Minireview Article

Infection of snail host with trematode larval stages in India: A minireview

Abstract:

Digenetic life cycle is very complex completing in ~~an intermediate and definitive hosts~~intermediate and definitive hosts. In trematode ~~parasite~~parasites, snails serve as the first intermediate host harbouring its larval stages such as sporocyst, redia and cercaria and the vertebral host servingas their definitive host. So,snail infection with trematodeparasite indirectly resultsin the infection of the definitive host including human. In India, limited studies are available on the infection status of snail ~~host~~ hostswith different trematodes larval stages. Most of the studies are confined ~~in~~tothe central India, a few from the southern region but almost no reports are available from the ~~north eastern~~northeastern states. But, native peoplesin some states of ~~north eastern~~northeastern India, usually ~~consumes~~ consumesnails as their delicacy. From the present analysis, there arises urgency for an extensive survey in the infection status of snail host with various parasites in every ~~corners~~ cornerof the country.

Keywords: Snails, trematode, cercaria, intramolluscan, India,

1. Introduction

India lies in the~~sub tropical~~sub-tropicalregion which has a rich flora and fauna. The environmenthasfavourable conditions for the growth and propagation of helminthic parasite thus they are highly diverse in nature. They are found parasitizing and infecting a wide range of vertebrate ~~host~~hosts. Most of the parasitic infections are highly concern as they pose ~~an~~ important public health issues, particularly in tropical and subtropical regions [1].

Among the helminth parasite, the digenetic trematode also known as flukes are common parasites of wild and domestic animals [2]. Some of them are medically important, as causing various~~disease~~diseasesin ~~human~~ humanssuch as paragonimiasis, Opisthorchis, Clonorchis, Schistosomiasis, fasciolosis, etc, especially in ~~south east~~south-east Asia countries [3,4,5]. The life cycle of digenetic trematode is very complex completing in one or more than one intermediate host depending on the type of species [6,7,8, 9]. In its life cycle, molluscs or freshwater snail serve as ~~a~~ thefirst intermediate host where its asexual reproduction occur, harbouring the larval stages- Radia, sporocyst, cercaria, metacercaria. The sexual reproduction of the parasite occur in vertebrate definitive host ranging from fish, ~~amphibian~~amphibians, reptiles, birds and mammals, thus ~~affecting~~affectingtheir health andcan even led totheir death [10, 11,12].

2. ~~Snail borne~~Snail-borne parasitic diseases (SBPD)

Snails are a good source of proteins and ~~,~~ minerals and have been used as ~~a food supplements~~food supplements. They inhabit in all forms of water bodies ranging from ponds, small streams, large lakes and rivers [13]. They ~~are consume~~are consumedwidely by the local population especially in south-East Asian countries as

a delicacy and also as a part of customary. Many freshwater snails have been harvested in Indo-Burma region for consumption process [14,15]. The digenean trematodes commonly used two major snails groups namely prosobranchs and pulmonates for completing their life cycle (16). In at least 71 species of trematode, snails in the group of *Lymnaea* are responsible for establishing their infection (17). So, they are highly significant medically as their consumption has been associated with various ~~food borne~~food-bornetrematodiasis (18). Among them, ~~snail borne~~snail-borne parasitic diseases (SBPD) are one of the major parasitic diseases which are clinically important and are widely prevalent particularly in underdeveloped countries. Because ~~of~~ the snails serving as an intermediate host for different trematode harbouring its larval stages have contributed important role in transmitting many helminthic diseases(19,20). SBPD has been reported in approximately 90 countries with millions of people are being infected. For some trematode species namely *A. cantonensis* and *S. mansoni*, snails are the only intermediate hosts, and for some species namely*C. sinensis, P. westermani, F. buski*, and *F. hepatica* snail host serve as the first intermediate hosts. These undergo several larval stages development within the snails, thus showing that the snail host are very important for the completion of their life cycle.

3. SBPD in India

In India, ~~snails~~snailsthat belong to a class of gastropodshave been reported ~~serving~~to serveas an intermediate host for parasites belonging to families Heterophyidae, Schistosomaitidae, Fascioledea, Opisthorchiidae, Cryptogonimidae, Echinostomatidae and amphistome (2, 21, 22,23,24,25). So, the presence and abundance of snail species in the region indicates the possibility of spreading trematode infection (26). Several workers have worked on the trematode intra-molluscan larval stages from different parts of India(26, 27,28,29; 30, 31; 32; 33,34, 35; 36; 37) and has observed infections with different kinds of trematode cercarial stage (amphistome, echinostome, furcocercous, gymnocephalous, monostome, xiphidiocercous etc.) and metacercariae (aspidogaster, echinostome, opisthorchid, plagirchiid, strigeid etc.).The information regarding trematode larval infection in freshwater snails islimited in the public domain (38).

SBPD is one of the neglected tropical disease which draw less attention by the helminthologist towards studying their prevalence, infection status, biology and other related aspects with the exception of some diseases like schistomiasis, fasciolosis, etc. So, helminthologists need to focus and carry out more work on mollusc which is a mandatory intermediate host in order to bring out the clear picture of snail borne infection status, their biology and understanding the relationship with other species.Better understanding of the snail biology explains the difference in parasites community among different snail species which are attributed due to host growth, reproduction and life span (39).In addition to the certain factors of the intermediate host, environmental factors which include light, temperature, water quality also affects the infection of digenetic trematode in intermediate host (40; 41).The population dynamics of the infected intermediate host determines the infection prevalence in the definitive host (42).

In this paper, data on the infection status of trematode larval stages in various snail host prevailing in different regions, states in India are surveyed. This analysis will brings out the status of the infection in different parts of the country. It will also brings out the gapsin research field needed to be addressed and focussed on, thus attracting the helminthology community in this field to give more importance.

4. Present State:

In India, very less information are available in the public domain on the occurrence of the intracellular larval stages of trematode in molluscan host. Most of the published reportsare mainly the two medically important two flukes: *Paragonimus*and *Fasciola.* In this study, review is done on the reports of trematode larval stages in different molluscan host in different parts of the country. It is depicted in**table 1**. The data used in the study are available in the public domain. The papers that had reported intramolluscan larval stages are cited in the reference section.

From the analysis, it appears that different types of cercariae from different families are found infecting different snail host (table 1). So, there is high probability that many infected snail host ~~are~~ remain unexplored. The studies on the intramolluscan larval stages of trematode parasite in India are mainly resptricted in Rajasthan, Kerela, Bihar, Tamil Nadu, UP, MP, Jharkhand, Maharashtra, Western Ghats, Malabar. But the studies on this ~~aspects~~ aspectare also very limited. In some states of North east region of the country, native peoples consumed snails as their delicacy and also as a part of their customs, but no research or studies are available in the region. So, this need to be focus by the helminthologist and correlate with any trematode infection in the region.

5. Perspective:

There is a need for ~~Neede~~d further research on the biology of the trematode, prevalence on the infection status, dominant parasite infection in the region. There are many untouched parameters in the parasite biology, their life cycle and the possible intermediate host which can serve as the intermediate host for SBPD. With this study, we can get the detailed biology of the life cycle of the parasites, and can even study the relation between the larval stages through in vitro studies. So far, no study has been carried out regarding the completes larval development in the lab. In present situation, there is limited information available regarding the SBPD although variety of snail species are available in the country and are also consumed as a food supplement. So, anextensive and detailed study of the biology of SBPDs and their relation with their intermediate hosts will help in understanding their geographical distribution and its expanding nature.

6. Conclusion

The present review on the larval stages in commonly edible freshwater ~~snails host~~snail hostsreveals that ~~helminthologist~~ helminthologistshave mainly focussed on only the cercarial spp. parasitizing the intermediate host in the Indian mainland. The most commonly reported cercaria include monostome, amhistome, echinostome, furcocercous, gymnocepahlous and xiphidiocercous. Studies are only restricted mainly in the mainland of the country, almost no information ~~are~~ isavailable in several ~~part~~ partsof the country, ~~north eastern~~northeastern states in particular. Also study on the biology of the larval stages and their association with the host are also lacking.It becomes a prerequisite to get the baseline information on the probable snail intermediate host, types of parasites and transmission types. So the scientific community need to focus to study on the various aspects on the host parasite relationship, their intensity of damaged caused by the parasite. Importantly need for extensive studies for finding the infection prevalence in every regions of the country, if any.

References

1. Lu XT, Gu QY, Limpanont Y, Song LG, Wu ZD, Okanurak K, Lv ZY. Snail-borne parasitic diseases: an update on global epidemiological distribution, transmission interruption and control methods. Infectious Disease of Poverty. 2018; 7: 28.
2. Schell SC. How to know the trematodes, Wm. C. Brown Company, Dubuque, Iowa. 1970.
3. Chai JY. Human Intestinal Flukes From Discovery to Treatment and Control, Springer Nature B.V., Dordrecht, Netherlands. 2019
4. Chai JY, Shin EH, Lee SH, Rim HJ. Foodborne intestinal flukes in Southeast Asia. The Korean Journal of parasitology. 2009; 47: S69-S102. doi: 10.3347/kjp.2009.47.S.S69
5. Hung N, Madsen H, Fried B. Global status of fish-borne zoonotic trematodiasis in humans. Acta Parasitologica. 2013; 58: 231-258. doi: https://doi.org/10.2478/s11686-013-0155-5.
6. Pandey K. Prevalence of Fasciolopsis in buffaloes in relation to *Fasciola* larvae infection in *Lymnaea* snails in DevbhumiBaluwa VDC of Kavre district [MSc thesis]. Kathmandu: Central Dept Zoology, Tribhuvan University. 2001; 58 p
7. Devkota R. Inventory of trematode cercariae infections in freshwater snails in Chitwan and Nawalparasi districts and trematodes infections in domestic elephants of Sauraha [MSc thesis]. Kathmandu: Central Dept Zoology, Tribhuvan University. 2008; 41 p
8. Karki K, Manandhar P. 2008. Incidence of gastrointestinal helminthes in captive elephants in wildlife reserves of Nepal. Articles base, Free Online Articles Directory.
9. Lotfy W, Brant S, Ashmaway K, Devkota R, Mkoji G, Loker L. A molecular approach for identification of paramphistomes from Africa and Asia. Veterinary Parasitology. 2010; 174(3–4): 234 – 240.
10. Sherchand JB, Ohara H, Sherchand S, Matsuda H. The Suspected Existence of Schistosoma mansoni in Dhanusha District, Southern Nepal. Annals of Tropical Medicine and Parasitology. 1999; 93(3): 273–278.
11. Yong TS, Sim S, Lee J, Ohrr H, Kim MH, Kim H. A small scale survey on the status of intestinal parasite infections in rural villages in Nepal. The Korean Journal of Parasitology. 2000; 38 (4): 275–277.
12. Poulin R, Cribb TH. Trematode life cycles: short is sweet? Trends in Parasitology. 2002; 18: 176-183. doi: 10.1016/S1471-4922(02)02262-6.
13. Ramitha UC, Vasandakumar MV. Survey of freshwater snails in Malabar, Kerala and an account on the prevalence of infection by digenean (platyhelminth) parasites. J. Chem. Bio. Phy. Sci. 2015; 5: 4.
14. Nagachinta A, Piamtipmanus M, Jivaluk J, Punyaganok W, Totanapoka J. Utilization of freshwater molluscs of Thailand. Bangkok, Thailand, Department of Fisheries, Ministry of Agriculture and Cooperative. 2005
15. Köhler F, Seddon M, Bogan AE, Tu DV, Sri-Aroon P, Allen D. The status and distribution of freshwater molluscs of the Indo-Burma region. 2012; pp. 66–88 in Allen DJ, Smith KG, Darwall WRT (Eds) Eds) The status and distribution of freshwater biodiversity in Indo-Burma. Cambridge, Gland, Switzerland, IUCN

16. Fretter V, Graham A. British Prosobranch Molluscs: Their Functional Anatomy and Ecology, Ray Society. 1962.
17. Soldanova M, Selbach C, Sures B, Kostadinova A, Pérez-del-Olmo A. Larval trematode communities in *Radix auricularia* and *Lymnaeastagnalis* in a reservoir system of the Ruhr River. Parasit. Vectors. 2010; 3: 56-68.
18. Madsen H, Hung N. Reprint of "An overview of freshwater snails in Asia with main focus on Vietnam". Acta tropica. 2014; 141. 10.1016/j.actatropica.2014.08.005.
19. Elsheikha HM, Elshazly A. Host-dependent variations in the seasonal prevalence and intensity of heterophyid encysted metacercaria (Digenea: Heterophyidae) in brackish water fish in Egypt. Vet. Parasitol. 2008; 153: 65-72.
20. Saijuntha W, Andrews RH, Sithithaworn P, Petney TN. Biodiversity of Human Trematodes and Their Intermediate Hosts in Southeast Asia. In Biodiversity of Southeast Asian Parasites and Vectors causing Human Disease. In: Petney, T.N., Saijuntha, W., Mehlhorn, H. (Eds) Parasitology Research Monographs. 2021; 14: 63 – 95. DOI: 10.1007/978-3-030-71161-0_4
21. Velusamy R, Singh B P, Raina O K. Detection of *Fasciola gigantica* infection in snails by polymerase chain reaction. Veterinary Parasitology. 2004; 120: 85–90.
22. Magalhaes K G, Jannotti-Passos L K, Caldeira R L, Berne M E, Muller G, Carvalho O S, Lenzi H L. Isolation and detection of *Fasciola hepatica* DNA in *Lymnaeaviatrix* from formalin-fixed and paraffin-embedded tissues through multiplex-PCR. Veterinary Parasitology. 2008; 152: 333–38.
23. Chontananarth T, Wongsawad C. Prevalence of *Haplorchistaichui* in field collected snails: a molecular approach. Korean J Parasitol. 2010; 48: 343-346.
24. Chontananarth T, Wongsawad C. Epidemiology of cercarial stage of trematodes in freshwater snails from Chiang Mai province, Thailand. Asian Pac J Trop Biomed. 2013; 3; 237-243.
25. Frandsen F, Christensen NO. An introductory guide to the identification of cercariae from African freshwater snails with special reference to cercariae of trematode species of medical and veterinary importance. Acta Trop. 1984; 41: 181-202.
26. Choubisa S.L. Snails as bio-indicators for dreaded trematodiasis diseases, J. Commun. Dis., 2010; 42(3), 223-226.
27. Ganpati PN, Rao KH. On anomalous emission of echinostome larval stages and their intra-redial encystment of cercariae in the snail, *Pila globosa* Swainson. Curr Sci. 1969; 37:19–20
28. Singh RN. Seasonal infestation of *Indoplanorbisexustus* (Deshayes) with furcocercous cercariae. Proc Natl Acad Sci India. 1959; 29:61–72
29. Mukherjee RP. Seasonal variation of cercarial infection in snails. J Zool Soc India. 1966; 18:39–45
30. Murty AS. Life cycle of Pseudodiplodiscoidespilai (Trematoda: Diplodiscidae) from the gut of the apple snail, Pila globosa (Swainson). J Parasitol. 1973; 59(2):323–326
31. Mohandas A. Studies on freshwater cercariae of Kerala. I. Incidence of infection and seasonal variation. Folia Parasit. 1974; 21:311–317.
32. Jain SP. Studies on amphistomes II. A survey of incidence and nature of amphistome infection in aquatic snail. Agra Univ J Res (Sci). 1976; 25:81–89.

33. Pandey KC, Agrawal N (1978) Larval trematodes and seasonal variations in snails of Kathauta Tal. Lucknow. Indian J Parasit. 1978; 2(2):139–143.
34. Choubisa SL, Sharma PN. Seasonal variations of cercarial infection in snails of Fateh Sagar Lake of Udaipur, Indian J. Parasit. 1983; 7(1), 111-113.
35. Janardanan KP, Shiny AC. Two new species of xiphidiocercariae from the apple snail, *Pila globosa* (Swainson) of Kerala. RivParasitol. 1989; 50:47–52.
36. Rajendran KV, Janardanan KP. Studies on the life cycle of *Tremiorchisranarum* Mehra and Negi, 1926. J Helminthol. 1993; 67:95–101.
37. Sanil NK, Janardanan KP. Two new species of xiphidiocercariae from apple snail *Pila virens* in Malabar. J Parasit Dis. 2016. doi:10.1007/s12639-015-0741-6
38. Choubisa SL. Focus on pathogenic trematode cercariae infecting fresh water snails (Mollusca: Gastropoda) of tribal region of southern Rajasthan (India). J Parasit Dis. 2008; 32(1):47–55.
39. Esch GW, Fernandez JC. Snail-trematode interactions and parasite community dynamics in aquatic systems: A review. The American Midland Naturalist. 1994; 131, 209-237. doi: 10.2307/2426248.
40. Fingerut J, Zimmer C, Zimmer R. Patterns and processes of larval emergence in an Estuarine parasite system. Biol. Bull. 2003; 205(2): 110.
41. Graham AL. Effects of snail size and age on the prevalence and intensity of avian *Schistosome* infections. J. Parasitol. 3003; 89(3): 458-63.
42. Chitsulo L, Engels D, Montresor A, Savioli L. The global status of schistosomiasis and its control. Acta Trop. 2000; 77: 41 – 51. DOI: 10.1016/s0001-706x(00)00122-4.
43. Choubisa SL. A gymnocephalous cercaria, Cercaria Johrii n. sp. from fresh water snail, *Melanoidestuberculatus* (Muller) of Fateh Sagar Lake, Udaipur (Rajasthan). Indian J Parasit. 1985; 9(2): 245–247.
44. Choubisa SL, Sheikh Z. Parasitic castration in freshwater snail *Melanoidestuberculatus* (Mollusca: Gastropoda). Proc Natl Acad Sci India Sect B: Biol Sci. 2013; 83(2):193–197. doi: 10.1007/s40011-012-0133-y.
45. Tigga MN, Bauri RK, Deb AR, Kullu SS. Prevalence of snail's intermediate host infected with different trematodes cercariae in and around Ranchi, Veterinary World. 2014; 7(8): 630-634
46. Bauri RK, Chandra D, Lalrinkima H, Raina OK, Tigga MN, Kaur N. Epidemiological studies on some trematode parasites of ruminants in the snail intermediate hosts in three districts of Uttar Pradesh, Jabalpur and Ranchi. Indian J Anim Sci. 2015; 85: 941-946.
47. Choubisa SL, Jaroli VJ, Sheikh Z. First record of a rare transversotrematid cercaria larva (Trematoda: Digenea) from Rajasthan, India: focus on seasonal occurrence and host-specificity of diverse cercariae. J Parasit Dis. 2017; 41(2):496–502.
48. Nagare KR, Dummalod CB. (2017) Cercarial diversity from vector snail Lymnaea acuminata from Aurangabad region, Maharastra India. IJRBAT. 2017; 1(V)
49. Sanil NK, Janardanan KP. Two new species of furcocercous cercariae infecting the fresh water snail, *Thiara tuberculata* (Müller) in Kozhikode and Malappuram districts of Kerala. J Parasit Dis. 2017; 41(4):1147-1152. doi: 10.1007/s12639-017-0951-1.

50. Sanil NK, Janardanan KP. Furcocercous cercariae infecting freshwater snails in Malabar: two new species from *Lymnealuteola* Lamarck and *Gyraulusconvexiusculus* (Hutton). J Parasit Dis. 2018; 42(2):220-225. doi: 10.1007/s12639-018-0987-x.
51. Arusha K, Prasadan PK. Two new species of furcocercous cercariae from freshwater gastropods of Western Ghats. J Parasit Dis. 2018; 42(4):621-629. doi: 10.1007/s12639-018-1045-4.
52. Arusha K, Prasadan PK. A parapleurolophocercous cercaria and a furcocercous cercaria from the freshwater gastropods of the Western Ghats. J Parasit Dis. 2019; 43(3):479-486. doi: 10.1007/s12639-019-01114-6.
53. Prasad YK, Dahal S, Saikia B, Bordoloi B, Tandon V, Ghatani S. (2019) *Artyfechinostomumsufrartyfex* trematode Infections in Children, Bihar, India. Emerging Infectious Diseases. 2019; 25(8). DOI: https://doi.org/10.3201/eid2508.181427
54. Sanil NK, Janardanan KP. Four new species of virgulate xiphidiocercariae infecting the freshwater snail, *Bithynia* (*Digoniostoma*) *pulchella* (Benson, 1836) in Malabar, Kerala. J Parasit Dis. 2019; 43(3): 368-378. doi: 10.1007/s12639-019-01100-y.
55. Anbarasu K, Rajagopal A, Lakshmanan B, Vinod Kumar K, Devada K, Thamil Bharathi LM. A study on echinostome infection in snail intermediate hosts in different habitats of Palakkad district, Kerala. J. Vet. Anim. Sci. 2020; 51 (1): 52 – 55.
56. Sanil NK, Janardanan KP. Three new species of virgulate xiphidiocercariae infecting the freshwater snails of Kerala. J Parasit Dis. 2020; 44(4): 772-780. doi: 10.1007/s12639-020-01240-6.

Table 1. Snail host infection with trematode larval stages from different parts of India.

Sr. No	Parasites	Larval Stage	Snail Host	localition	Reference
1	-A gymnocephalous cercaria, Cercaria johrii n. sp.	Cercaria	-*Melanoidestuberculatus*	Rajasthan (Fateh Sagar Lake, Udaipur)	43
2	- furcocercous - xiphidio, -monostome -gymnocephalous cercariae - sporocsyts contained numerous large sized active furcocercous cercariae	-Cercaria -Sporocyst	-*Melanoidestuberculatus*	-Rajasthan	44
3	-	-	-*Indoplanorbis*spp. -*Gyraulus*spp. -*Lymnaea* spp. - *Viviparas*pp	Jharkhand (Ranchi)	45
4	-*Fasciola gigantica*, -*Explanatumexplanatum*, -*Paramphistomum epiclitum*, -*Fischoederius elongatus* -*Schistosoma spindale*	Cercaria	-*Lymnaeaauricularia*, -*L. luteola*, -*Gyrausconvexiusculus* -*Indoplanorbisexustus*	-Uttar Pradesh (Meerut, Bareilly and Jhansi) - Madhya Pradesh (Jabalpur) - Jharkhand (Ranchi)	46
5	-Family: Transversotrematidae;	cercaria	-*Melanoidesstriatella tuberculate*	Rajasthan (Udaipur)	47

	transversotrematid cercaria; -Amphistome, - Echinostome, - monostome, - gymnocephalous, - furcocercous - xiphidiocercous		-pulmonate and operculate snails		
6	- *Fasciola hepatica* - *Plagiorchisvespectilionis* - *Echinostome sp.* - *Pseudoechinoparyphium* sp. -*Trichobilharziaocellata* - *Diplostomumhepaticum*	Cercaria	- *Lymnaea acuminata*	Maharashtra, Aurangabad	48
7	Two new species of -furcocercous cercariae	Cercaria	-*Thiara tuberculata*	Kerala (Kozhikode and Malappuram)	49
8	Two new species of -furcocercous cercariae	Cercaria	-*Lymnealuteola* -*Gyraulusconvexiusculus*	Malabar	50
9	Two new species of -furcocercous cercariae	Cercaria	-*Indoplanorbisexustus* -*Thiara tuberculata*	Western Ghats (Wayanad region)	51
10	Two new cercaria - parapleurolophocercous cercaria -furcocercous cercaria	cercaria	-*Digoniostomapulchella* -*Indoplanorbisexustus*	Western Ghats (Wayanad region)	52
11	*Artyfechinostomum sufrartyfex*	metacercaria	-*Pila globosa*	Bihar	53
12	Four new species of virgulate xiphidiocercariae	Cercaria	- *Bithynia* (*Digoniostoma*) *pulchella*	Kerala (Malabar)	54
13	Echinostome	Cercaria	-*Indoplanorbisexustus* -*Lymnaealuteola*	Kerala (Palakkad)	55
14	Three new species of virgulate xiphidiocercariae	Cercaria	-*Bellamya bengalensis* -*Thiara tuberculata*	- Kerala (Malappuram) - Kerala	56

			-*Paracrostomahuegelii*	(Wayanad)	