WATERBORNE DISEASE

Billharzia and its snail vectors under the spotlight in current study

A Water Research Commission funded project is looking into the distribution and endemic knowledge of bilharzia in South Africa, particularly considering the potential increase of this waterborne disease due to climate change. Article courtesy Lizaan de Necker.

Nico Smit

Project leader, Dr Lizaan de Necker, with fellow postdoctoral fellow Dr Hannes Erasmus and Honours students Nobukhosi Sithole and Herman le Roux conducting field work for the bilharzia research project

Climate change and its predicted associated changes to rainfall patterns and air temperatures is one of the most important threats that aquatic ecosystems face in the 21st century. Freshwater ecosystems are some of the most at-risk habitats, particularly where these systems are already exploited by humans (UNU-EHS 2016).

The most prominent predicted ecological consequences of climate change include modification to water quantity and quality, aquatic species distribution and ranges, and increased waterborne and vector-borne diseases (see Dallas and Rivers-Moore 2013 for a full review). Climate change also poses a great threat to human health, and it is predicted that by 2030 sub-Saharan Africa will carry the greatest burden of mortality due to impacts of climate change (WHO 2009).

Climate change can severely impact human health directly by increasing the frequency of severe weather and climatic events such as flooding, droughts and extreme temperatures, and indirectly through environmental changes that affect food security, air quality and the distribution and occurrence of various diseases (Nhamo and Muchuru, 2019). Within the interior of South Africa, it is predicted that mean annual air temperatures will increase by 3-3.5°C while the coastal regions will experience a 1.5-2.5°C increase. In summer rainfall areas the mean annual rainfall will increase by 40-80 mm per decade while this will decrease by 20-40 mm per decade in the winter rainfall areas. Limpopo, Mpumalanga and Kwa-Zulu Natal (summer rainfall regions) will therefore experience hotter and wetter conditions in summer and autumn, while the Western Cape and southern parts of the Eastern Cape (winter rainfall regions) will experience hotter and drier winter conditions (Dallas and Rivers-Moore 2013).

Schistosomiasis, commonly known as bilharzia, is a disease caused by parasitic trematodes (flatworms) of the genus ***Schistosoma*** that affects both humans and animals and is classified as a neglected tropical disease by the World Health Organisation (WHO). The parasitic larvae (cercariae) are transmitted to humans and animals through contact with waterbodies that contain the intermediate snail hosts (vectors) contaminated with the parasite (Adenowo et al. 2015).

The disease is found in approximately 78 countries worldwide, including South Africa, and is most prevalent in tropical and subtropical areas, particularly in poor and rural communities (WHO 2016). An estimated 166 million people are infected with the disease in sub-Saharan Africa while at least 5.5 million people required treatment for schistosomiasis in South Africa in 2018, according to the WHO. Individuals most vulnerable to schistosomiasis are children, women and those working in close contact with freshwater habitats (Adenowo et al. 2015; Sacolo et al. 2018).

Three aquatic snail species are known vectors of the parasitic trematodes causing schistosomiasis, and three of the five ***Schistosoma*** spp. that have the potential to infect humans and animals are found in South Africa. The snail ***Biomphalaria pfeifferi***, serves as vector for ***Schistosoma mansoni*** which causes intestinal schistosomiasis. ***Bulinus africanus*** and ***Bulinus globosus***, are the vectors ***of S. haematobium***, causing urinary schistosomiasis in humans, and ***S. mattheei,*** causing schistosomiasis in cattle and sheep (Day and de Moore 2002). Although effective treatment for schistosomiasis exists in the form of the drug praziquantel, re-infection through continued exposure to infected water occurs frequently in endemic regions (Kalinda et al. 2017).

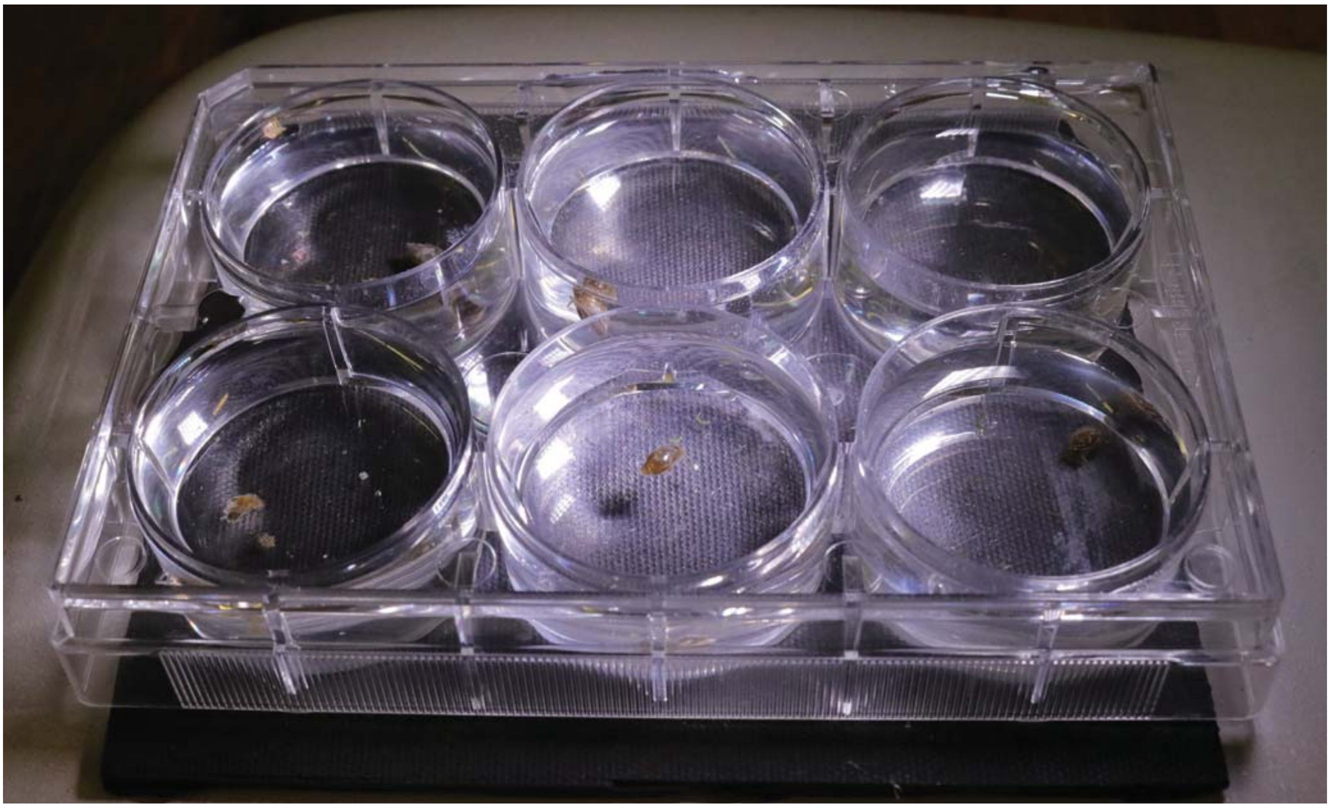
Chronic infection with schistosomiasis and resistance to praziquantel treatment pose long-term health threats to humans and animals. This is particularly true for rural, poverty stricken areas where access to effective medical care and treatment is limited. Chronic effects of schistosomiasis in humans and animals includes liver fibrosis, anemia and weight loss, while ***Schistosoma mansoni*** (intestinal bilharzia) also causes undernutrition and growth stunting in children (King et al. 2008).

"A better understanding of perceived health risk could inform public health policies and actions and influence mitigation and adaptive responses."

Nico Smit

The snails prefer vegetated aquatic habitats located in areas close to human and animal activity

Lizaan de Necker



Snails are placed under a light source to stimulate shedding of the parasitic cercariae

Chronic infection with ***S. haematobium*** (urinary bilharzia) leads to chronic granulomas in the bladder that can result in bladder cancer or Female Genital Schistosomiasis. This causes greater susceptibility to sexually transmitted diseases and, if left untreated, can lead to infertility, miscarriage and other birth complications (Kukula et al. 2019). Infected humans and animals also have reduced immune responses and are more susceptible to other parasites and diseases. Infected snails are therefore a threat to both humans and livestock in South Africa (de Kock and Wolmarans 2005).

The snails and parasites are found predominantly in areas with relatively mild to warm air temperatures and high rainfall. In South Africa, the disease is largely confined to the northern and eastern parts, including Limpopo, Mpumalanga and the coastal parts of KwaZulu-Natal. However, isolated populations are found in the upper parts of North-West, Gauteng and the Eastern Cape (de Kock et al. 2004).

The eggs of ***S. haematobium*** are transmitted from humans to water through urine and these parasites most frequently occur in summer in regions where people play and swim in the water. The eggs of ***S. mansoni*** and ***S. mattheei*** are transmitted to waterbodies through the faecal matter of humans and animals, respectively. These two parasites therefore most often occur in regions where there are farmlands (both subsistence and commercial) and rural and informal settlements close to waterbodies. In many cases, people in these areas do not have access to adequate sewerage systems and are highly dependent on nearby water sources for both domestic (drinking, irrigation, washing and fishing) and recreational (playing and swimming) activities (Wolmarans et al. 2006).

Continued human population growth along with future predicted climate changes could alter the ranges of the snail vectors and their parasites, thus leading to changes in the presence and prevalence of schistosomiasis. Warmer temperatures may cause greater spread of the disease in endemic regions while areas that were too cold for the disease before may become new areas of infection. Changes in annual average precipitation may also alter disease transmission with greater infection occurring in areas with increased rainfall and reduced transmission in areas will decreased rainfall. Increased frequency and intensity of heatwaves may lead to outbreaks of the disease in regions that were previously low or zero transmission areas. Changes in river flow and flooding regimes due to droughts or extreme floods could also cause the establishment of snails in new regions and/or temporary or permanent removal of snails in endemic regions (McCreesh and Booth 2013). It is thus essential to understand if and how future predicted climate change may influence the transmission of schistosomiasis in order to protect public health.

At present, we do not have a clear indication of the distribution of schistosomiasis transmitting vectors and parasites in South Africa as the most comprehensive snail distribution studies occurred in the 1950's to 1960's as part of the collections for the National Freshwater Snail Collection (NFSC) of South Africa. Local studies have also assessed the prevalence and distribution of schistosomiasis in humans in rural communities in the Eastern Cape (Meents and Boyles 2010), North-West (Wolmarans et al. 2006), KwaZulu-Natal (Manyangandze et al. 2016) and Limpopo (Samie et al. 2010) provinces. These studies provide valuable insights into the prevalence of schistosomiasis in humans in South Africa but do not provide a holistic indication of the present distribution and abundance of the vectors, parasites or what the potential future distribution of schistosomiasis may be. Given how human population has grown in the past 60 years, along with changes in temperatures and rainfall patterns, the distribution of schistosomiasis transmitting vectors and parasites may have changed already, particularly in regions that were on the distribution fringes.

Since schistosomiasis mainly affects poor, rural agricultural communities, it is important to understand how affected communities experience climatic and environmental change and how these changes impact their health, well-being and livelihoods. An understanding of the physical environment, and the broader social environment in which people live and work is necessary to fully understand vulnerability to schistosomiasis infection (Kukula et al. 2019).

A better understanding of perceived health risk could also inform public health policies and actions and influence mitigation and adaptive responses, as perceptions can drive health related behaviours. Designing effective response programs requires an understanding not only of changes the distribution of schistosomiasis vectors and parasites, but also the existing knowledge, attitudes, perceptions and practices (KAPP) surrounding schistosomiasis in endemic communities (Sacolo et al. 2018).

Models that predict the potential effects of climate change on schistosomiasis distribution can provide valuable information regarding areas that will become suitable for transmission in the future (McCreesh and Booth 2013). These models need to be carefully designed with specific parameters for each study region, intermediate hosts and parasites in question as these can vary greatly. Although such models have been created and tested in several African countries including Ethiopia (Kristensen et al. 2001); Uganda (Stensgaard et al. 2006) and Zimbabwe (Pedersen et al. 2014), this has not been undertaken in South Africa.

Through a combined field and desktop based study approach Dr Lizaan de Necker and her fellow researchers (Nisa Ayob, Ncobile Nkosi, Farina Lindeque, Dr Wynand Malherbe, Dr Dirk Cilliers, Dr Roelof Burger, Prof Nico Smit and Prof Victor Wepener) aim to address the lack in knowledge about the present distribution of schistosomiasis in South Africa. Their project entitled 'Current status and future predicted distribution patterns of bilharzia transmitting snails and implications for vector-borne diseases in South Africa' is funded by the Water Research Commission (**Project No. C2019/2020-00151**) and is a collaboration between the Water Research Group of North-West University, the South African Institute for Aquatic Biodiversity and University of Limpopo. The overarching aims of the study are to determine whether the ranges of schistosomiasis vectors and parasites have changed in the past half-century; how it could change in the future given predicted climate change and how communities in endemic regions perceive and experience the disease.

Using climate modeling techniques, historic distribution data collected for the NFSC and a specific set of environmental conditions from the past 60 years', decadal maps will be created to show the estimated spatial distribution of schistosomiasis vector snails in South Africa. These maps will be used to identify areas as localities where the range of schistosomiasis has potentially extended into. Field collection will then occur in these areas to determine if the snails and parasites are indeed present and so verify the predictive capabilities of the created model. These results will then be used to adjust the model where necessary and applied to determine potential new distribution ranges of schistosomiasis in relation to future predicted climate change.

Surveys will be conducted with local communities in endemic schistosomiasis areas to gather information about how the people experience climatic and environmental change and assess community KAPP surrounding schistosomiasis. At the end of the project, workshops will be held with the community to provide information on schistosomiasis and the threats of exposure to this disease. The project will also create a digital version of the Bilharzia Atlas of South Africa to provide information on the distribution of schistosomiasis in South Africa which will be accessible to the general public through a web-based platform.

More about Schistosomiasis

- Schistosomiasis is an acute and chronic disease caused by parasitic worms.
- People are infected during routine agricultural, domestic, occupational, and recreational activities, which expose them to infested water.
- Lack of hygiene and certain play habits of school-aged children, such as swimming or fishing in infested water, make them especially vulnerable to infection.
- Schistosomiasis control focuses on reducing disease through periodic, large-scale population treatment with praziquantel; a more comprehensive approach including potable water, adequate sanitation, and snail control would also reduce transmission.
- Estimates show that at least 290.8 million people required preventive treatment for schistosomiasis in 2018, out of which more than 97.2 million people were reported to have been treated.

Source: WHO