The life cycle of *Schistosoma mansoni* and schistosomiasis disease: an educational approach

O ciclo de vida do *Schistosoma mansoni* e a doença da esquistossomose: uma abordagem educacional

El ciclo vital de *Schistosoma mansoni* y la enfermedad de schistosomiasis: un enfoque educativo

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Maria Eduarda Alves Almeida
Master in Applied Sciences in Health Products
Institution: Universidade Estadual de Goiás (UEG)
Address: Anápolis, Goiás, Brazil
E-mail: meaa@aluno.ueg.br

Yasmim Rodrigues dos Reis Silva
Master in Applied Sciences in Health Products
Institution: Universidade Estadual de Goiás (UEG)
Address: Anápolis, Goiás, Brazil
E-mail: yasmimrrsilva@gmail.com

Mariana Barbosa Detoni
Master in Experimental Pathology
Institution: Universidade Estadual de Londrina (UEL)
Address: Londrina, Paraná, Brazil
E-mail: mariana.detoni@uel.br

Thiago Lopes Rocha
Doctor in Marine, Earth and Environmental Sciences
Institution: Universidade Federal de Goiás (UFG)
Address: Goiania, Goiás, Brazil
E-mail: thiagorochabio20@ufg.br

Luciana Damacena-Silva
Doctor in Tropical Medicine and Public Health
Institution: Universidade Estadual de Goiás (UEG)
Address: Anápolis, Goiás, Brazil
E-mail: luciana.silva@ueg.br

ABSTRACT

Schistosoma mansoni, a digenetic trematode, is the causative agent of intestinal schistosomiasis, an infectious parasitic disease that affects approximately 54 million people annually and has a high mortality rate. Disease control involves treatment with the anthelmintic praziquantel, environmental sanitation, access to treated water, and population management of *Biomphalaria* snails, the intermediate hosts of the parasite. Understanding the life cycle of *S. mansoni* is an educational challenge due to the complexity of its multiple biological and ecological stages, requiring knowledge in parasitology, molecular biology, ecology, and public health. This difficulty affects students in both basic and higher education. In this context, the creation of illustrative diagrams and educational videos of the parasite's life cycle proves to be an effective approach. Visual representations facilitate the understanding of the life cycle stages and their relationship to the disease, promoting more accessible theoretical and practical learning. Furthermore, these materials strengthen schistosomiasis control actions, especially in endemic regions, and contribute to the training of public health professionals. This study, therefore, aims to present an illustrative diagram and an educational video that address the different stages of *S. mansoni*'s life cycle. For the illustrations and graphic element assemblies, digital software and platforms such as Inkscape, Microsoft PowerPoint, Canva, and the GNU Image Manipulation Program were used. It is concluded that the use of graphic design software to create high-quality visual materials contributes to improving education and knowledge dissemination.

Keywords: Snail Disease. Educational Graphic Design. Illustrative Diagram. *Biomphalaria* Snail.

RESUMO

Schistosoma mansoni, um trematódeo digenético, é o agente causador da esquistossomose intestinal, uma doença infecto-parasitária que afeta cerca de 54 milhões de pessoas anualmente e apresenta alta mortalidade. O controle da doença envolve o tratamento com o anti-helmíntico praziquantel, saneamento ambiental, acesso a água tratada e manejo populacional dos caramujos do gênero *Biomphalaria*, hospedeiros intermediários do parasito. Compreender o ciclo de vida do *S. mansoni* é um desafio educacional devido à complexidade de suas múltiplas fases biológicas e ecológicas, o que exige conhecimentos em parasitologia, biologia molecular, ecologia e saúde pública. Essa dificuldade afeta tanto estudantes do ensino básico quanto do superior. Nesse contexto, a criação de diagramas ilustrativos e vídeos educativos do ciclo de vida do parasito se apresenta como uma abordagem eficaz. Representações visuais facilitam a compreensão das etapas do ciclo e sua relação com a doença, promovendo um aprendizado teórico e prático mais acessível. Além disso, esses materiais reforçam as ações de controle da esquistossomose, especialmente em regiões endêmicas, e contribuem para a capacitação de profissionais de saúde pública. Este estudo, portanto, tem como objetivo apresentar um diagrama ilustrativo e um vídeo educativo que abordem as diferentes fases do ciclo de vida do *S. mansoni*. Para as ilustrações e montagens de elementos gráficos foram utilizados softwares e plataformas digitais como Inkscape, Microsoft PowerPoint,

Canva e GNU Image Manipulation Program. Conclui-se que o uso de software de design gráfico para criar materiais visuais de alta qualidade contribui para melhorar a educação e a disseminação do conhecimento.

Palavras-chave: Doença do Caramujo. Design Gráfico Educacional. Diagrama Ilustrativo. Caramujo *Biomphalaria*.

RESUMEN

Schistosoma mansoni, un trematodo digenético, es el agente causal de la esquistosomiasis intestinal, una enfermedad infecto-parasitaria que afecta anualmente a unos 54 millones de personas y tiene una elevada tasa de mortalidad. El control de la enfermedad implica el tratamiento con el antihelmíntico praziquantel, el saneamiento ambiental, el acceso a agua tratada y la gestión de la población de caracoles *Biomphalaria*, huéspedes intermediarios del parásito. Comprender el ciclo vital de *S. mansoni* es un reto educativo debido a la complejidad de sus múltiples fases biológicas y ecológicas, que requieren conocimientos de parasitología, biología molecular, ecología y salud pública. Esta dificultad afecta tanto a los estudiantes de enseñanza primaria como a los de enseñanza superior. En este contexto, la creación de diagramas ilustrativos y vídeos educativos del ciclo vital del parásito constituye un enfoque eficaz. Las representaciones visuales facilitan la comprensión de las etapas del ciclo y su relación con la enfermedad, promoviendo un aprendizaje teórico y práctico más accesible. Además, estos materiales refuerzan las acciones de control de la esquistosomiasis, especialmente en las regiones endémicas, y contribuyen a la formación de los profesionales de la salud pública. El objetivo de este estudio es, por tanto, presentar un diagrama ilustrativo y un vídeo educativo que abarquen las distintas fases del ciclo vital de *S. mansoni*. Para crear las ilustraciones y ensamblar los elementos gráficos se utilizaron programas informáticos y plataformas digitales como Inkscape, Microsoft PowerPoint, Canva y GNU Image Manipulation Programme. La conclusión es que el uso de programas de diseño gráfico para crear materiales visuales de alta calidad contribuye a mejorar la educación y la difusión de conocimientos.

Palabras clave: Enfermedad del Caracol. Diseño Gráfico Educativo. Diagrama Ilustrativo. Caracol *Biomphalaria*.

1 INTRODUCTION

Schistosoma mansoni is the causative agent of intestinal schistosomiasis, a debilitating infectious parasitic disease that affects approximately 54 million people each year, causing morbidity and high mortality. This digenetic trematode is endemic in sub-Saharan Africa and the Middle East. The parasite arrived in

South America through the transatlantic trafficking of enslaved people (Anderson; Enabulele, 2021).

The prevalence and intensity of infection is significant in school-aged children; reduced contact with water containing cercariae released by *Biomphalaria* spp. snails and acquired immunity reduce infection in adults. Pathogenesis in the human host results from granulomas that form around eggs that are lodged in the liver and intestine (Anderson; Enabulele, 2021). Control methods include the use of praziquantel (PZQ), the main anti-helminthic used in the treatment of individuals diagnosed with schistosomiasis, as well as the use of molluscicides to control the population of intermediate host snails (WHO, 2022). In this sense, environmental sanitation through the provision of treated water to the population and sanitary engineering are important prophylactic measures against transmission and infection by the parasite (Olveda *et al.,* 2014; Santos *et al*., 2023; Sokolow *et al*., 2016).

The complex life cycle of *S. mansoni* in both vertebrates, including humans, and invertebrate hosts (freshwater snails) passes through five larval stages (in addition to the egg) (Mutapi *et al*., 2017). Humans act as definitive hosts (hosts in which sexual reproduction occurs), and other vertebrates such as monkeys and rodents are classified as susceptible hosts (Anderson; Enabulele, 2021). Snails of the genus *Biomphalaria* (Preston, 1910) are the intermediate hosts in which the parasite undergoes asexual reproduction (Mutapi *et al*., 2017; LoVerde, 2019).

Despite control strategies such as antiparasitic medications and host snail control, the understanding of the life cycle of *S. mansoni* is complex, especially in the educational context. The difficulty faced by students in basic education and in biology and health courses is related to the complexity of the process, which involves several biological and ecological stages, requiring the integration of concepts from parasitology, molecular biology, ecology, and public health.

In this context, an illustrative diagram of the *S. mansoni* life cycle emerges as an effective approach to facilitate learning, providing a clear representation of the biological stages and helping students make connections between the disease's phases.

Theoretically, this approach improves understanding of the biological cycle and the mechanisms of transmission and control of schistosomiasis. Practically, innovative educational materials, such as the diagram, can support disease control efforts, especially in endemic regions, and contribute to the training of more qualified public health professionals.

Therefore, the development of graphic materials is essential to facilitate student learning and spread crucial information about the control and prevention of schistosomiasis.

The objective of this study is to create and present an illustrative and educational diagram of the *Schistosoma mansoni* life cycle, with the purpose of simplifying students' understanding of this complex process.

2 METHODOLOGY

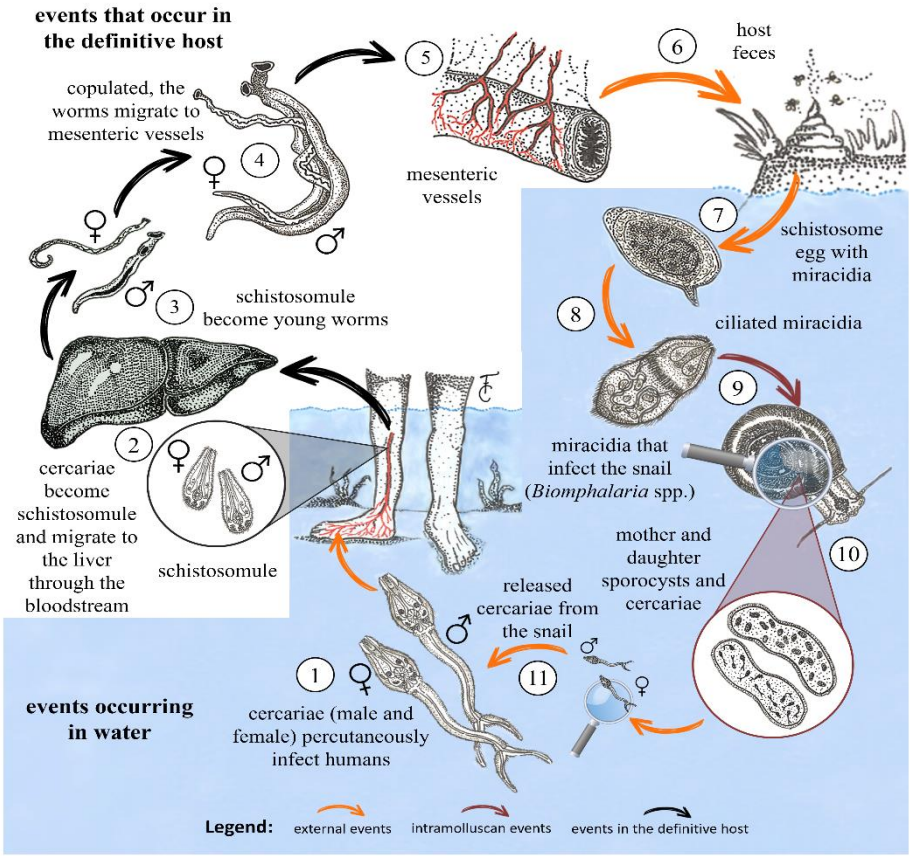
For the graphic preparation of the life cycle, freehand illustrations were created using India ink pens, and vector drawings were produced using the freely accessible software Inkscape® (version 1.3.2, https://inkscape.org/pt-br/). The ink artwork was digitized through the use of the Inkscape software.

The graphic elements were assembled using Microsoft PowerPoint® software (Professional Plus 2021) and the Canva® graphic design platform (https://www.canva.com/pt_br/). Subsequently, the assembled cycle was imported into the GNU Image Manipulation Program software (GIMP, version 2.10.38, https://www.gimp.org/). The resolution was adjusted to 600 dpi, the dimensions were modified, and the colors were altered. The final result was exported in Portable Network Graphics (.png), raster image (bitmap, .jpg), and Tagged Image File Format (.tiff) formats. For pedagogical reasons, the use of fantastical colors was employed, and the elements were not depicted in actual scale.

3 LIFE CYCLE OF *Schistosoma mansoni*

1. Upon contact with water containing cercariae (500 µm), humans or other susceptible hosts become infected through the skin or mucous membranes. Following penetration of the skin, the male and female cercariae lose their tails, while the anterior portion, which remains in the host, undergoes significant morphological and physiological changes;
2. Consequently, within a period of two hours, the cercariae, free-living larvae, become obligate endoparasites, assuming the form of the schistosomule (100–400 µm). At this stage, the parasite travels through the venous circulation to the lungs, where it remains for approximately three to ten days. During this period, it becomes resistant to the host's immune response and migrates to the hepatic portal vein;
3. The parasites reach the liver via the venous circulation approximately eight to ten days after infection. Once within the organ, the schistosomules undergo a differentiation process, resulting in the formation of juvenile and subsequently adult worms;

Figure 1. Life cycle of the parasite *Schistosoma mansoni*. (1) The cercariae actively penetrate the skin or mucous membranes of humans; (2) After penetrating the human organism, the cercariae (males and females) lose their forked tails and are called schistosomules; (3) Via the venous circulation, the schistosomules reach the liver and differentiate into young worms; (4) After mating with the male, the female reaches sexual maturity and the pair migrates to the mesenteric vessels; (5) Adult worms (male and female) live in the mesenteric vessels, with the female releasing eggs into the systemic circulation; (6) Egg containing miracidium is shed with human faeces; (7) Egg in the aquatic environment; (8) The miracidium hatches in the aquatic environment; (9) The miracidium finds and enters the host snail by rotation and chemotaxis; (10) Within the snail, the miracidium differentiates into successive generations of sporocysts and later into cercariae; (11) The cercariae break through the snail's shell and are released into the water.



Source: Prepared by the authors

4. Chemotaxis, which is the attraction between the sexes, occurs after the third week, which is when mating takes place. The helminths complete their development within the intrahepatic portal system within four weeks. Subsequently, the adult male and female worms migrate to the mesenteric vessels to engage in mating;
5. Adult schistosomes are dioecious and exhibit sexual dimorphism, with females measuring 1.5 cm and males measuring 1 cm. Both sexes possess oral and ventral suckers (acetabula), although female worms are

filiform in comparison to the male worms, which exhibit tubercles on the surface and a ventral groove (gynaecophore canal) into which females enter for maturation, mating, and egg production. Following mating, the worms move in a direction opposed to the blood flow from the hepatic portal vein to the lower mesenteric vessels. Subsequently, the female begins to lay an average of 300 eggs per day, with an average size of 110–180 µm, four weeks after infection;

6. The eggs contain the miracidia (ciliated larvae), which are released into the bloodstream. Some of these larvae cross the lining of the mesenteric vessels by mechanical action of the dorsal spicule present in the egg and enzymes released by the miracidia. They then migrate through the intestinal wall into the lumen and are excreted with the host's feces. Approximately 20 to 55 percent of the eggs are excreted, while the remainder are carried systemically and reach the host's tissues, where they cause blood flow obstruction;
7. The arrival of these eggs in the aquatic environment is facilitated by human defecation in nearby locations or within the water resources, in addition to the absence of adequate sanitary engineering in endemic regions;
8. The miracidia emerge from the eggs in response to favorable environmental conditions, including high light intensity, sufficient oxygen content in the water, temperatures above 20 degrees Celsius, and hypotonic conditions;
9. The miracidia (160–180 µm) penetrate the *Biomphalaria* snail's integument (typically at the base of the tentacles and in the foot) via a process of rotation and chemotaxis;
10. At the site of penetration, the miracidia loses its cilia and differentiates into a primary sporocyst, a hollow, saccular structure filled with germinal fluid. In less than a week, the miracidia differentiates into a secondary sporocyst, which contains between 35 and 600 cercariae. After approximately 3 to 4 weeks of infection, the snail produces an average of 1,500 cercariae in 18 days. The cercariae that have developed in the secondary sporocyst enter the blood spaces that surround the digestive gland and gonads

(ovotestis) of the snail. They then reach the well-vascularized areas of the integument via the circulatory system;

11. Minute vesicles are generated on the external surface. The male and female cercariae utilize the contents of a pair of unicellular glands to rupture the vesicles, thereby releasing them into the external aquatic environment.

Figure 2. Life stages of *Schistosoma mansoni* – To gain access to the video, please scan the QR code with your mobile device or click on the image.

Source: Prepared by the authors

4 CONCLUSION

The results of this research can strengthen both educational practices in academia and awareness and prevention efforts in society. In academia, the study offers an innovative pedagogical tool that facilitates the teaching of parasitology and public health, making complex concepts more accessible and applicable in scientific articles and academic work. The use of graphic design software to create high-quality visual materials contributes to enhancing education and knowledge dissemination.

However, this research has some limitations, such as the need to evaluate the effectiveness of the diagram in the learning process and the limited reach to certain populations, especially in regions with low literacy rates or restricted access to technological resources. For future studies, it is recommended to assess the practical applicability of the material in different educational and social contexts, as well as to develop interactive and accessible versions for diverse audiences, thereby expanding the tool's impact on schistosomiasis awareness.

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