Some abiotic factors affecting schistosomiasis intermediate hosts: an overview

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Abstract

Schistosomiasis intermediate-hosts, snails, are usually surface dwellers of different type of freshwater bodies and their geographical distribution and population dynamics may be influenced by many factors such as temperature, oxygen dissolved in water, flooding and desiccation. In this study, we interested in temperture, rainfall, light, turbidity, dissolved oxygen and heavy metal ions, calcium and aestivation.

Keywords: Snails, schistosomes, abiotic factors.

Introduction

There are many parasitic trematodes causing diseases in humans and animals. Among those, schistosomiasis (Bilharzia) is the most important parasite. In addition, it is caused by members of the genus *Schistosoma* in the family Schistosomatidae [1-3]. Schistosomiasis causes a high morbidity and mortality in rural agricultural and suburban areas of tropical and subtropical regions of the world [4-8]. Schistosomiasis intermediate-host snails are usually surface dwellers of different type of freshwater bodies and their geographical distribution and density may be influenced by several factors such as temperature, rainfall, oxygen dissolved in water, flooding, calcium and desiccation, which is this study focused on.

Schistosomiasis life cycle

Adult Schistosomes pair in liver of the definitive host (mammals) and they produce their fertilized eggs [9,10]. Some of the eggs are excreted with feces or urine [11,12], and then they hatch and release in freshwater into a free swimming larva called miracidia, which can penetrate the specific intermediate host; snails in the water [13-15]. After penetrating into the snail, the miracidium differentiate into a larva called cercariae [16], which are released into the water where they actively search for the definitive hosts to penetrate. After entering a blood vessel which lead to the hepatic portal system in the hepatic portal vessels, where they grow and then maturation before the adult worms migrate either to the superior or inferior mesenteric veins or the vesical plexus [14,17,18].

Schistosomiasis intermediate-hosts

Schistosomes are transmitted by freshwater snails of the class Gastropoda in the phylum Mollusca. Two species of truly aquatic, Basommatophora genera, *Biomphalaria* and *Bulinus* snails, transmit *S. mansoni* and *S. haematobium*, respectively, with very different distributions; *Bulinus forskalii* snail transmits *S. intercalatum* and *Bobertsiella kaporensis* transmits *S. mekongi*; while many species and subspecies of the amphibious snail, *Oncomelania*, transmit *S. japonicum* [10,17,19-21].

Factors affecting snail host

Temperature

Temperature assumes great importance in subtropical and temperate areas. In many studies, it has an impact on stopping the proliferation of aquatic and semi-aquatic snails during the winter months ; for example, *B. truncatus* and *B. alexandrina* in Egypt, *B. truncates* in Iran, *Biomphalaria* and *Bulinus* in southern Africa and *Oncomelania nosophora* in Japan, and *O. hupensis* in mainland China [22-25]. Intermediate host snails can tolerate a wide range of temperature (0-40ºC), where their optimum temperature range usually is 20-28ºC [14,26-28]. Live snails have been found in high altitude water bodies in some tropical zones where the temperature sometimes drops to freezing. It has been documented that the optimal temperature for *O. hupensis* ranges between 20°C and 30°C and any changes below or above this range result in delayed or arrested development and reproduction of the snail [14]. Moreover, hibernation can also occur when the temperature drops below the critical threshold [29]. In Sub-tropical zones, snail population density becomes maximal, when temperature rises [30,31]. However, it has been reported that the high temperature is responsible for the reduced reproduction of *B. truncatus* and *B. pfeifferi* snails in Sudan [32]. In general, rising in temperature may affect the snail fecundity, growth and survival rates and their distribution [23,25,26,28,33-37].

Rainfall

Rainfall cycles are probably the most important factor affecting snail life cycles and population densities in the tropics [38]. During periods of heavy rainfall, floods sweep the snail out of their habitats and disperse their food [39-43]; snails are usually found in water of the velocity flow is below 40 cm/s [44], hence, the water current velocity is an important factor for snails distribution [23,45,46]. But rainfall fills standing water habitats, sometimes transforming non-productive and often polluted sites into ideal snail breeding habitats [47]. In such habitats, the population growth peak may be delayed until after peak rainfall. Prolonged dry periods between periods of rainfall have opposite effects on flowing and standing habitats, smaller standing pools dry out, causing high mortalities unless the snails are adapted to evade the effect of desiccation [48,49]. However, diminished water flows can change unfavourable flowing habitats into ideal snail sites, although these habitats too may eventually pull out into standing sites and ultimately dry up in prolonged droughts. Normally, rainfall acts locally where it falls, but there are examples in very large river basins where rainfall produces delayed seasonal effects, many hundreds of kilometers downstream as, for example, in Lake Volta, Ghana, seasonal effects in such areas may be modified by man-made interventions for the provision of perennial irrigation water to improve agriculture [50].

Light

Daylight is essential for growth of snails. This was observed among populations of snails in Sudan, where water turbidity levels dropped seasonally and with this change in turbidity, populations of snails increased dramatically [51,52]. On the contrary, it has been reported that Bulinid snails can be reared successfully for several generations in total darkness, suggesting that daylight is not necessary for the growth of snail populations [53]. Snails, that avoid either light or high water surface temperatures might conceivably reach a depth where hydrostatic pressures could affect their buoyancy, but with the possible exception of the central African lakes (inhabited by specially adapted species of snails, such as *B. choanomphala*) and man-made reservoirs, snail habitats are rarely more than 1 or 2 m deep. The hydrostatic pressure created at such depths does not have an adverse affect on either the snails or their eggs [54].

Turbidity

Snails occur in highly turbid water, where their population growth depends on the water turbidity levels; however, adult and juvenile snails do not appear to be harmed due to turbidity, but the silt deposition under highly turbid water conditions, harms their egg-masses. The silt deposition also limits the growth of aquatic plants, silt is carried with surges of flood water along major rivers serving irrigation schemes as in Sudan [51]. Both *B. pfeifferi* and *B. truncatus* snails occur at high densities with predominance of young snails in marginal grasses along major canals, indicating that the turbid water in itself is not detrimental to growth of snail populations [55]. However, water transparency allows sunlight to pass to the bottom that would assist the growth and proliferation of aquatic weeds [56], which promotes the growth and survival of the snail vectors.

Dissolved oxygen and heavy metal ions

The level of dissolved oxygen is the chief limiting factor in the ecology of snails [57-59].

Some host snails are sensitive to low oxygen levels characteristic of polluted ecosystems, whilst others can take in oxygen from both air and water and are generally tolerant of water with low dissolved oxygen [60,61]. Ions of heavy metals, such as Zinc, Iron, copper, Cadmium or Silver, are toxic to snails at relatively low concentrations [62-65]. Likewise, increasing of these metals is toxic to most aquatic organisms [66].

Calcium

Calcium is the most obvious chemical factor, because $CaCO_3$ constitutes the major component of snail shell and is vital for growth and reproduction of snails [67,68]. For hatching, snails need to build a strong shell soon after emergence and in this regard, some parental effort is extended in some species, providing calcium-rich feces or coating the eggs with a layer of calcium-rich soil [69]. The quantity and quality of snail food substances may be affected by calcium levels in the water; it has been shown that the composition of algal films varies according to the calcium concentrations [70].

Aestivation

Aestivation is a state of torpor that is probably best defined as a survival strategy for dealing with arid conditions, but is also typically associated with a lack of food availability and frequency with high environmental temperature [71]. Aquatic snail intermediate-hosts have the capacity to survive out of water for weeks or even months, which has a significant consequence in relation to the epidemiology of schistosomiasis and its control measures. Under dry conditions, the aquatic snail retracts into its shell and closes the aperture with a layer of mucous [72]. Snail populations that are frequently exposed to drying, often develop opertural lamellae to strengthen the shell. The amphibious *Oncomelania* snails have an operculum closing the shell opening during drought periods or can bury deep into the soil and aestivate when the temperature becomes too cold [73]. Snails survive better under rapid drying over several days compared to rapid drying of the habitat. Sometimes they disappear before drying of the habitat by presumably burying themselves in muddy substrates as conditions become unfavourable; they may also seek refuge under vegetation, especially in shaded places where lower temperatures and saturation vapor deficits minimize the severity of desiccation. Snail mortality tends to be least in young, sexually mature adults and snail eggs have little resistance to drying [74].

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