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What role do rodents have in human snail fever?

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Abstract

Schistosomiasis, or snail fever, is a *parasitic* disease, caused by *schistosomes*, which leads to long-term ill-health and affects millions of people, predominantly across Africa and Asia. In order to reduce the impact of this disease, we have to better understand the complicated *life cycle* of the parasite and all the creatures that carry and transmit it. This is why we wanted to see whether small small mammals (like rats, mice, and shrews) spread the form of schistosomiasis that affects humans. We trapped 420 small mammals in Senegal, West Africa and tested them for the presence of the parasite. We found that mice and rats were carrying two separate species of *Schistosoma*, as well as a *hybrid* form - the offspring of different types of schistosomes, some affecting humans and some affecting animals. Our data suggest that rodents play an important role in spreading schistosomes in West Africa.

Introduction

Schistosomiasis, also known as snail fever, is the second most important *parasitic* disease affecting humans (after malaria, spread by mosquitoes). Over 260 million people are infected with the disease and the most affected region is sub-Saharan Africa. In humans, schistosomiasis damages the internal organs - particularly the liver and bladder, depending on the infecting species. It can lie undetected for many months or even years, causing long-term damage and even death.

Snail fever isn't in fact caused by snails, it is caused by *schistosomes* – parasitic flatworms (Fig.1). Like most parasites, schistosomes have a complicated *life cycle* (Fig. 2), which includes an *intermediate host* where the parasites live and multiply (they do so *asexually*) – in this case, freshwater snails. This makes it harder to understand and control the disease and to predict how it will spread and thrive.

Nonetheless, the World Health Organization has set a goal to eliminate snail fever as a public health problem across the world by 2025. The means to achieve this ambitious goal is *mass drug administration* (MDA), where drugs to prevent and target the disease are given to particularly vulnerable

Figure 1:
Magnified image of an adult pair of male and female schistosomes. The female is emerging from the male's groove! Schistosomes are parasitic flatworms that use animals and humans as their definitive (final) hosts and snails as their intermediate hosts. They enter their hosts during contact with freshwater in affected areas.

Credit: Bruce Wetzel and Harry Schaefer on Wikimedia Commons

Please see Figure 2 on Page 2

groups such as school-aged children. MDA only works to eliminate this disease if humans are the only hosts of the mature form of the parasite (the *definitive hosts*), otherwise after we stop giving the drugs, the disease will quickly take hold again. We therefore need to find out what the situation is in West Africa (and beyond)- who or what is harbouring the parasites and how are they spreading?

There are two main schistosome species which cause snail fever in Africa:

1) *Schistosoma haematobium* – scientists believed only humans serve as definitive hosts for this parasite, where it causes *urogenital schistosomiasis* (this is when the disease affects the urinary tract and genitals)

2) *Schistosoma mansoni* – affects not only humans, but other mammals as well, such as rodents and non-human primates (apes and monkeys for example), and is responsible for *intestinal schistosomiasis* (affecting the digestive system) in humans.

There are other *Schistosoma* species which infect animals only (such as *Schistosoma bovis* which mainly affects cattle). However, recent research has discovered *hybrids* (mixed breeds) between *S. haematobium* which affects only humans, and schistosomes which we thought only affect animals. All of this taken together leads us to some questions:

1) Might rodents be an alternative 'definitive host' for the form of *S. haematobium* carried by humans?

2) What if different types of schistosome can breed (known as *hybridization*) in rodents as well?

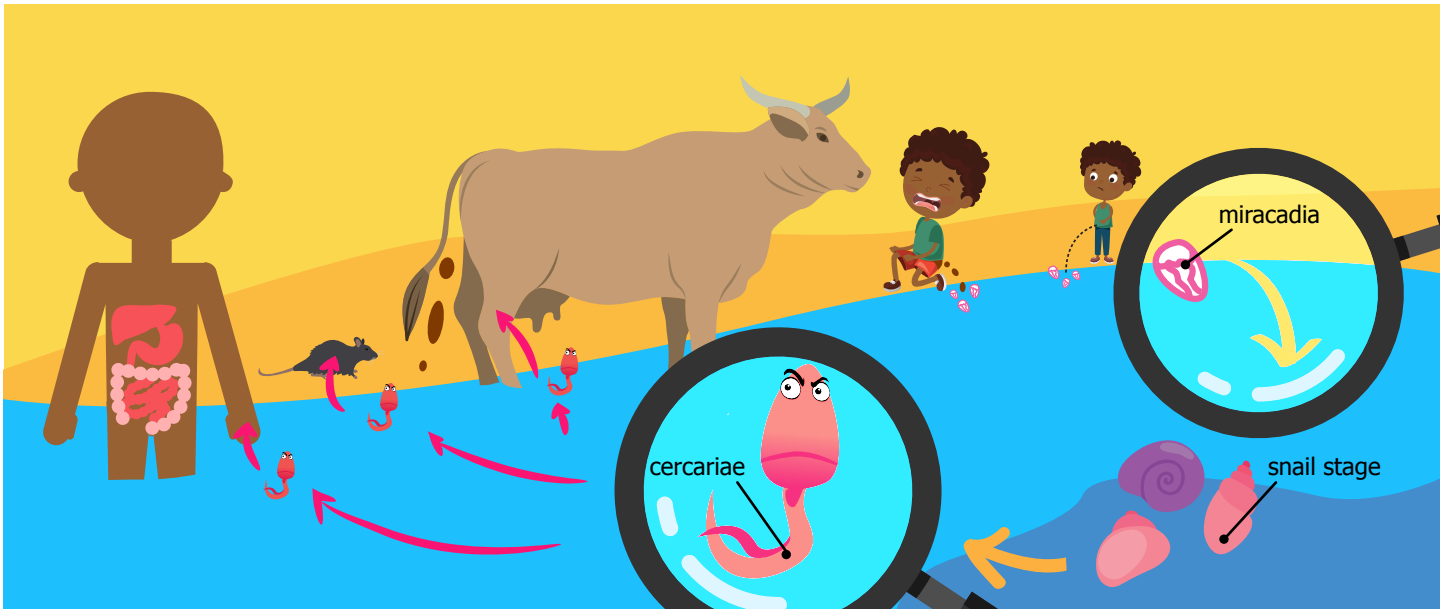

Figure 2:
The life cycle of Schistosomes.

Schistosome worms use two types of host to complete their life cycle: firstly, snails (the intermediate hosts) and secondly, mammals such as humans, cattle, or, as in our study, rats and mice (known as the definitive hosts)(Fig. 2). When infected humans or other infected host animals, urinate or defecate near water, the flatworms' eggs (which worms produce in the definitive host's body) get a ride to the outside world. In freshwater, the worm eggs hatch into the swimming larval stages called miracadia and start looking for a certain type of snail. They pierce their way into the snail's body where they multiply. They are then released as the next larval stage called cercariae which can infect humans and other animals such as rodents and cattle. Now you know why the disease is called snail fever - but it's people and other mammals, not the snails, that get the fever!

Methods

Between May 2016 and April 2017 we set live-traps near the Senegal River Basin to capture small mammals (Fig. 3). Back in the laboratory we identified every animal by species, gender and age. We then examined their organs for the presence of schistosomes. We then extracted DNA from both the adult flatworms and the larval stages. To identify the species and hybrids we *sequenced* the extracted DNA.

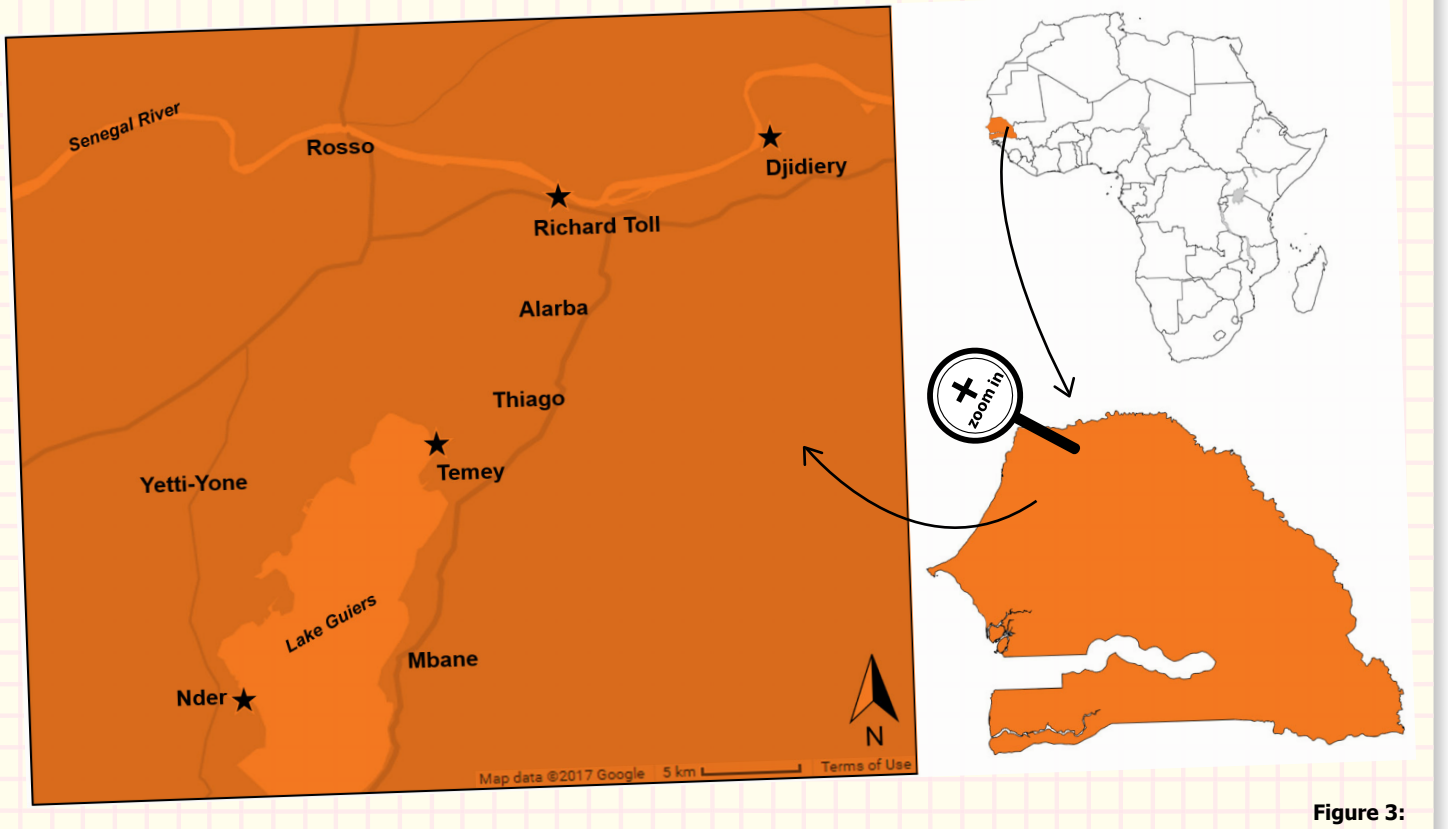

Figure 3:
The area in North Senegal, Africa, where we did our study.

Results

1) We captured a total of 420 small mammals – rats, mice, shrews and gerbils.

2) We found schistosomes in seven of the 172 mice and six of the 215 rats.

3) The parasites were present in 2 to 29% of the rodents, depending on where they were trapped (Fig.4).

4) The sequence analysis of the flatworms' DNA identified:

a. *S. mansoni* (an animal and human form) in seven mice and one rat;

b. *S. bovis* (another animal species, mostly found in cattle) in five rats

c. *S. mansoni* and a hybrid of *S. haematobium* (human form) and *S. bovis* (animal form) in one mouse

5) The sequence analysis of the larval DNA identified *S. mansoni* and S*. bovis*

6) Schistosomes were more prevalent in adult rodents than young ones.

Please see Figure 4 on Page 4

Locations	Total rats trapped	Percentage of rats infected	Total mice trapped	Percentage of mice infected
Djidiery 1	46	9	2	0
Alarba 1	28	0	7	0
Richard Toll 1	73	3	2	0
Thiago	0	0	4	0
Rosso	6	0	10	0
Djidiery 2	23	0	10	0
Richard Toll 2	0	0	8	0
Mbane	3	0	42	0
Temey	1	0	21	29
Nder	5	0	52	2
Yetti-Yone	0	0	8	0
Mbane 2	30	0	6	0

In which location was there the highest percentage of rats infected with Schistosoma? What about for mice?

Figure 4:
Percentage of rodents infected with schistosomes in our 12 study sites in West Africa.

Discussion

Our study confirms that rodents serve as an alternative definitive host of *S. mansoni*, the parasite, responsible for intestinal schistosomiasis in humans. The results also show that rats can serve as definitive host for the schistosome *S. bovis*. Moreover, we observed for the first time evidence of hybrids of human schistosome (*S. haematobium*) and livestock schistosome (*S. bovis*) in rodents. This means that both humans and rodents can be definitive hosts of human schistosome hybrids in West Africa.

These results suggest that schistosome species and hybrids adapt successfully and can use different types of hosts. This makes us believe that wild rodents (and perhaps other wildlife) in West Africa play an important role in spreading snail fever to humans in maintaining the population of schistosomes.

Conclusion

There are medicines to treat snail fever but by far the best approach is to avoid getting the disease in the first place. If you live in or travel to an area where schistosomiasis is present (such as West Africa, East Africa, Asia and parts of South America) make sure not to have direct contact with freshwater. Host snails release schistosome eggs into freshwater and from here they can enter humans. Any water you use to wash yourself or your clothes should be thoroughly boiled first.

In fact, in 2013 there was even an outbreak of schistosomiasis caused by a S.haematobium and S.bovis hybrid species in Corsica, France. This shows just how widespread the disease could potentially become if not controlled!

Glossary of Key Terms

Asexual reproduction – When an organism reproduces on its own. The offspring arises from one parent, and inherits the genes of that parent only. In their immature form inside snails, schistosomes reproduce asexually, however, when in their immature form in humans and other mammals, they reproduce sexually (by mating).

Definitive host – an organism which harbors the mature (can reproduce sexually) form of a parasite.

Host – in biology or medicine, this means an organism harboring a parasite (or a beneficial partner). In our case, the snails and humans (and rodents, cattle etc) are hosts for the parasitic fluke worm.

Hybrid – the offspring of two different species or varieties. For example, a mule is the offspring of a (male) donkey and (female) horse - two different species. However, mules are infertile and therefore cannot create offspring, whereas the hybrids borne of human schistosome and animal schistosome species are able to breed.

Hybridization – the process by which two different species or varieties of the same species inter-breed or inter-mix to produce a hybrid offspring that combines their DNA.

Intermediate host – an organism which harbors the immature (cannot sexually reproduce) form of a parasite.

Intestinal schistosomiasis – a schistosomiasis form (caused predominantly by *Schistosoma mansoni* within Africa) which affects the intestines and causes many pathologies including abdominal pain and liver damage.

Life cycle – a series of stages through which something (such as an individual, or a manufactured product) passes during its lifetime. Here, we're talking about the life cycle of the parasitic schistosome fluke worms which cause snail fever.

Mass drug administration (MDA) – the administration of drugs to whole populations, or groups of populations such as school-aged-children – both sick and healthy, to aim to control or eliminate a certain disease in the area.

Parasite – an organism (like the schistosome flatworm in our case) that lives inside or attached to another organism, called the host. The relationship is always the same – good for the parasite, bad for the host.

Schistosome – a group of parasitic flatworms that cause snail fever (i.e. schistosomiasis, also known as Bilharzia).

Schistosomiasis – a disease also known as "snail fever" that is caused by schistosome flatworms. People get infected when they come into contact with water that contains the larval stages of the parasitic worms. The worms need two different hosts to survive and multiply: humans (or other vertebrates), and also freshwater snails.

Sequencing (DNA sequencing) – The process of determining the precise order of the building blocks of DNA.

Urogenital schistosomiasis – schistosomiasis, caused by *Schistosoma haematobium* and / or a hybrid species combining *S. haematobium* and closely related schistosome species which affect animals. It affects the urinary tract and genitals, causing pain, bleeding, and infertility. It can also lead to cancer.

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Check your understanding

1 What is the difference between a definitive and an intermediate host of a parasite?

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2 How do humans get infected with snail fever?

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3 How can you protect yourself from snail fever?

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4 If rodents also harbor and transmit schistosomes to humans, would mass drug administration (MDA) be an effective method to stop snail fever?