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Review Article

Freshwater Snails in Malaysia: Diversity, Roles in Trematode Transmission, and Agricultural Impacts

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ABSTRACT

Freshwater snails play a critical role as intermediate hosts in the transmission of trematode diseases, affecting human and animal health and posing challenges to agriculture. This review summarises studies on freshwater snails and trematode diseases in Malaysia from 1973 to 2024, based on comprehensive literature searches across multiple databases, including Web of Science, PubMed, Scopus, and Google Scholar. A total of 32 snail species were identified, with *Radix rubiginosa* hosting five types of cercariae and *Robertsiella silvicola* acting as a host for furcocercous cercariae. Economically significant species, such as *Pomacea maculata* and *Pomacea canaliculata*, were highlighted for their agricultural impact. While treatments for trematode infections are available, prevention through controlling snail populations remains essential due to the complex transmission involving reservoir hosts. This study underscores the zoonotic potential of trematode parasites in Malaysia and identifies a significant research gap regarding intermediate host snails.

Keywords: Freshwater snails, trematode, Malaysia, overview

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INTRODUCTION

Snails are prevalent in freshwater environments across tropical and subtropical regions, notably Southeast Asia (Böhm et al., 2021). Scholars suggest that more than 350 snail species may have medical or veterinary significance (Madsen & Hung, 2014). Around 45 species from 26 genera and seven families in Southeast Asia are implicated in transmitting trematodes (Lu et al., 2018; Madsen & Hung, 2014).

Mud and freshwater snails act as obligatory intermediate hosts for approximately 71 trematode parasites (Lu et al., 2018; Phiri et al., 2007). These parasites include members of the families Clinostomidae, Echinostomatidae, Fasciolidae, Schistosomatidae, Paramphistomidae, and Pronocephalidae (Tookhy et al., 2023; Saijuntha et al., 2021). In humans and animals, snails, for example, the *Bulinus, Biomphalaria, Lymñaea* and *Oncomelania* (Tookhy et al., 2023; Martin & Cabera, 2018; Dida et al., 2014; Dung et al., 2013) serve as the common intermediate parasitic hosts. Furthermore, according to Yahaya et al. (2017) and Greene (2018), some particular species of snails, for example, apple snails, constitute a major challenge as they can destroy rice plantations.

As reported by Lu et al. (2018), Prasopdee et al. (2015), and Tookhy et al. (2023), infections by some trematodes are an example of parasitic diseases transmitted by snails, and they represent an important health challenge to people and livestock, which can lead to socioeconomic losses. According to Martin and Cabera (2018), the exchange of nutrients between aquatic and terrestrial systems is being expedited by the roles played by some freshwater snails in the aquatic environment.

Among the foregoing is a critical fascioliasis disease by *Fasciola hepatica* and *Fasciola gigantica*, from which man and livestock suffer (World Health Organization [WHO], 2020). Almost two million and four hundred thousand people in about 700 nations of the world, by estimation, are victims of fascioliasis (WHO, 2018). In the same vein, other zoonoses and neglected tropical diseases, such as schistosomiasis, kill about 200 million people yearly, affect around 230 million individuals, and more than 700 million people are at higher risk of being infected globally (Colley et al., 2014; WHO, 2016). The diagnosis of schistosomiasis has been made more difficult by the massive human population drift to the western part of the globe.

Although there are reports on human and livestock trematode infections in Malaysia, there is, however, grossly inadequate research that specifically addresses the role and impact of snails in the transmission of this parasite. Attwood et al. (2005), Greer et al. (1988), and Tookhy et al. (2023) have documented the significance of human medical and veterinary trematodes. In-depth findings into the roles played by snails in the transmission of this parasite in the environment are lacking. This is a knowledge gap that has hampered the proper understanding and implementation of appropriate snail control measures to manage and prevent disease transmission.

Therefore, this work aims to provide a comprehensive overview of Malaysian freshwater snails and their role as intermediate hosts in the transmission of trematode parasites. By a critical review of the ecology and epidemiology of freshwater snails, their importance in human and livestock health will be discussed, as well as specific control measures.

OVERVIEW OF TREMATODE INFECTIONS IN MALAYSIA

Different species of trematodes, such as *Fasciola* spp., have been documented in various locations and have been encountered in many states in Malaysia. Among the cattle in Terengganu, and according to studies by Khadijah et al. (2017), Rita et al. (2017), and Saad et al. (2019), *Fasciola* infection has been established and reported; the infection has also been established in buffalo along with cattle in Sabah (Kamaruddin et al., 2021). In Pahang, as documented by Rosilawati et al. (2017), *Fasciola* infections were predominant in buffalo, while the study of Diyana et al. (2020) has reported the infection in cattle and buffalo in Selangor and Perak. In Kuala Lumpur, *Fasciola* infections have been reported in humans by Naresh et al. (2006). Infection by the rumen fluke has been reported in cattle and buffalo from Terengganu (Kahdijah et al., 2021; Rita et al., 2017; Saad et al., 2019); Sarawak (Harizt et al., 2021) and Perak (Tookhy et al., 2024). Furthermore, in Perak, a 2% mortality rate was reported among local cattle (Debbra et al., 2018), and in Johor, among buffalo (Jamnah et al., 2013). Infection due to *Paragonimus westermani* was documented in Selangor when *Brotia costula* was established as an intermediate host (Kim, 1978); this infection has also been found in tigers in Selangor (Lee, 1965).

Schistosoma spp. infections have been documented across different regions and hosts, with *Schistosoma malayensis* infections in humans reported in Selangor and Pahang, the latter also showing infections with *Robertsiella* spp. (Attwood et al., 2005; Greer et al., 1988; Latif et al., 2013). *Schistosoma japonicum* infections have been observed in humans in Peninsular Malaysia (Greer & Anuar, 1984), while a variety of *Schistosoma* spp. and other trematodes have been reported in wildlife, with no associated mortality. Notably, the intermediate host is unknown in Malaysia for most of the above trematodes.

The overview of the pattern of distribution and identification methods, comprising conventional morphological assessment and molecular analyses such as polymerase chain reaction (PCR), for different species of snails found in various aquatic ecosystems across Malaysia is shown in Table 1. Details such as species nomenclature, geographical location, preferred habitats (wetlands, rivers or streams), and identifiable types of cercaria, where possible. Notably, this study from Peninsular Malaysia highlighted a relatively small

Table 1
Snail species reported in different water resources based on different methods and their larval stage

Snail	Location	Water resources	Cercarial	Identification	References
Radix rubiginosa	Perak	Wetlands	*Echinostome, gymnocephalus, xiphidiocercariae, furcocercous*	Morphological ID and PCR (COI)	Tookhy et al. (2023)
Robertsiella silvicola	Perak	Stream	*Furcocercous cercaria*	Morphological ID	Attwood et al. (2005)

Table 1 *(continue)*

Snail	Location	Water resources	Cercarial	Identification	References
Brotia costula	Kuala Lumpur	Stream		Morphological ID	Kim (1978)
Melanoides tuberculata *Brotia costula* *Thiara scabra* *Pila ampullaceal* *Bithynia* *Pygmaea* *Stenothyra cambodiensis* *Gyraulus chinensis* *R. gismanni* *R. kaporensis*	Perak	Stream			Attwood et al. (2005)
Pomacea maculata *Pomacea canaliculata*	Peninsular	Rivers, streams, lakes, ponds	-	PCR (COI)	Hah et al. (2022)
Pomacea maculata *Pomacea canaliculata*	Selangor	Wetlands	-	PCR (COI)	Phoong et al. (2018)
P. canaliculate *P. maculata*	Peninsular	Pond, lakes, rice fields	-	SM and PCR (COI)	Rao et al. (2018)
Pomacea maculata	Selangor,	Rice fields	-	Morphological ID	Arfan et al. (2014)
Pomacea canaliculata	Perak, Penang, Kedah and Kelantan				
Physella acuta *Indoplanorbis exustus* *Melanoides tuberculata* *Sinotaia guangdungensis* *Pila ampullacea* *Pila scutate* *Clea bangueyensis* *Neritina pulligera* *Septaria porcellana* *Vittina variegate* *Coromandeliana* *Sulcospira pageli* *Paludomus everetti* *Paludomus luteus* *Mieniplotia scabra* *Tarebia granifera*	Sabah	Different water bodies	-	Morphological ID	Ng et al. (2017)

number of freshwater snail species, with only 15 species identified through a combination of molecular and morphological approaches. Through morphological evaluation, 17 species were identified in Sabah, a region in Malaysia rich in a variety of freshwater snails. It was observed that cercarial types were reported in only two species, *R. rubiginosa* and *R. silvicola*, suggesting that they play a role in Malaysian freshwater ecosystems. All the cercaria reported are zoonotic, suggesting they are of public importance.

THE IMPORTANT SNAIL FAMILIES PRESENT IN MALAYSIAN FRESHWATER ENVIRONMENTS

Family: Lymnaidae
Genus: Lymnea
Species: *Radix rubiginosa*

Earlier, the presence of *R. rubiginosa* and cercariae in the wetlands of Perak was established using both morphological and molecular (PCR, ITS2) methodologies by Tookhy et al. (2023). The identification of cercariae, such as *Echinostome, Gymnacephalous, Xiphidiocercariae,* and *Furocercous,* corroborates the ecological diversity within this environment (Tookhy et al., 2023). Additionally, Tookhy et al. (2023) have reported that *R. rubiginosa* can accommodate the larval stage of *Schistosoma* spp., which causes human cercarial dermatitis in Malaysia. The freshwater snail of the *Lymnaeidae* family has gained enormous interest because of its involvement in the life cycle of different trematodes, which have great biomedical and veterinary importance (Bargues et al., 2016; Saijuntha et al., 2021).

Family: Pomatiopsidae
Genus: Robertsiella
Species: *Robertsiella silvicola*

As reported by Attwood et al. (2005), the small size, lack of a defined spiral macrosculpture on the shell, and distinctive style characteristics are suggestive of *R. silvicola,* differentiating it from other species in the *Robertsiella* genus. This species of snail can be found in different aquatic environments ranging from diminutive, spring-fed, first-order streams to meagre rivulets originating from forest hillsides. The occurrence of this snail species is restricted to limestone regions surrounding the mountainous bases of the Perak and Kedah states in West Malaysia. It is important that *R. silvicola* display affinity to serve as an intermediate host for the parasitic blood fluke *S. malayensis* that infects humans and livestock (Attwood et al., 2005).

Family: Ampullariidae
Genus: Pomacea
Species: *Pomacea maculata* and *Pomacea canaliculate*

It has been reported that *Pomacea maculate* and *P. canaliculate* have been isolated in diverse bodies of water such as streams, rivers, lakes, wetlands and ponds within Peninsular

Malaysia (Hah et al., 2022; Rao et al., 2018) as well as in Selangor (Arfan et al., 2014; Phoong et al., 2018). In this study, PCR (COI) confirmed the presence of these two species of snails, suggesting that they can adapt and be found in various ecosystems.

The financial loss and damage caused by apple snails in rice farming are enormous; hence, their management has taken centre stage (Yahaya et al., 2017). The feeding patterns of these two snail species, which consume aquatic plants, thereby altering the food chain, may significantly impact the community structure, water quality, and functionality of aquatic ecosystems in wetlands (Horgan et al., 2014).

Family: Thiaridae
Genus: Melanoides
Species: *Melanoides tuberculate*

The *M. tuberculate,* commonly known as red-rimmed Melania or the Malaysia Trumpet Snail (Müller, 1774), is a benthic freshwater gastropod of the *Thiaridae* family. According to a report by Krailas et al. (2014), *M. tuberculate* is indigenous to Asia and Africa. Naturally, this species is widely distributed, including Africa, the East Indies, southern Asia, northern Australia, Madagascar, the Mediterranean, and the Pacific Islands (Maciaszek et al., 2019; Facon et al., 2003).

The presence of *M. tuberculata* (Müller, 1774) has been documented by Piechocki et al. (2003) in Europe (Hungary, Germany, Malta, the Netherlands, Spain and Austria), where it has been identified as an intermediate host for many trematode species, some of these trematodes are of paramount importance in human and livestock health (Francis, 2012; Lopes et al., 2021; Post et al., 2022).In Malaysia, and as documented by Ng et al. (2017), the prevalence of *M. tuberculata* cut across various regions, such as offshore islands like Tenom, Kota Kinabalu, Tuaran, Pulau Gaya, Tawau, Pulau Tiga, Kota Belud, Pulau Bodgaya near Semporna, and Pulau Bohey Dulang. It inhabits rivers, paddy fields, and man-made concrete drains.

Family: Planorbidae
Genus: Indoplanorbis
Species: *Indoplanorbis exustus*

Indoplanorbis exustus is widely found throughout Southeast Asia, especially in rice plantations, and it plays the role of an intermediate host for some trematodes (Dumidae et al., 2024; Bawm et al., 2022; Nguyen et al., 2022). Following harvest, farmers often introduce ducks into their rice fields to consume these snails, thereby facilitating the maintenance and completion of the parasitic trematode life cycle through a zoonotic route. Thailand has reported a notable prevalence of *Echinostoma* infections in free-ranging ducks, as documented by Saijuntha et al. (2013). *Indoplanorbis exustus* also act as intermediate host of furcocercous cercaria (*Schistosome cercariae*) (Dumidae et al., 2024). In Peninsular Malaysia, this species has been demonstrated to harbour *S. spindale*, which is responsible for causing cercarial dermatitis in humans who become infected (Chiew et al., 2009).

ROLE OF SNAILS IN AGRICULTURE

Freshwater snails exhibit a dual role in agriculture, beneficial and detrimental, depending on the context. Economically, they are valued in rural communities as a source of food and traditional medicine (Gupta & Khanal, 2024). Nonetheless, a species such as *Pomacea canaliculate,* commonly called the golden apple snail, is a stubborn pest and a threat to agricultural success, predominantly in rice cultivation, by extensively damaging the shoots of young rice plantations, which results in a gross reduction in crop yields (Joshi et al., 2020). The combination of these roles highlights the complication of their impacts on the environment and the economy.

Yusa et al. (2006) have highlighted that *Pomacea canaliculata* is a main pest in Southeast Asia; however, it is less encountered, with less associated damage in other regions with lower annual precipitation, like parts of South Asia. Variations in climate, crop management, or the presence of a predator could have been the reason for this. Therefore, this suggests that the environment and geographical locations might have meaningfully impacted the level of infestation and resultant damage occasioned by freshwater snails.

Considering the level of loss in high-yielding crops, as reported by Kumar (2020) and Yusa et al. (2006), this urgently calls for effective and operational control measures. However, the differences in loss levels across regions and studies could be attributed to variations in farming systems, snail population densities, and mitigation strategies. For instance, integrated pest management methods that incorporate natural predators and manual removal are promising in reducing infestations (Thakuri et al., 2019). The report states that snails contaminate agricultural by-products with zoonotic parasites after they have damaged the by-product (Kumar, 2020). In the area of food security and livestock health, this perspective could have broader implications, especially in resource-limited settings. It is believed that if this study is compared with other studies on the dynamics of parasite transmission in other snail species, there could be better clarity. Unexpectedly, some studies have reported increased snail populations during dry spells within the rainy season (Faiz, 2010). It could indicate adaptive behaviour or resilience in certain species, necessitating further research on the triggers and ecological factors that enable such growth.

One potential strategy for mitigating the negative impacts of freshwater snails while leveraging their benefits involves utilising them as food and animal feed sources. This approach reduces their population and provides economic incentives for farmers. There could be better insights if studies on the nutritional and economic feasibility of snail-derived feed were compared against those of traditional livestock feed.

THE ROLE OF SNAIL IN MEDICINE AND VETERINARY PRACTICE

From time immemorial, snails have been known for their potent therapeutic properties, principally in traditional medicine. For instance, the mucus of some snail species, such as *Helix aspersa* and *Eremina desertorum,* is rich in bioactive compounds that have anti-inflammatory and antimicrobial effects by regulating transforming growth factor beta 1 (TGF-β1) and vascular endothelial growth factor (VEGF) gene expression that promotes wound healing (El-Zawawy & Mona, 2021). Also, Noothuan et al. (2021) have reported the antibacterial, antioxidant, and anti-tyrosinase properties demonstrated by mucus from *Hemiplecta distincta* and *Lissachatina fulica*, while available documents on *Helix aspersa* show it is effective in the treatment of gastric ulcers and reduction of oxidative stress, inflammation, and skin conditions (Gugliandolo et al., 2021).

Furthermore, lipids in *Bellamya benghalensis*, comprising oleic acid and cyclopropane fatty acids, possess anti-inflammatory potential for managing immune-related diseases, such as rheumatism, through the modulation of macrophage activity (Bhattacharya et al., 2014). Antimicrobial properties against infection, such as whooping cough, have been demonstrated in snail meat (Cobbinah et al., 2008). Furthermore, cancer-combating potential has been raised in the mucus of *Achatina fulica* (EFSA Panel on Nutrition, Novel Foods and Food Allergens et al., 2024). However, concerns about the consistency and safety of *Helix aspersa* maxima mucus as a novel food, according to the European Food Safety Authority (Adeyeye et al., 2020). Despite these challenges, snails are promising for medicinal purposes and as a novel food or feed source.

In animal production, snails can serve as an unconventional protein source, as they can be raised on low-grade biowastes and bioresources (Pathak et al., 2024). Therefore, they are a valuable and sustainable option for animal feed, as they reduce reliance on conventional feed resources (International Feed Industry Federation, 2021). Conversely, these snails also serve as a reservoir for zoonotic parasites and other pathogenic microbes, constituting health threats such as Fascioliasis, Schistosomiasis, Angiostrongyliasis and microbial diseases like Gastroenteritis and Rat-bite fever (Tookhy et al., 2024; Pathak et al., 2024). Specifically, ruminants and humans are susceptible to liver fluke disease (Lee et al., 2017). While snail farming presents opportunities for sustainable food and feed production, these health risks will necessitate careful and effective management to ensure the safe commercialisation of snails.

GENETIC CHARACTERISATION OF SNAIL

The extinction of some species has been a continuous event in the long history of nature, driven by various natural processes and human activities (Ceballos et al., 2017; Barnosky et al., 2011). Currently, the five leading drivers of species extinction are well-documented: habitat loss, invasive species, exploitation, disease, and climate change (Sodhi et al., 2009).

The most diverse group of animals, next to arthropods, is the molluscs, which are principally vulnerable, with an estimated number of known species falling between 70,000 and 120,000. The International Union for Conservation of Nature (IUCN) Red List has documented about 83,125 mollusc species, out of which 8,934 have been evaluated, with about 2,340 species (11%) currently on the verge of extinction (Chapman, 2009; IUCN, 2021).

Freshwater snails are a critical component of marine bionetworks. However, their environment is highly fragile, and coupled with the rising pressures due to man's activities, they can easily become extinct (Johnson et al., 2013; Strayer & Dudgeon, 2010). For example, lymnaeid snails display considerable eco-phenotypic plasticity with highly varying shell morphology, which is intensely affected by the environment (Hurtrez-Bouss et al., 2005). This variability can confound the taxonomy using only shell characteristics, as morphological variations may lead to misclassification (Vinarski et al., 2020).

The standard tools for accurately identifying species, particularly when morphological characteristics are insufficient, are molecular phylogenetics and molecular taxonomy (Japa et al., 2021). The commonly employed genetic markers like the internal transcribed spacer 2 (ITS2), mitochondrial cytochrome c oxidase subunit I (COI) and 16s rRNA genes were known to be reliable in the study of lymnaeid snails (Tookhy et al., 2023; Japa et al., 2021). These are valuable molecular markers for species identification, investigating genetic divergence, and understanding the structural relationships within snail populations. This methodology offers a more accurate and reliable understanding of the taxonomy and genetics of freshwater snails (Mirfendereski et al., 2021; Vinarski et al., 2020).

SNAIL CONTROL

Methods for the control of snails include physical, chemical, and biological methods (Lu et al., 2018). Physical control measures target the reduction of snail populations by effective management of the environment (Garba Djirmay et al., 2024). For example, the removal of natural bodies of water, like the marshes and ponds, and controlling human settlements in high-risk zones are effective approaches. In other areas, the spread of *Schistosoma haematobium* and *Schistosoma japonicuma* has been significantly brought low employing appropriate drainage systems and environmental engineering, such as upsetting epilithic snail habitats by the use of boat-mounted rototillers or tractors with rakes, which is also effective in eliminating a substantial portion of snail populations (Li et al., 2016). Other methods, such as removing bird roosting sites, introducing mechanised farming, and rotating between aquatic and xerophytic crops, help further reduce snail populations (Leighton et al., 2000).

In chemical control, molluscicides are a widely used method since they rapidly decimate snail populations, thereby reducing disease transmission (Xia et al., 2014). However, its long-lasting effect is a function of sustained application (Maes et al., 2021).

Chemical control measures typically involve the use of synthetic or natural molluscicides, and this is one of the most effective methods for managing snail populations (Xia et al., 2014). Since the 1950s through the 1970s, compounds such as sodium pentachlorophenate (NaPCP), copper sulfate, Ntritylmorpholine, and niclosamide (Bayluscide) were widely used, especially in the control of snails responsible for the transmission of schistosomiasis in regions of Asia, Africa, and South America (King et al., 2015).

The biological control of molluscs is a more sustainable approach, where natural predators, parasites, or competitors to subdue the number of snails are introduced (Younes et al., 2017). Predatory fish, ducks, or some kind of insects can be employed to control the snail population; nonetheless, success is a function of the availability of appropriate predators and the ability to maintain ecological balance (Sokolow et al., 2015). Predatory prawns, like *Macrobrachium vollenhoveni*, have been used to reduce infected snails and schistosomiasis transmission in Senegal (Sokolow et al., 2014). The water bug Sphaerodema urinator and black carp (*Mylopharyngodon piceus*) have been reported to effectively control snails that host parasitic diseases (Younes et al., 2017). Even though these techniques display potential, careful management is required to prevent negative impacts on human health. Biological control benefits humans and the environment (Hung et al., 2013).

CONCLUSION

This literature review on freshwater snails and trematode diseases in Malaysia has highlighted the complex roles these snails play in human and animal health, as well as in agriculture. The findings of this study underscore the multiplicity of snail species in the region and their association with diverse trematode infections, including zoonotic parasites. Moreover, the economic importance of certain snail species in agriculture stresses the need for effective control procedures to prevent the spread of risks. Conversely, despite advancements in medical treatments for trematode diseases, preventive schemes that target intermediate hosts are of great importance, given the complexity of transmission dynamics involving the final hosts. The paucity of research centred on snails as intermediate hosts suggests an essential area for further exploration to improve the understanding of disease transmission, hence facilitating concerted control efforts. Employing integrated control methods, physical, chemical, and biological, can help avoid the negative impacts of snails while promoting sustainable practices. A well-adjusted approach is fundamental to maximising the benefits of freshwater snails while minimising their challenges.

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