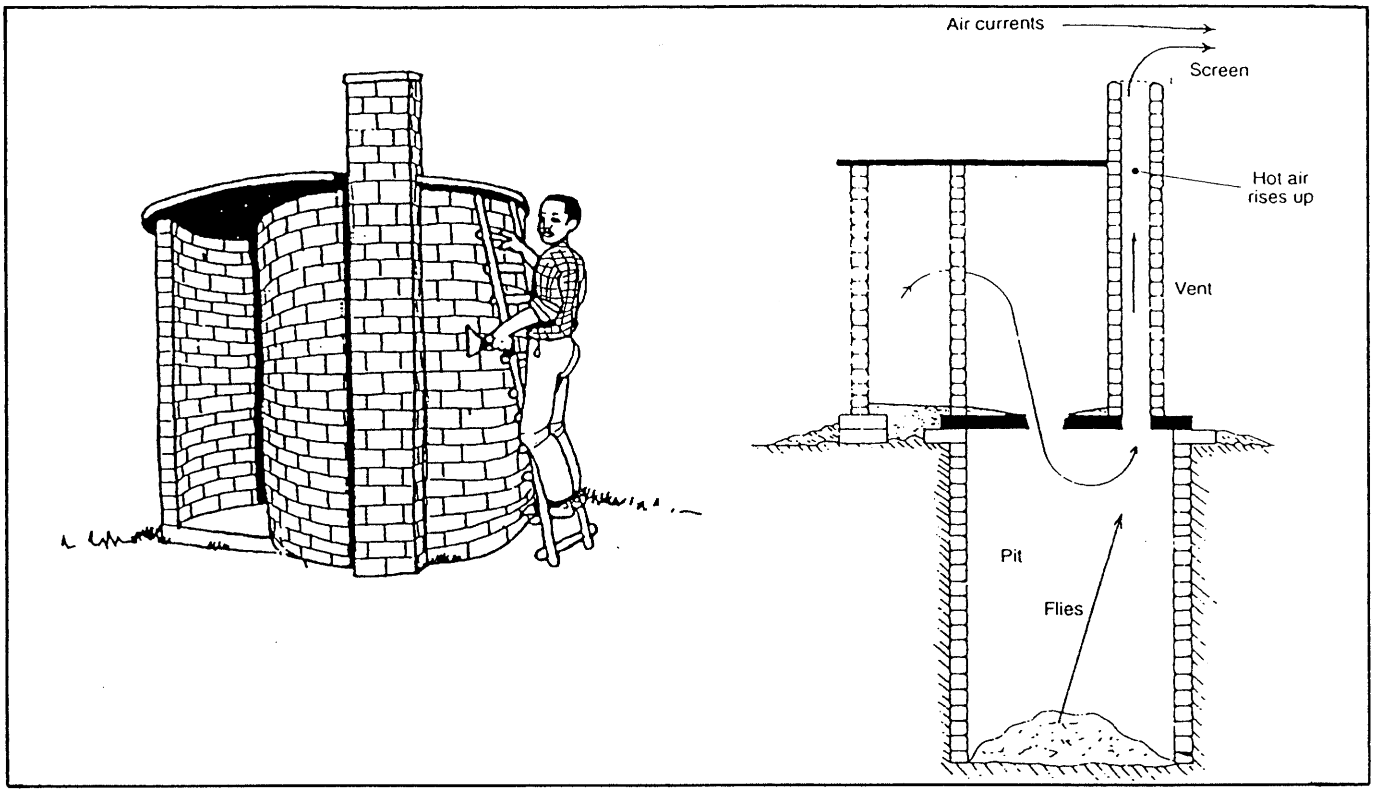


Figure 10 Blair latrine

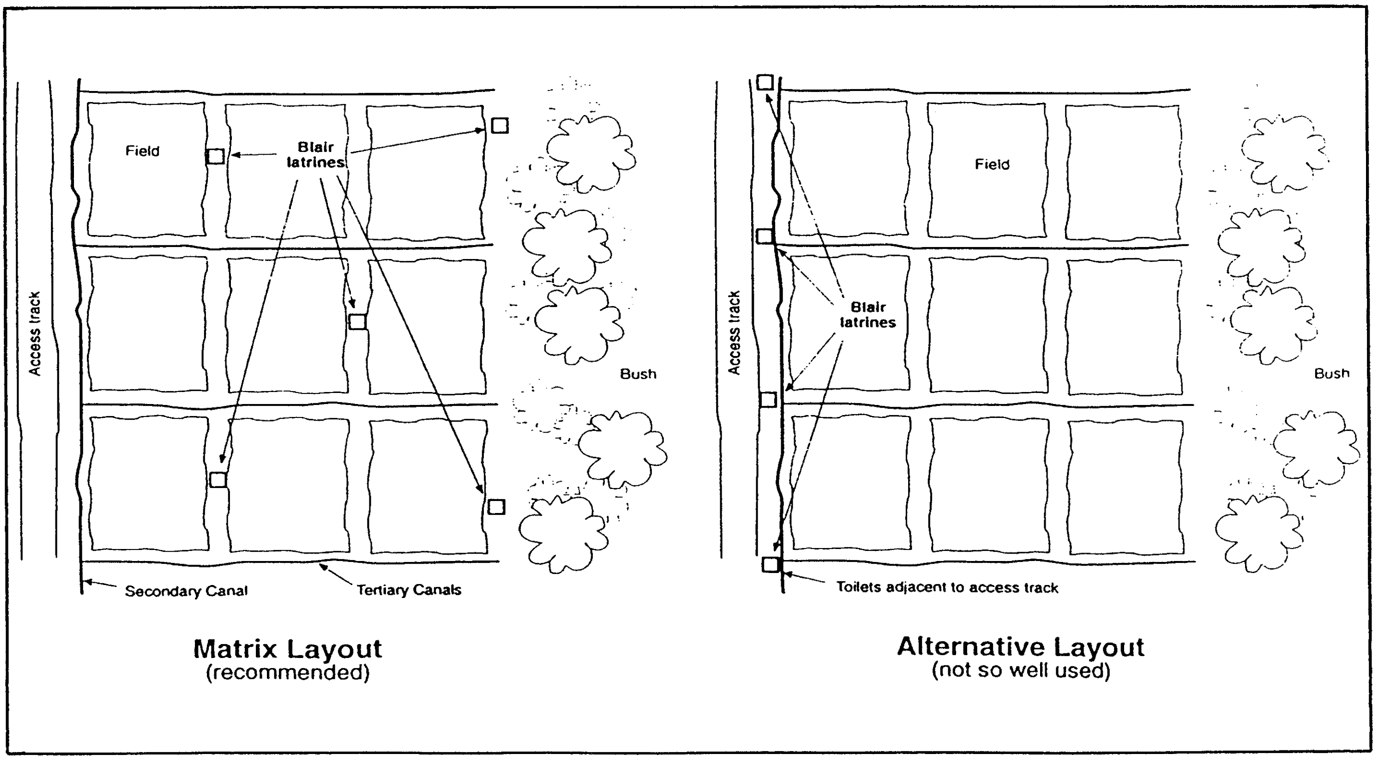


Figure 11 Alternative field layouts of Blair latrines

- At the Mushandike project, two measures were adopted to encourage good sanitation practices.

  (i) At their homesteads the farmers were encouraged to construct 'Blair Latrines'. This encouragement was through construction demonstrations and the provision of cement, reinforcement wire and fly screens to farmers who had dug an acceptable pit. The costs of constructing the latrines was borne by the farmers themselves.

  (ii) 'Blair Latrines' were constructed in the fields. This was included as a component of the basic design of the scheme. A ratio of one field toilet to every four farmers was found to be a good balance between costs and convenience of usage.

  Most farmers soon organised a rota system amongst themselves for taking turns to clean 'their' toilet.

  Of the different toilet layouts tried the matrix system, where the farmers are never far from a toilet, was found to produce the best usage and recorded a high 'satisfactory' rating in a KAP survey (Knowledge, Attitude and Practices). (Chimbari et al, 1993)

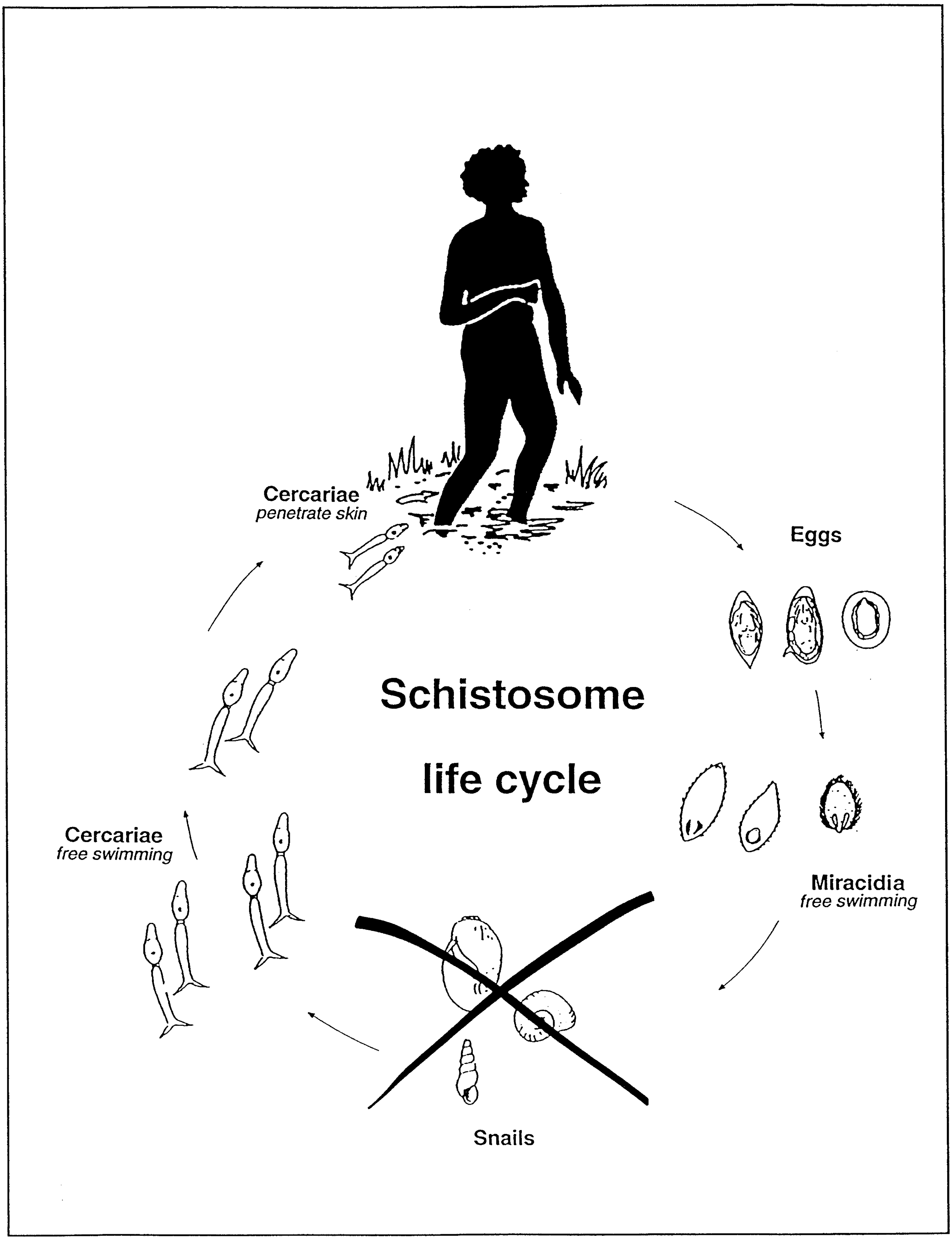


Figure 12 Part of schistosome life cycle targeted by (i) chemical, (ii) engineering/environmental, and (iii) biological control measures - the snails

3.4 Snails

Control measures aimed at reducing or eliminating the snails which serve as intermediate hosts for the miracidia $\rightarrow$ cercariae stage of the schistosome life cycle can be classified as, (i) chemical, (ii) engineering/environmental, and (iii) biological.

3.4.1 Chemical

- Many different chemicals have been used as molluscicides in the past but, at present, only one namely 'niclosamide', is commercially available.

- Although the use of 'niclosamide' can play an important short-term role in the control of snails in highly endemic areas, there are several important disadvantages. First, it is extremely expensive. For this reason it is now primarily applied only focally to known transmission sites. While this reduces chemical consumption, it increased the operational costs. Experience has shown that the man-power and transportation required for surveillance and application at the required frequency, are high. Second, it is not a selective pesticide but is toxic to fish and other aquatic life.

- With high developmental costs, and poor prospects of revenue from an insecure market, chemical companies have virtually stopped research on potential new synthetic molluscicides.

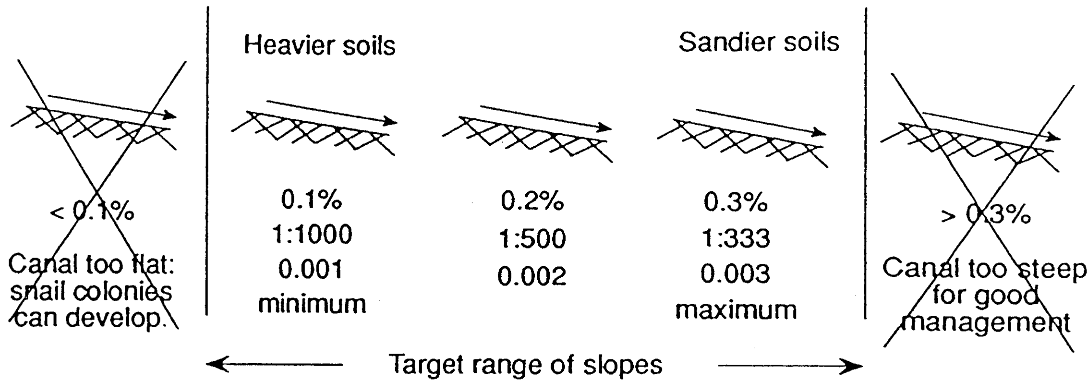
- This has stimulated an increase of interest recently in the development of plant molluscicides prepared locally and based on local plants, in particular *Phytolacca dodecandra*. The berries of this natural African plant have been found to possess molluscicidal properties.

- Validation of the plant molluscicide approach to snail control awaits further chemical, ecotoxicological and especially operational research. However, recent safety testing of *P.dodecandra* (sometimes known as ENDOD) following OECD guidelines for pre-market chemicals was satisfactory and intervention trials using ENDOD are now justifiable (Madsen, 1992).

- The main interest in using plant derived molluscicides are the possibility of spending less foreign currency (on expensive 'niclosamide') and of incorporating snail control into community based health care programmes.

Canal Slopes

Lined canals



Constraints on gradient are:-

Lower limit - maintain velocity at or above 0.5m/s in order to discourage growth of snail colonies.

Upper limit - maintain velocity below 1.0m/s which should ensure subcritical flow at design discharge.

This will avoid problems in controlling flow at structures, and simplify syphoning from tertiary canals.

Figure 13 Recommended canal slopes for lined canals

3.4.2 *Engineering/Environmental*

- The link between irrigation developments and an increase in schistosomiasis is now well documented. The reservoirs and canals are ideal habitats for snails, and intense human water contact in irrigation areas promotes transmission of schistosomiasis.

- With a planned increase in irrigation developments in many arid and semi-arid countries, designers and planners of such developments are concerned to find measures which can be incorporated to reduce the spread of schistosomiasis.

- Experience from the Muschandike scheme shows that, by careful design, it is possible to limit the extent of snail colonisation.

- Such measures are best considered during the preparatory phase of new irrigation developments and incorporated into the basic design. Structural changes within existing schemes may not be possible for either practical or economic reasons.

- Concrete lining of canals, especially secondary and tertiary canals downstream of night storage ponds, is recommended. This is now standard practice in a number of countries such as Zimbabwe. There are a number of advantages:

  (i) greater control over water distribution,
  (ii) reduced seepage and swamp areas,
  (iii) easier introduction of flow measuring structures,
  (iv) higher water velocities.

- In addition, there are other specific measures which can be incorporated into the design aimed at limiting snail colonisation of the canal network. These are:

  (i) free-draining hydraulic structures which permit canals to dry out when not in use,
  (ii) water scheduling which allows regular rotation between field blocks and maximises the time for each stretch of canal to remain dry.

<u>Water velocity</u>

- Although high water velocities are recommended for assisting in snail control, irrigation designers will be aware that they cannot be so high that supercritical flow results. The flow in an irrigation channel should always be subcritical.

- It is important to keep the water velocity within a range defined by an upper and a lower limit. On steep land it is necessary to use drop structures which reduce the energy of flow so as to keep the velocity below the upper limit. On flat land it is important to keep the flow above about 0.5m/s to prevent the deposit of suspended sediment and to discourage snail colonisation.

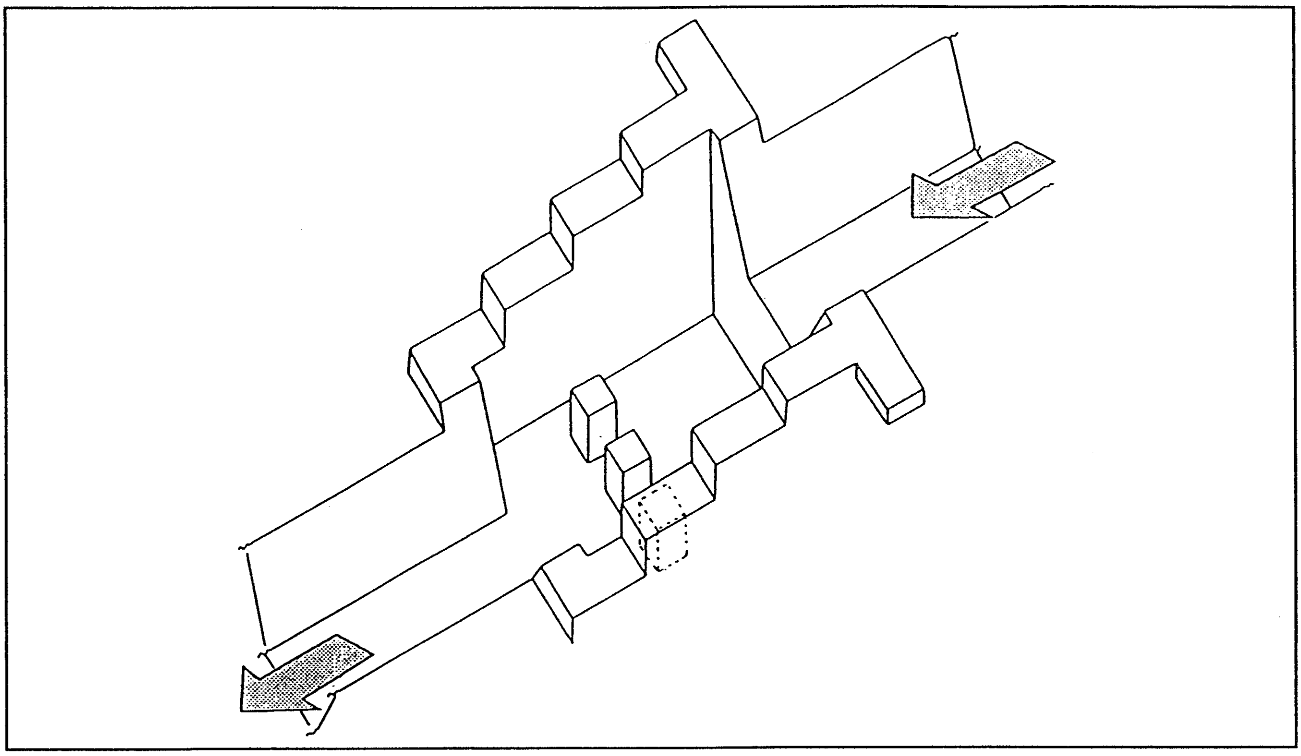


Figure 14 Free draining drop structure

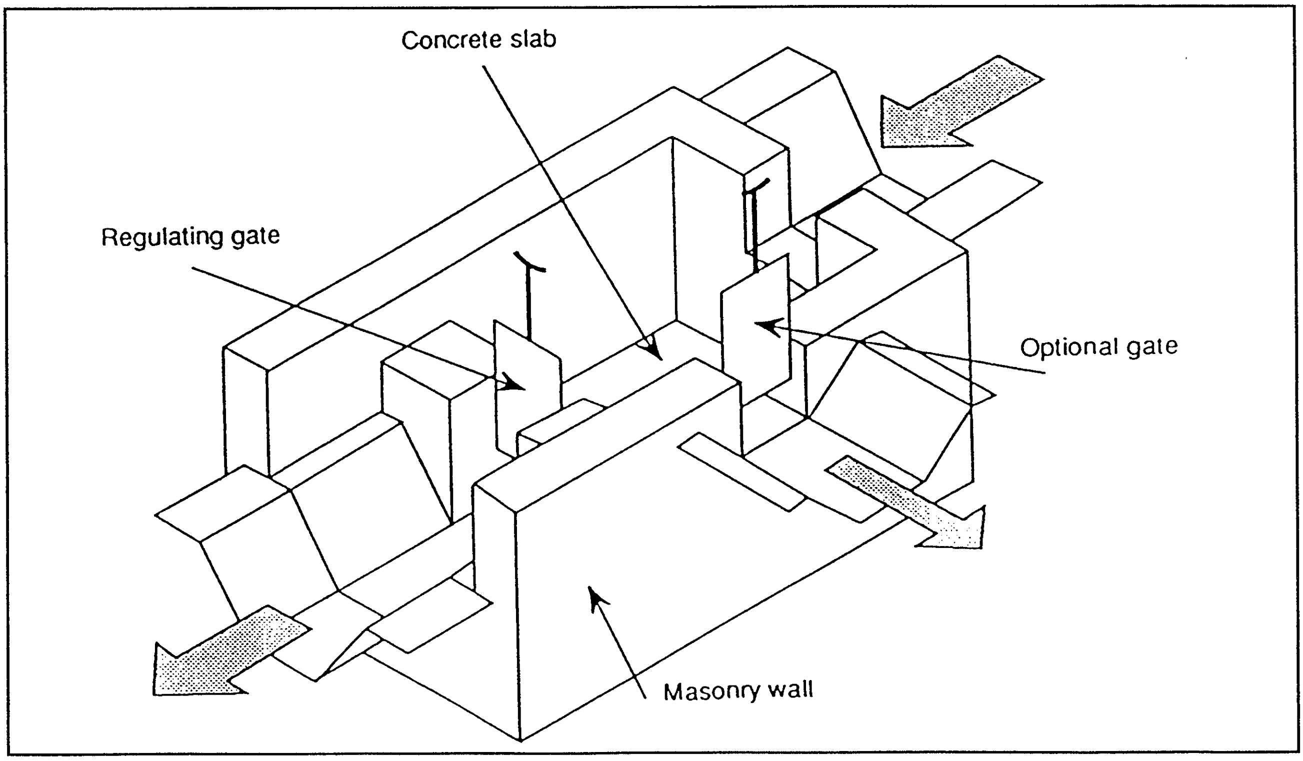


Figure 15 Free draining combined offtake and drop structure

For example, at Mushandike, a canal gradient of 0.2% was selected for the standard size of secondary canal. This gave a maximum water velocity of 0.85m/s. Since the natural land slope was 1-2%, a canal gradient of 0.2% gave rise to frequent drop structures. Despite the cost of these structures, the canal could not be steepened to reduce the number because of the danger of creating supercritical flow.

The recommended canal slopes for lined canals are given in Figure 13.

<u>Hydraulic structures</u>

- Conventional drop structures are generally designed with a sunken stilling basin to dissipate energy. This can result in a permanent pool of water. In the type shown in Figure 14 baffle blocks are used to dissipate the energy and water drains away when flow is switched to another part of the system.

- The structure shown in Figure 15 is a combined offtake and drop suitable for use on steeply sloping land, say 0.5% and above, where surplus head needs to be dissipated. By avoiding a conventional sunken drop basin design, water does not pond when the canal would otherwise be dry e.g. between rotations and at night. Also the raised weir still on the tertiary offtake avoids unintended leakage which is commonplace with gates.

- On gently sloping land where head is to be conserved, 'Duckbill Weir Offtakes' are sometimes used (Figure 16). They incorporate a gated outlet to admit or shut off flow to an offtake and a fixed duckbill weir. The long crest of the weir ensures that the flow downstream can vary over a wide range whilst the head remains fairly constant, thus maintaining a reasonably constant offtake discharge.

- Weepholes provided in the weir, if properly maintained, allow the structure to drain freely. However, in practice the holes may become blocked with weeds and other debris, or farmers, may do so deliberately to divert a greater flow into the tertiary. Duckbill weirs should not be used if it is possible to include alternative free-draining structures.

- The division box shown in Figure 17 is designed to divide flow into two or more streams of similar size or to divert the entire flow into one branch without sufficient loss of head. The outgoing canals are gated and the structure can be drained.

- All of the above mentioned hydraulic structures have been used at Mushandike and all have been found to function well except for the duckbill weir type of offtake. It was found that the drain holes frequently became blocked and water ponded resulting in snail colonisation.

<u>Culverts and Inverted Syphons</u>

- Standard pipe culverts are used to carry water flow under roads, access tracks and other obstacles. It is normal practice to design irrigation culverts for free surface flow. Thus the velocity of water in the pipe channel is not significantly greater than in the adjacent channel. Apart from reducing head losses, this means that the potential erosion damage at exit is much reduced.

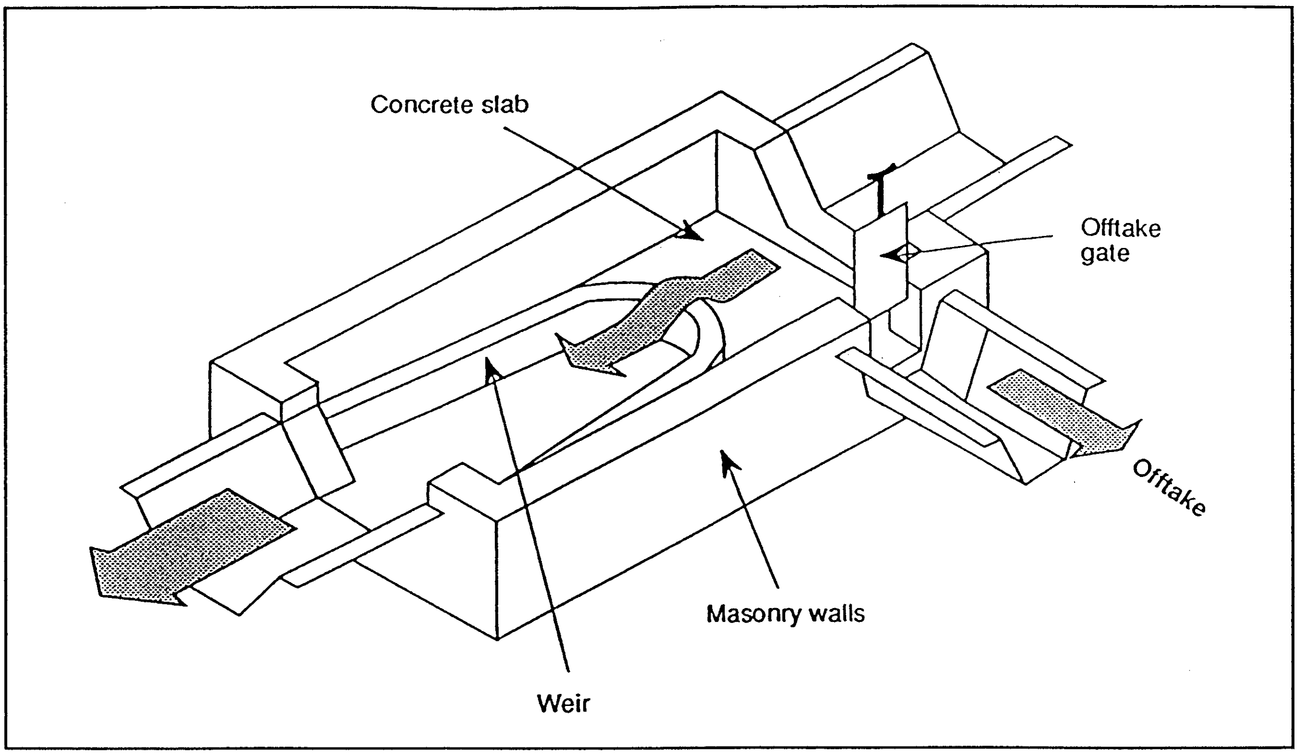


Figure 16 Duckbill weir offtake

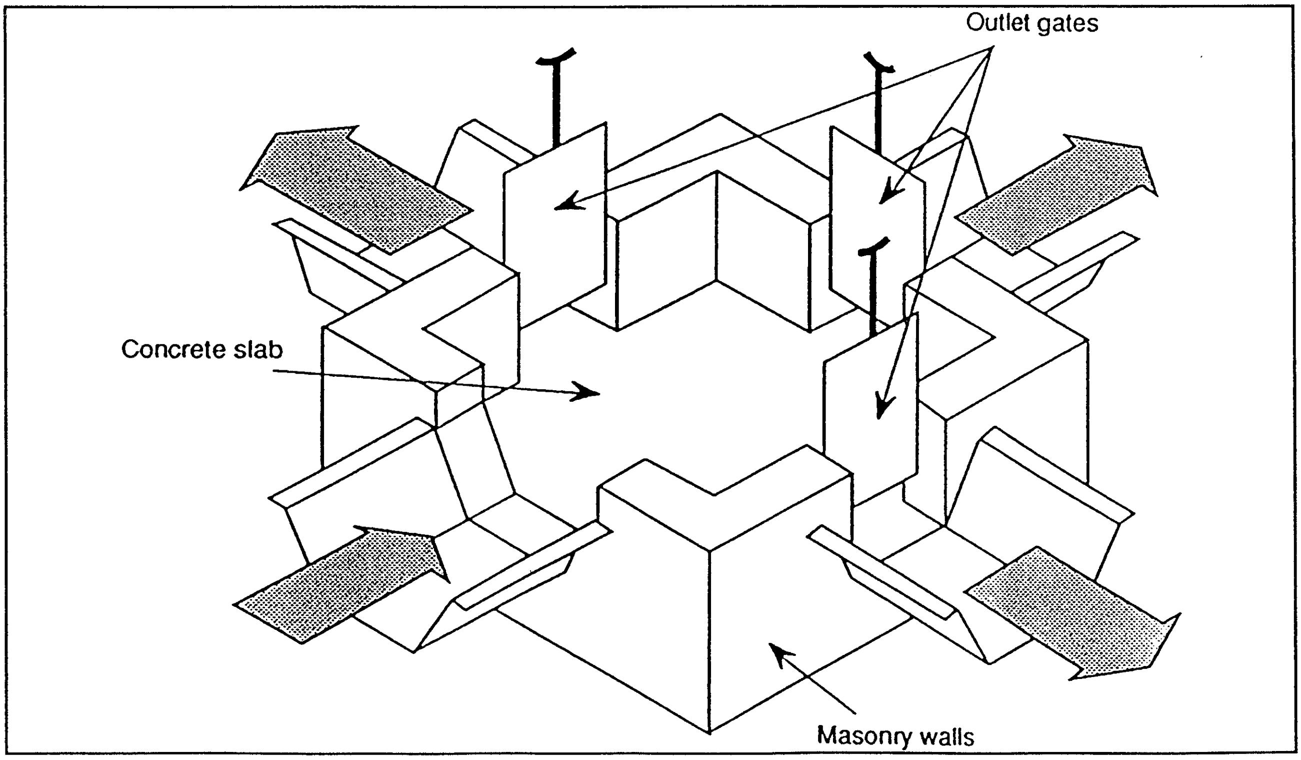


Figure 17 Division box

- Although, in small irrigation schemes, a small diameter culvert might fit the above criteria, in practice potential maintenance problems need to be taken into account. It is necessary to use a size of pipe which is not likely to become blocked by floating debris and can be cleaned of sediment and weed-growth. Long culverts of small diameter are particular problems to maintain. They may even need to be re-excavated from ground level if they become damaged.

- Inverted syphons, which are sometimes called depressed culverts or sag pipes, are culverts with a drop at entry and a rise at exit. They operate under pressure and are particularly prone to blockage by deposited sediment and weed growth. Water ponds in the syphon permanently providing, not only an ideal habitat for snails but also, an attractive site for human water contact activities. They are therefore, potential high risk transmission sites for schistosomiasis, and should not be used in areas where schistosomiasis is or may become a problem.

Water scheduling

- Downstream of main canals, the irrigation layout can be designed for rotation of supply rather than for continuous flow. By careful design and operation, the time each section of the canal system remains dry can be maximised.

- Management also needs to be as simple as possible, allowing control so that water can be distributed in the right quantities at the right time. Flexibility of operation is also important. At Mushandike, for example, the AGRITEX employees only operate the system during the working week. At times of peak irrigation demand, or when water needs to be 'made up' to farmers who have received less than their due, the system operates at night or at weekends under the control of the farmers.

- Unless the control structures and rotation patterns are simple to understand, the overall average irrigation performance is likely to suffer. Tertiary blocks should be of similar shape and size so that they will receive irrigation water for similar lengths of time. This simplifies water scheduling. The block size should be limited so that the whole block can be irrigated within available irrigation time slots. If the crop, soils or ground slopes differ between blocks or between different parts of a single block, a simple rotational schedule becomes more difficult to devise.

- The most efficient method of irrigating with syphons is where farmers can irrigate simultaneously on both sides of the canal. The water bailiff can control two or more sets of syphons working upstream of a temporary check and irrigation can proceed in step down the canal.

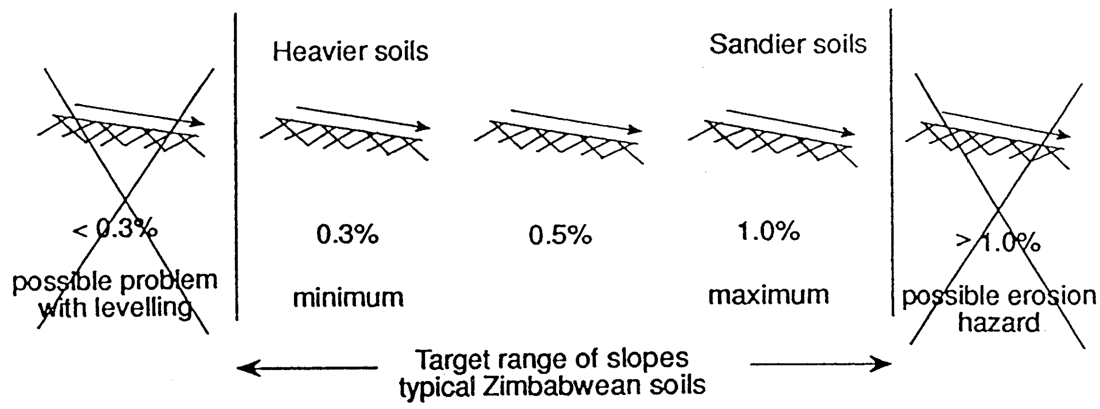
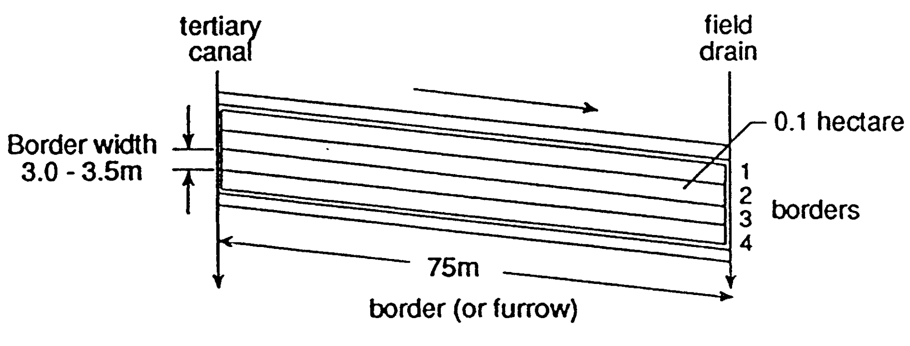


Figure 18 Practical field parameters on small holdings - field slopes

On smallholdings field lengths are mainly limited by: -

1. Total holding size
2. Non-mechanised land preparation



Holdings may vary between 0.1ha and 2.5ha on AGRITEX schemes. 0.5ha is typical. Long and narrow holdings are not practical.

A practical field length is around 75m for a range of loamy soils.

Very sandy soils are not suited to surface irrigation

Figure 19 Practical field parameters on smallholdings - field lengths

- For the preferred slopes and field lengths (shown in Figures 18 and 19 for Zimbabwe soils found at Mushandike), each furrow needs to be irrigated at a minimum rate of about one litre per second. Although the diameter of the syphons in use tends to vary (25-50mm), the smaller size is preferable as it will deliver around one litre per second. From experience at Mushandike and other irrigation schemes in Zimbabwe, farmers are able to manage not more than 10-15 syphons each, and it is difficult to coordinate the use of more than 30-40 syphons (3-4 sets). The manageable flow rate in the tertiary canal is, therefore, not more than about 40 litres per second. The optimum size of the blocks and the length of the tertiary canal are therefore determined by practical constraints.

- Provided the soil has adequate moisture-holding capacity, rotation cycles of seven days at peak time, or multiples thereof at other times, are convenient to implement and easily understood by farmers. For this reason a basic seven day rotation cycle was adopted for the Mushandike project even though some adjustment is necessary throughout the growing season to match varying crop needs.

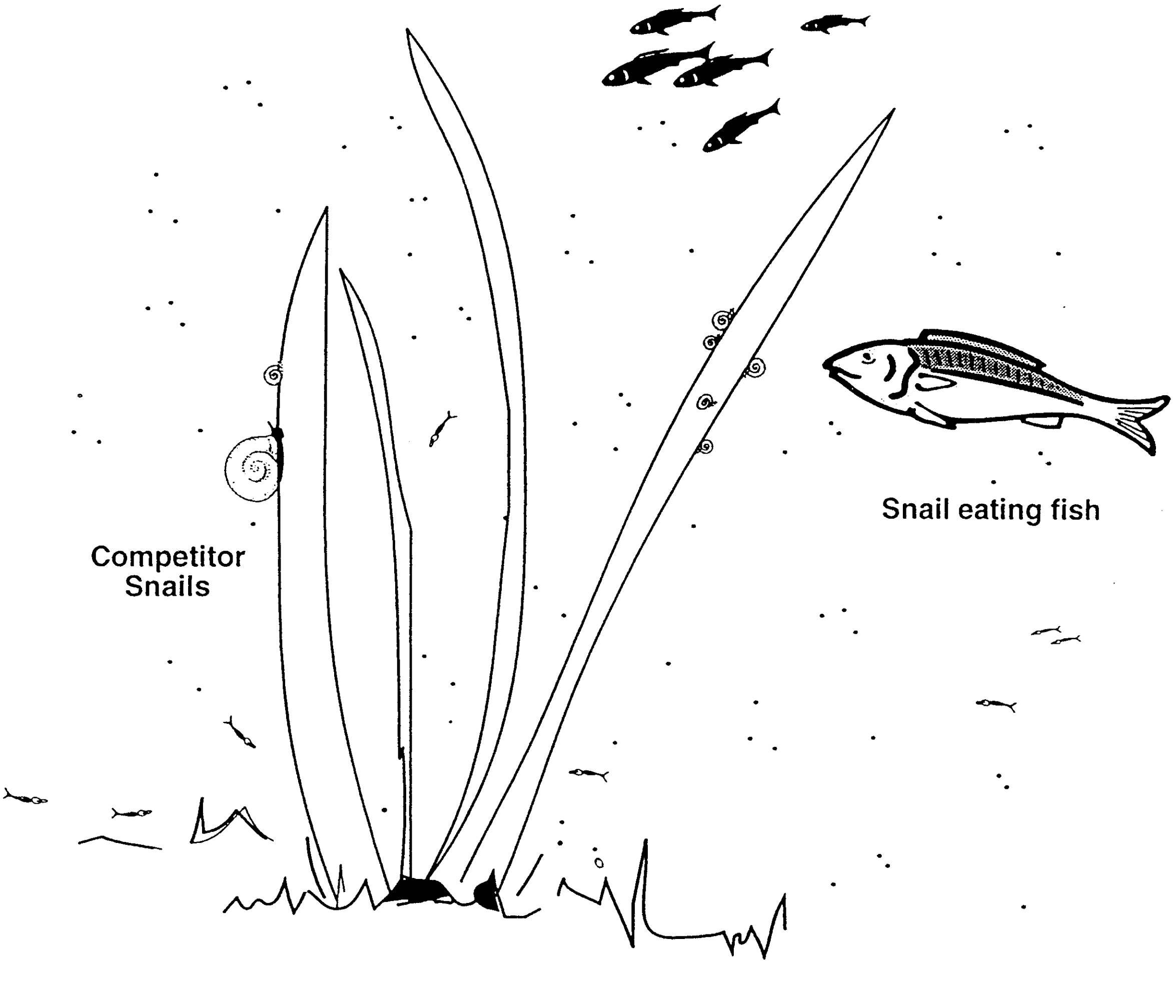


Figure 20 Examples of biological control - competitor snails and snail eating fish

3.4.3 *Biological*

- Biological control comprises the use of living organisms to reduce the density of the target species. These organisms may be categorised as predators, parasites, pathogens and competitors. Biological control in its broadest sense also includes other forms of control which are biology-based, such as genetic manipulation and fertility control.

- Biological control of the intermediate host snails of schistosomes is, at present, mainly in the experimental phase.

- Predators are active organisms which seek their food and consume a number of prey during their lifetime. Predators of freshwater snails include species from virtually every major group of the animal kingdom. Most of these, however, are predators which consume a wide range of prey. Fish predation may be an important factor in determining the distribution of freshwater snails. The potential for using snail eating fish to control schistosomiasis snails is currently being investigated in Zimbabwe.

- Parasites tend to weaken rather than kill their host. They depend on the host throughout their existence except for short periods when they disperse. Some trematode worms and, in particular, the schistosome species are, of course, the most prominent and well known parasites of freshwater snails. There are others, such as certain nematode worms, and some young leeches may develop parasitically in large snails.

- Pathogens are micro-organisms that often kill their host with subsequent liberation of millions of individual microbes. Some bacteria have been reported to be pathogenic to freshwater snails and some fungi to kill their eggs but only a few are thought to harm their hosts.

- The most promising approach in biological control, to date, is the introduction of competitor organisms which may affect the abundance of the target species through competition for common resources. Competitors of the intermediate hosts are, primarily, other freshwater snails that do not act as intermediate hosts. Other invertebrates, such as bivalves and insects have also been considered.

- The most extensively studied competitor snails are *Marisa cornuarietis, Helisoma duryi*, *Thiara granifera* and *Melanoides tuberculata.* These competitors may be effective in certain habitats. However, there seems to be the important limitation in their use that their habitat preferences only partially overlap with those of the intermediate hosts.

- The introduction of new snail species to an area should be done only after a very careful evaluation. What may seem to be an answer to one problem may result in the creation of many more problems. Introduced species may be carriers of parasites which cause diseases in humans or livestock. They may also cause damage to crops and to other non-target beneficial species. At present the World Health Organisation (WHO, 1993) does not recommend either the introduction of new snail species, or any other method of biological control of intermediate host snails.

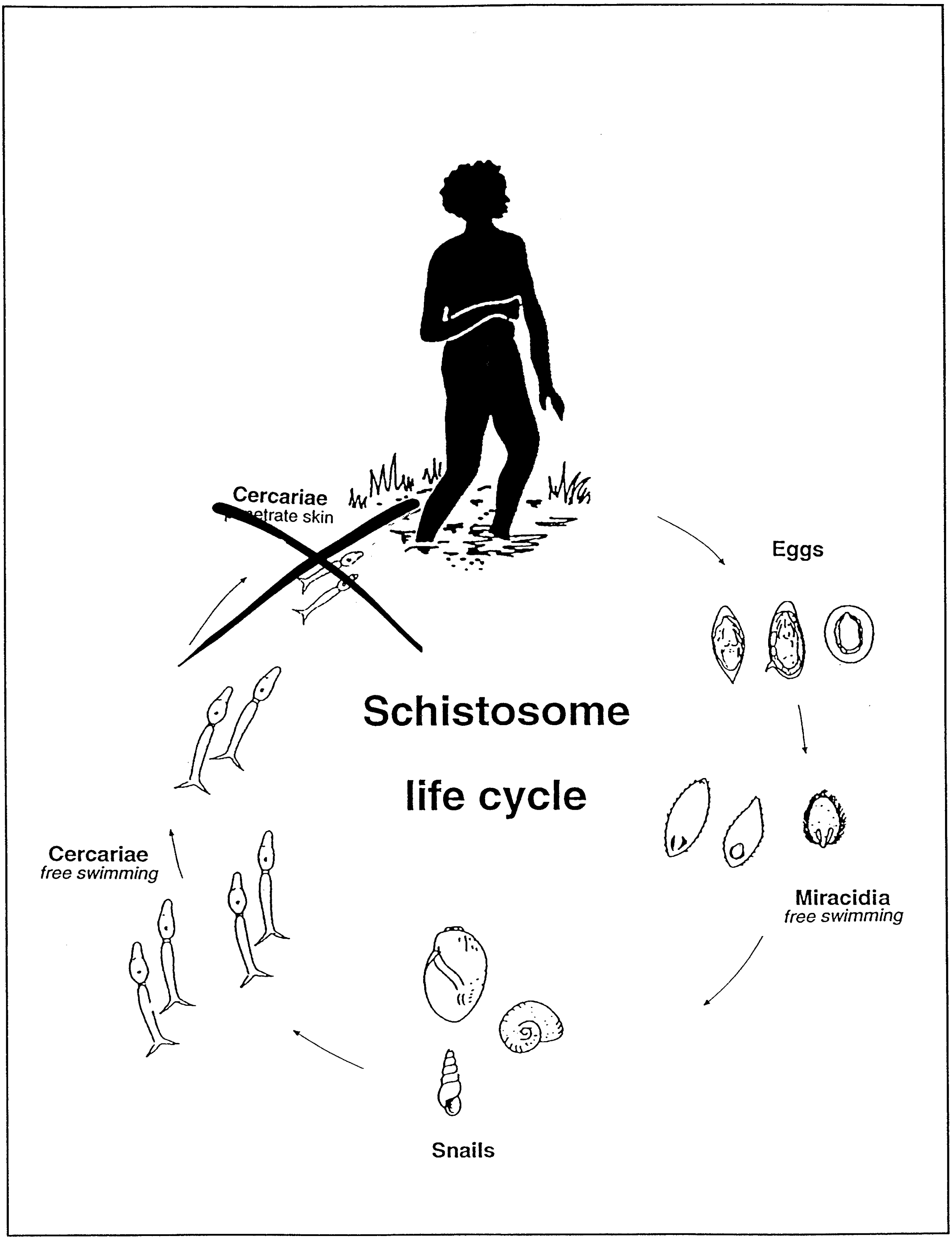


Figure 21 Part of schistosome life cycle targeted by reducing contact with potential transmission sites.

3.5 Reducing contact with cercariae infested water

- It is a simple fact that if people do not come into contact with cercariae infested water then they will not become infected and develop schistosomiasis.

- This is why it is important for planners and design engineers of irrigation developments to consider all aspects of the scheme and not just concentrate on their own particular specialisation in isolation.

- It is generally agreed that reduction in contact with cercariae infested water may be achieved principally through potable water supply and sanitation programmes backed up by intensive health education.

- However, experience has shown that, while people are careful about the water they use for drinking and cooking, for other domestic, occupational and social activities such as laundry, cattle watering, brick making, bathing and swimming (particularly among the younger members of the population), they are not so careful.

- It is desirable, therefore, for villages to be sited sufficiently far from potentially infected water bodies to discourage their use, and for water and sanitation programmes to be supplemented by the provision of snail-free water bodies suitable for sustaining recreational and domestic activities.

4 Recommendations

1. For effective control of schistosomiasis in an irrigation scheme it is necessary to consider the whole scheme and the surrounding area especially the parts close to areas of habitation.

2. At the planning stage of proposed irrigation developments, early discussions with the various agencies involved in the project should take place. This will help to

   - focus minds on water-related health problems
   - utilise respective strengths of the participating departments
   - produce the most appropriate outline plan

   The irrigation design engineers will be principally involved in the engineering aspects of the system. Their main concern is to ensure that water flows from one end of the system to the other and is available in sufficient quantity when and where required by the farmers. Usually they are unaware of water-related diseases or consider this to be outside their sphere of interest.

   The health professionals, on the other hand, may be unaware that preventive measures are available to irrigation design engineers and do not realise that their early involvement would be beneficial. For example, discussions with health professionals will make the design engineers aware of the need to avoid areas in the irrigation system where water will pond permanently. This will occur at inverted syphons, drop structures with sunken stilling basins and offtakes which are not free-draining. These parts of the irrigation system will attract people and become colonised by aquatic snails leading to the establishment of disease transmission sites. The irrigation network can usually be designed to avoid these types of structures. For example, inverted syphons are often used at junctions with access roads to avoid the need to construct expensive bridges. However, if considered at the early design phase, access roads can usually be incorporated into the overall canal network such that canal/road junctions are minimised. If a few bridges are necessary, to eliminate the need for inverted syphons, the costs can be justified by the benefits to the health of the population and the reduced loss of production due to illness from schistosomiasis.

   Other important aspects of the engineering design which have been found to contribute significantly to reducing the presence of aquatic snails are

   - concrete lining of secondary and tertiary canals,
   - where ground conditions permit, fast flowing canals,
   - water scheduling which permits each section of the canal network to periodically dry out.

3. Other decisions made at the early planning phase can also have long-lasting implications for the health of the population. The siting of villages will have a long term influence on the health of the respective populations in these villages. There is a good correlation between villages which are located sensibly from a health point of view and the low prevalence and intensity of schistosomiasis in these villages.

   Distance from potentially infected water bodies should, therefore, be an important consideration in the selection of sites for locating villages. Potential transmission sites include

   - long main canals,
   - night storage ponds,
   - pools in natural streams.

4. The provision of safe water supplies and adequate sanitation will contribute significantly to reducing infection levels and preventing contamination of water bodies with schistosome eggs. As water supply programmes tend to be implemented by other branches of government apart from health and agriculture, this is another part of the overall planning procedure where active collaboration is beneficial.

   For example, at Mushandike, decisions were taken at the planning stage with regard to sanitation which proved to be highly successful. These were

   - construction of field toilets as part of the basic scheme design,
   - encouragement of farmers to build toilets at their homesteads by the supply of cement and other materials.

5. In considering a package of control measures for schistosomiasis in new irrigation schemes, an assessment of the impact of the scheme on the environment should be made. Particular attention should be paid to end drainage areas. If drainage is inadequate, marshy areas can develop which, not only provide a habitat for snails, but can also become breeding sites for mosquitoes. If drainage is adequate, the consequences of seasonal streams becoming perennial, should also be considered. Pools in these streams can be very attractive in the hot, dry season, particularly to the younger segments of the population. Studies have shown a close relationship between age and the prevalence and intensity of infection, with the peak generally occurring in the 10-14 age group.

6. Screening and treatment of all infected newcomers to a new irrigation scheme is recommend. This should be followed by periodic testing and treatment of all those found to have a heavy egg burden. If funds are limited it is recommended that, after the initial screening, follow up screening and treatment should be targeted at school children.

5 References

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