Environmental influences on the distribution and ecology of the fluke intermediate host *Galba truncatula*: A systematic review.

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Introduction

The snail *Galba truncatula* is the primary intermediate host of the liver fluke Fasciola hepatica and the rumen fluke *Calicophoron daubneyi*, both of which are extremely important trematode parasites [1]. Fascioliasis is estimated to cause €2.5 billion in damage to the global agricultural industry and over 17 million people may be infected worldwide [2]. *C. daubneyi* has long been a concern in tropical countries but has become widespread in Europe in recent years [3].

Understanding how various environmental factors influence the presence of *G. truncatula* is therefore crucial in developing strategies to prevent infection. This is especially pressing given the spread of resistance to Triclabendazole, the main anthelminthic drug used to treat *F. hepatica* [4], and the potential impacts of climate change on the snail's distribution.

Aims and Objectives

This study aimed to systematically collate and assess the current state of knowledge of the environmental preferences of *G. truncatula* in the literature, specifically regarding:

(1) The preferred habitats of G. truncatula and how they are defined.

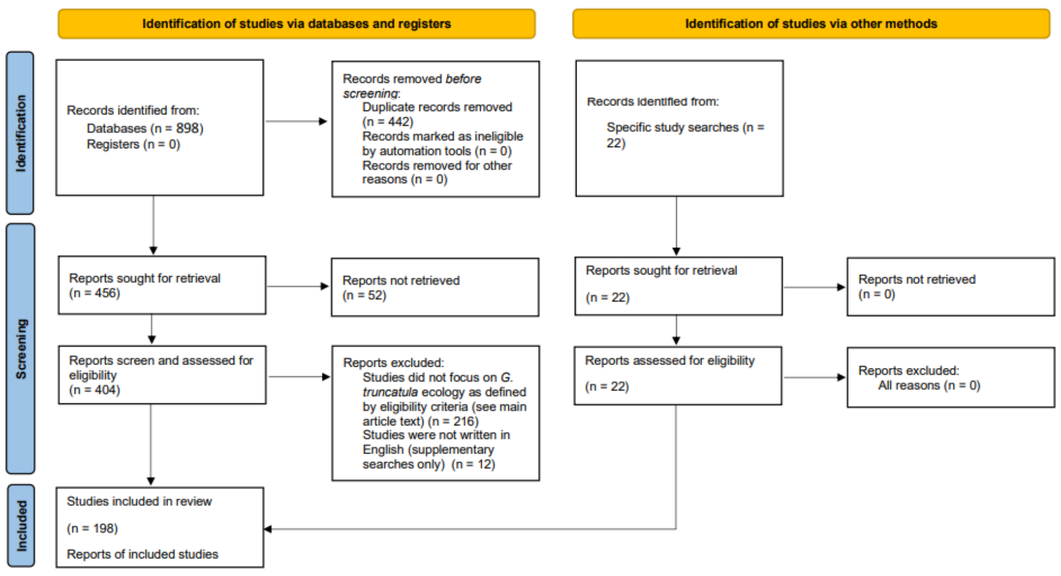
(2) The impact of large-scale climatic factors and local ecological factors on *G. truncatula* populations.

(3) Environmental factors and human activities that impact *G. truncatula* ecology, and finally

(4) How *G. truncatula* ecology impacts the transmission and spread of livestock parasites.

Methodology

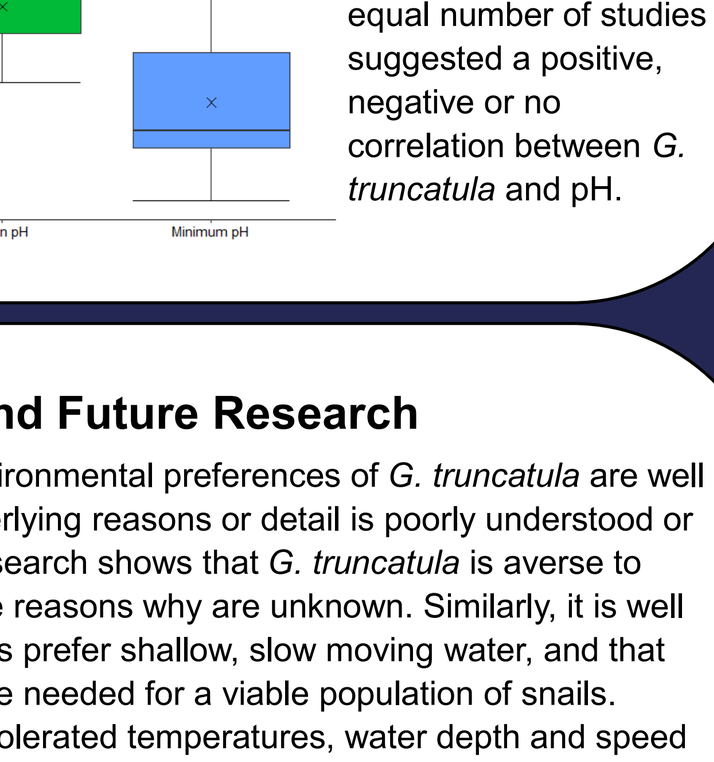
Literature searches were conducted on Web of Science and Google Scholar using a modified version of the PRISMA methodology (see below) to find papers which specifically contained data on *G. truncatula*. Laboratory experiments, field experiments, literature reviews and environmental surveys were all included. After being filtered for repeats and the eligibility criteria, the country/countries of origin of the data, habitats where *G. truncatula* was identified, number of each habitat type, and the water and/or soil pH of those habitats was noted. Any further information about how environmental or ecological factors influenced the presence, abundance or physiology of *G. truncatula* were also noted.

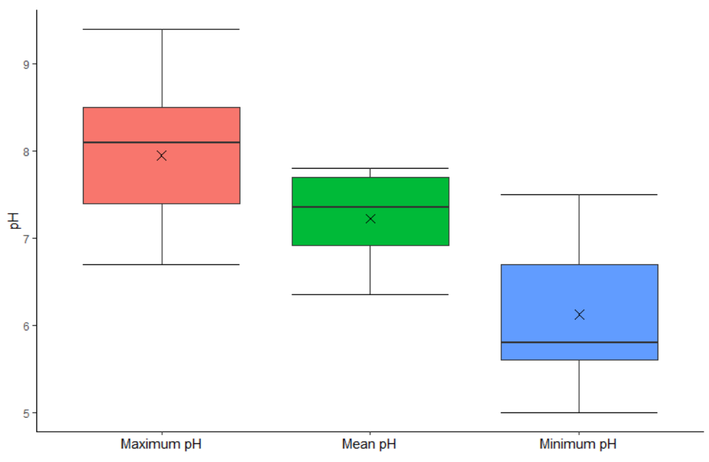


Results

198 studies were examined after filtration containing data from 64 countries. Data from France was the most abundant, being found in 43 studies.

The habitat found across the most studies (**A**) were Rivers and Riverbanks, while drainage furrows were by far the most common counted across all studies (**B**). However, the vast majority of drainage furrows were counted from three French studies.





The minimum, maximum and mean water pH noted across habitats were 5.0, 9.4 and 7.14. A roughly equal number of studies suggested a positive, negative or no correlation between *G. truncatula* and pH.

Overall Picture and Future Research

Some aspects of the environmental preferences of *G. truncatula* are well established, but the underlying reasons or detail is poorly understood or unclear. For instance, research shows that *G. truncatula* is averse to peatland habitats, but the reasons why are unknown. Similarly, it is well established that the snails prefer shallow, slow moving water, and that temperatures of 10 °C are needed for a viable population of snails. However, the maximum tolerated temperatures, water depth and speed lack clarity, and may depend on local habitat conditions.

Other aspects of *G. truncatula* preferences are even less clear, particularly in regards to the physiochemical properties of their habitats such as soil and water pH and mineral content and soil texture. The impact of shade levels also requires further research, especially given environmental schemes that encourage the planting of trees.

The impact of climate change seems to depend on the region in question, with warmer temperatures allowing the snail to colonise colder regions while droughts and heat waves are likely to be detrimental.

The lack of clarity of the snail's preferences is exacerbated by unclear and inconsistent use of habitat terminology between studies. In order to address this, a greater effort is needed to make results more easily comparable between studies. In addition, the impact of soil properties and shade levels should be a priority to examine, while environmental DNA could be a useful tool in identifying snail habitats more quickly than more traditional physical search methods.

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