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Indoplanorbis exustus: A Systematic Review on an Intermediate Host for Trematode, Its Cercarial Infection and Identification of Its Cercariae

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Abstract

This systematic review examines Indoplanorbis exustus as an intermediate host for trematodes, with a particular focus on cercarial infections and the identification of its cercariae. Trematode parasites, which rely on various intermediate hosts to complete their life cycle, commonly utilize freshwater snails such as Indoplanorbis exustus as hosts for their larval stages. These snails become infected with trematode larvae, which subsequently develop into cercariae that are released into the surrounding environment, where they can infect definitive hosts. Understanding the dynamics of cercarial infections in Indoplanorbis exustus is crucial for unraveling the transmission patterns of these parasites, which is essential for both public health and ecological management. This review provides a comprehensive analysis of existing literature on Indoplanorbis exustus as a host for trematode species, with a particular emphasis on the prevalence, morphological characteristics, and genetic markers of the cercariae produced by this snail species. The review synthesizes key findings related to the distribution of cercarial infections in various geographical regions and ecological contexts, offering insights into how environmental factors such as water quality, temperature, and host density influence the prevalence and survival of cercariae. Moreover, the morphological and genetic identification of Indoplanorbis exustus cercariae is explored, providing a foundation for more accurate diagnosis and monitoring of trematode infections. This knowledge is invaluable in improving our understanding of trematode epidemiology and in designing more effective control strategies to reduce the transmission of these parasitic infections in human and animal populations.

Keywords: *Molluscan Parasitology, freshwater Snail, Indoplanorbis exustus, Cercarial Infection.*

Introduction

The intricate and fascinating world of parasitology continues to unveil hidden facets of life cycles, interactions, and adaptations that occur within the realm of parasitic organisms. Among the numerous hosts and parasites, freshwater molluscs play a pivotal role as intermediate hosts for various trematode species (Giari et al., 2022; Laidemitt et al., 2019). One such mollusc, *Indoplanorbis exustus*, has garnered considerable attention in recent years due to its pivotal role in the life cycle of several medically and veterinary vital trematodes. *Indoplanorbis exustus*, commonly known as the Indian ramshorn snail, is a freshwater gastropod mollusc that inhabits a wide range of aquatic ecosystems across the Indian subcontinent and neighbouring regions. Its significance lies in its role as an intermediate host for a diverse array of trematode parasites, making it an essential subject of scientific inquiry. Understanding the life cycle of these parasites, particularly the cercarial stage within *Indoplanorbis exustus*, is critical for comprehending the epidemiology and transmission dynamics of trematode diseases in both human and animal populations (Liu et al., 2010).

This systematic review aims to provide a comprehensive overview of the current state of knowledge regarding *Indoplanorbis exustus* as an intermediate host for trematodes, with a particular focus on the mechanisms of cercarial infection within this snail species. Additionally, we will explore the techniques and methods employed in the identification and characterization of cercariae that emerge from *Indoplanorbis exustus*, shedding light on the taxonomy and diversity of these parasitic organisms.

Through a critical examination of the existing literature, this systematic review seeks to contribute to our understanding of the intricate relationships between *Indoplanorbis exustus* and trematode parasites, ultimately advancing our knowledge of the transmission dynamics and potential control strategies for these medically and economically important pathogens (Anucherngchai et al., 2016; Anucherngchai et al., 2017).

Type of Cercaria in Fresh Water Snails

These findings from a field study conducted by Jabal and colleagues 2022, investigating trematode infections in snail species collected from Tunggu Pampang Reservoir in Manggala Sub-district, Makassar. A total of 500 snails were examined, representing five distinct genera: Ampullariidae (*Pila* sp.), Viviparidea (*Bellamya* sp.), Lymnaeidae (*Lymnaea rubiginosa*), Planorbidae (*Indoplanorbis exustus*), and Thiaridae (*Melanoides* sp.). Notably, all snail species were found to harbor trematode larvae, indicating their role as intermediate hosts. The overall prevalence of snails infected with cercariae was determined to be 33.4%. This study sheds light on the prevalence and potential epidemiological significance of trematode infections within these snail populations, serving as valuable baseline data for further research and control efforts (Jabal et al., 2022; Yumnam et al., 2024).

The other findings of a comprehensive study conducted by Thapana Chontananarth and Wongsawad, focusing on cercarial infections in snail intermediates. A total of 2,479 snail individuals, belonging to 7 families, 11 genera, and 14 species, were collected and examined. Among these, 8 snail species exhibited infections with an overall prevalence rate of 17.27% (428/2,479). These infections were attributed to nine distinct cercarial groups, including gymnocephalous cercaria, strigea cercaria, megalurous cercaria, monostome cercaria, parapleurolophocercous cercaria (*Haplorchis cercaria*), pleurolophocercous cercaria, furcocercous cercaria (*Transversotrema cercaria*), xiphidiocercaria, and virgulate cercaria. Notably, parapleurolophocercous cercaria emerged as the dominant type, accounting for 64.25% of cercarial infections within the snail population. This review provides valuable insights into the diversity and prevalence of cercarial infections in snail intermediates, contributing to our understanding of parasite transmission dynamics (Chontananarth, and Wongsawad, 2013).

The medical importance of *Indoplanorbis exustus*:

The freshwater snail *Indoplanorbis exustus* is a significant source of intermediate host for several trematode parasites, making it an important player in the transmission of Schistosoma nasale Rao, 1933 and Schistosoma Spindale (Montgomery, 1906; Subba Rao, 1989). as well as other trematodes like Echinostoma spp. and some spirorchids. It is the sole member of its genus and can be found across the tropics. While other snails have been implicated in the transmission of these three Schistosoma spp., I. exustus is the most important host for S. nasale and S. Spindale, as well as for S. indicum in certain regions. In fact, on the Indian sub-continent, I. exustus may be the only natural intermediate host for these three Schistosoma species. It's worth noting that the three Schistosoma species are parasites of Artiodactyla, which includes buffaloes, cows, goats, pigs, and sheep. Two of the species cause intestinal schistosomiasis, while S. nasale inhabits blood vessels of the nasal mucosa and causes "snoring disease" in cattle. As such, surveillance for cattle schistosomiasis is generally inadequate, and while the literature on the subject is limited, past small-scale studies provide some insight into the problem.

I. exustus, a cattle-borne parasite, has been found to have a significant impact on human populations in a number of countries. In India, Laos, Malaysia, and Thailand. *I. exustus* has been linked to outbreaks of cercarial dermatitis, a skin rash caused by an allergic reaction to larval schistosomes (cercariae) shed by infected snails into freshwater bodies like lakes, ponds, and paddy fields. The cercariae cause pruritis and popular eruptions, which can lead to severe secondary infections. This occurs as the cercariae attempt to infect a non-permissive definitive host and ultimately die in the skin. While I. exustus may primarily affect cattle, it is clear that this parasite has significant implications for human health in certain regions.

The historical biogeography of *Indoplanorbis exustus:*

The Lymnaeae and Planorbidae species have been studied for their evolutionary relationships and it appears that they may have shared a common ancestor in the Permian, which is believed to have been around 250 million years ago based on fossil records (Remigio and Blair, 1997). Interestingly, there have been fossils of Planorbinae and Bulininae found in mid to upper Cretaceous rock formations in Africa and India (Newton, 1920). It is believed that the Tethys Sea separated Africa and Laurasia until 10-5 million years ago (Smith et al., 1994). This led Meier-Brook in 1984 to suggest that Indoplanorbis likely originated in Africa (Gondwanan) and then moved to Asia via rafting on the northward migrating Indian craton since the Cretaceous. This author also considered the possibility of a Europe to Southwest Asia tract or an Africa to South India dispersal (Meier-Brook, 1984). In contrast, Morgan et al. in 2002 attributed the occurrence of Indoplanorbis in India to colonization from Africa via the Middle East land connection (Morgan et al., 2002). Similarly, Attwood et al. in 2007 described a Sinai-Levant dispersal tract, from Africa to central Asia, for Schistosoma Spindale during the early Pleistocene. Clearly, the two different dispersal mechanisms imply very different chronologies. The Gondwanan vicariance hypothesis implies that proto-Indoplanorbis has been present in India since the late Eocene, which was approximately 35 million years ago during the India: Asia collision (Ali and Aitchison, 2008). On the other hand, the dispersal via the Sinai-Levant suggests that Indoplanorbis arrived in India during the Plio-Pleistocene era.

The assumption that the Indoplanorbis lineage has been present on the Indian craton since the Cretaceous period is questionable based on paleogeographic evidence. Throughout the Cenozoic era, there were several opportunities for Gondwanan taxa to disperse off India and into Asia. For instance, during the middle Eocene around 45 million years ago, greater India's northern corner came in contact with western Indonesia and later with Sumatra and Myanmar (Ali and Aitchison, 2008). Even before the Indian craton's hard collision with Asia (i.e., with the Lhasa block at 35 million years ago), faunal exchange was possible via volcanic arc terranes. Some of these

terranes formed exposed plateaus in the oceanic crust that subducted at the collision zone from around 130 million years ago onwards (McKenna, 1995). The presence of these terranes offers further evidence that the Indoplanorbis lineage may not have been present on the Indian craton since the Cretaceous period, as previously assumed.

Destruction of Eggs

The study conducted by Aditya and Raut investigated the destruction of *Indoplanorbis exustus* egg capsules through experimental trials involving *Pomacea bridgesi* of varying sizes. The results revealed size-dependent variations in the behaviour of P. bridgesi towards these egg capsules. Among *P. bridgesi* measuring 5–9 mm, only 20% of the trials resulted in damage to egg capsules, primarily through biting. In contrast, larger *P. bridgesi* (10–14 mm) exhibited varied responses, with some snails not touching the capsules at all, while others ruptured 2–6 capsules. Snails measuring 15–19 mm and 20–24 mm displayed more consistent egg capsule destruction, with size-dependent consumption rates. Similarly, snails in the 25–29 mm and 30–34 mm size classes demonstrated varying consumption and rupture patterns. These findings emphasize the influence of snail size on the destruction of *Indoplanorbis exustus* egg capsules by *Pomacea bridgesi* (Aditya and Raut, 2001; Aditya and Raut, 2002).

Survival and Emergence of Cercariae Larva

The survival and emergence of trematode cercariae are influenced by several factors, including the presence or absence of a definitive host, the presence of an intermediate host that serves as a distribution channel for parasitic organisms, flora and vegetations that act as food and shelter for parasites, and animal excreta that requires a source of water in which cercariae can migrate and reach their respective host. External factors such as the velocity of water current, changes in temperature, depletion of oxygen, an increase in the concentration of carbon dioxide, changes in the hydrogen ion concentration (i.e., pH value of water), salinity, and mineral contents of water also affect the number and survival rates of intermediate hosts, as well as the longevity of free-swimming miracidia and cercariae of certain trematode parasites (McCarthy et al, 2002; Burton and Thomas, 2019). Therefore, it is important to consider all these factors when studying the emergence and survival patterns of trematode cercariae.

The phylogeography of *Indoplanorbis exustus*

In their recent study, Liang Liu et al. 2002, has embarked on a captivating exploration of the radiation history of bulinine snails, shedding light on their evolution in South Asia. Their research, which delves into the late Miocene to mid-Pleistocene period, provides intriguing insights into the evolutionary dynamics of these organisms.
One of the most striking findings of the study is the indication of a radiation event that commenced in the late Miocene. This event marked the divergence of an ancestral bulinine lineage into two distinct clades: one in Assam and the other in peninsular India. This initial divergence sets the stage for a compelling narrative of evolution and adaptation in response to changing environmental conditions.

Perhaps one of the most significant discoveries made by Liu et al. 2010 is the emergence of a Southeast Asian clade from the peninsular India clade during the late Pliocene. This branching off into a new clade represents a pivotal moment in the evolutionary history of these snails, suggesting that environmental factors or geographic isolation played a crucial role in shaping their genetic diversity.

What truly captures the imagination, however, is the subsequent rapid radiation of the Southeast Asian clade. This clade's ability to proliferate and colonize various regions within the sampled range of Indoplanorbis during the mid-Pleistocene is a testament to its adaptability and resilience. This phase of rapid diversification paints a vivid picture of the evolutionary pressures these snails faced during this period.
Liu et al.'s research is not only a testament to the meticulous work of these scientists but also to the significance of studying the evolutionary history of seemingly unassuming organisms. By reconstructing the past, they have uncovered a rich tapestry of events that have shaped the genetic diversity of bulinine snails in South Asia (Liu, et al., 2010).

In conclusion, Liang Liu and his colleagues in 2010 have provided a captivating account of the radiation of bulinine snails, tracing their evolutionary journey from the late Miocene to the mid-Pleistocene. Their findings, particularly the divergence of clades and the subsequent rapid radiation, offer valuable insights into the dynamics of evolution in response to changing environmental conditions. This research serves as a reminder of the complex and fascinating stories that can be uncovered through the study of evolutionary biology.

Prevalence of snail's intermediate host infected with different trematodes cercariae

In their research study, Tigga and their colleagues 2014, have undertaken an extensive examination of 600 snails, encompassing different species, including Indoplanorbis, Gyraulus, Lymnaea spp., and Vivipara. Their objective was to assess the prevalence of trematode cercariae infection within these snail populations, using the cercarial shedding method as the primary screening technique (Tigga et al, 2014).

The findings of this study are both informative and enlightening. Out of the 600 snails examined, 44 snails, constituting 7.33% of the total sample, were discovered to be positive for various trematode cercariae. This highlights the presence of trematode infections in a substantial portion of the snail population studied, indicating the potential role of these snail species in the transmission of these parasites.

One notable aspect of the research is the breakdown of infection rates among the different snail species. Indoplanorbis spp. exhibited a prevalence rate of 7.22%, indicating a relatively consistent infection rate within this species. In contrast, Lymnaea spp. showed a slightly higher prevalence of 8.60%, possibly indicating a greater susceptibility or a different ecological role in trematode transmission. The most striking finding, however, is the high infection prevalence in Gyraulus spp., which recorded an infection rate of 14.67%. This observation may be

crucial in understanding the dynamics of trematode transmission and the ecological interactions within this particular snail population.

A particularly intriguing outcome of the study was the absence of trematode cercariae infection in the Vivipara snail species. This observation raises questions about the resistance mechanisms or ecological factors that might render Vivipara less susceptible to these particular trematodes. It also highlights the need for further investigation into the factors influencing trematode infections across various snail species.

In conclusion, the study conducted by Tigga et al., 2014, provides valuable insights into the prevalence of trematode cercariae infection within different snail species. The results not only contribute to our understanding of the epidemiology of these parasites but also underscore the importance of considering the ecological diversity of snail populations when studying disease transmission dynamics. This research serves as a valuable resource for future studies aiming to elucidate the intricate relationships between snail hosts and trematode parasites.

Recent range expansion of *Indoplanorbis exustus*

In their comprehensive study, Gauffre-Autelin et al., 2017, delve into the fascinating world of phylogenetic inference, shedding light on a cryptic species complex those challenges conventional morphological identification. Their findings not only reiterate the importance of genetic analysis in taxonomy but also offer valuable insights into the evolutionary history and biogeography of this enigmatic group.

One of the most striking revelations from Gauffre-Autelin and her colleagues in 2017, research is the identification of five highly divergent clades within what was previously considered a single, morphologically indistinguishable species. The genetic distances among these clades, ranging from 4.4% to 13.9%, strongly support the notion that this nominal species is, in fact, a cryptic species complex. This discovery underscores the limitations of relying solely on morphological characteristics for species classification.

The authors' exploration into the origins of this species group is equally intriguing. They suggest that it may have originated in the humid subtropical plains of Nepal or neighbouring southern regions during the Early Miocene. Furthermore, the study highlights the temporal coincidence of major cladogenetic events with significant periods of monsoonal intensification and paleogeographic shifts in the Miocene, as well as climate fluctuations during the Plio-Pleistocene epochs. This temporal alignment offers a compelling narrative of how environmental factors have played a pivotal role in shaping the evolutionary history of these organisms.

A particularly noteworthy aspect of this research is its coverage of the Indo-Australian Archipelago (IAA). The discovery of a single clade within this region is noteworthy, challenging previously held assumptions about the distribution of these organisms. It suggests a more complex pattern of colonization and dispersion than previously anticipated, underscoring the importance of studying the biogeography of cryptic species.

Surprisingly, the authors did not find any population genetic structure among islands within the IAA or along well-established zoogeographical regional barriers. This implies that the colonization of these islands may have occurred relatively recently, seemingly unaffected by natural biogeographical constraints. These finding challenges conventional expectations and opens up intriguing avenues for further research into the mechanisms and factors driving the dispersal of these organisms.

In conclusion, Gauffre-Autelin and her colleagues have provided a remarkable contribution to the field of evolutionary biology and biogeography. Their study not only identifies a cryptic species complex but also unravels its evolutionary history, shedding light on the intricate relationship between genetics, environmental change, and the distribution of species. This research serves as a reminder of the ever-evolving nature of taxonomy and the vital role that molecular techniques play in unravelling the complexities of life on Earth (Gauffre-Autelin, et al., 2017).

Result and Conclusion:

This study confirmed that Indoplanorbis exustus is an important intermediate host for various trematodes, including the *Schistosoma nasale*, *S. spindale*, and *Echinostoma* spp. *Indoplanorbis exustus* play an important role as intermediate hosts in the trematode life cycle, facilitating disease transmission to animal and human. The diversity of pathogenesis of cercarial infection and the genetic diversity of these organisms demonstrate their importance in infectious diseases. Understanding the virulence and evolutionary history of trematode parasite is essential for developing effective control strategies against them.

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Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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