

Plants as Molluscicides: A recent update

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Abstract

Molluscs are responsible for causing the number of diseases in humans like abdominal pain, dysentery, bloody stools, urogenital and neurological disorders. Molluscicides, commonly used to control molluscs (snails, motts and slugs) are synthetic ones. These pesticides have high import cost and leads to various problems of toxicity in non-targeted organisms, also cause environmental hazards (destruction of fish, birds and other wildlife) and increase resistance among molluscs so plant molluscicides have gained importance because of their potent action, less resistance and greater biodegradable rate. In this review, an attempt has been made to signify the natural control of molluscs including plants extracts and secondary metabolites present in them. More than fifty plant drugs mentioned in tabular form in this review article and all this information have been incorporated from scientific databases.

Keywords: molluscs, plants, schistosoma

Introduction

Molluscs have been exploited by humans for centuries. They are the sources of luxury goods like pearls, sea-silk, tyrian purple dye ^[1] and chemical compounds ^[2] but are also obligate hosts for trematode parasites ^[3]. Trematodes (parasites) are responsible for infecting molluscs and spread infection in humans and animals ^[4,5]. Schistosoma is a cause for cholecystitis ^[6], hematuria ^[7], trigger erythrocyte cell death ^[8], bronchial inflammation ^[9] and hepatic functions ^[10]. Poor hygienic conditions and contaminated water make people more prone to infection. The Life cycle of schistosoma is completed in two stages in the human body and aquatic zone (Fig. 1). *B. tenagophila*, *B. straminea* and *B. glabrata* are prone to infection by trematode Schistosoma mansoni which is a causative agent for Schistosoma.

Cercariae and Miracidium are two larval stages involved in the life cycle of Schistosoma. Cercaria present in water enters into the human by penetrating skin and remains there for some periods then enters into the circulatory system. During this period cercariae find its infecting site (intestine, bladder) and hatched eggs there. These eggs penetrate into the lumen and excreted in faeces releasing Miracidium, which were the parasitic larvae of snail hosts ^[11]. Snail fever or schistosomiasis affect various countries like China ^[12], Africa, Latin America ^[13], Kenya ^[14], Mali ^[15] India ^[16], and Pakistan ^[17] hence become a major concern today. Considering this major problem scientists are trying to develop/design vaccines against *S. mansoni*, *S. haematobium* and *S. japonicum* as anthelmintic drugs to be used conventionally ^[18,19].

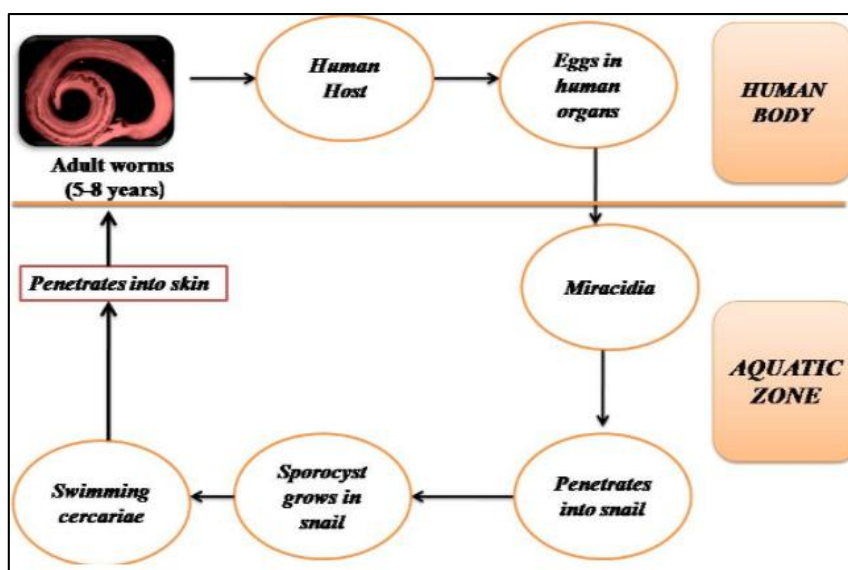


Fig 1: Stages in life cycle of schistosoma

Control over Molluscs: There are several methods to control population of molluscs, which includes cultural control,

physical barriers, chemical control and biological control ^[20]. **Cultural control:** These include agricultural or gardening

practices by maintaining moisture level and hygiene of soil and weed control.

Physical barriers: Snails and slugs inhabit in wet places only. Lines/rings of sawdust and super phosphate fertilizer act as physical barriers against molluscs and snails. The barriers of copper tapes (Fig. 2) act as repellent around pots and prevents snails and slugs climbing up hence protecting plants from any harm caused by them.



Fig 2: Copper slug tapes as physical barrier

Chemical control: These include synthetic as well as compounds derived from plant sources. Large numbers of synthetic compounds have been used to treat molluscs like poly-quaternary ammonium compounds, aromatic hydrocarbon, metals and their salts (iron phosphate, aluminium sulfate, ferric sodium EDTA), niclosamide etc. These synthetic compounds have high toxicity profile in comparison to the natural phyto-constituents and molluscs acquire resistance against them upon prolonged use whereas natural compounds, which are readily available are eco-friendly, biodegradable having very low toxicity profile and chances of developing resistance among molluscs are also very less.

Biological control: *Phasmarhabditis hermaphrodita* is facultative parasitic nematode that can kill slugs and snails thereby providing biological control over them.

Plant secondary metabolites as Molluscicides: There are several advantages of using plants as molluscicides over synthetic compounds (Fig. 3) Secondary metabolites in plants are used in form of extracts and are responsible for exhibiting molluscicidal action. Saponins present in the ethanolic

extract of *Tamarindus indica* bark exhibit significant inhibition in enzyme AChE (acetylcholinesterase), ACP (acid phosphatase) and ALP (alkaline phosphatase) in vector snail *L.acuminata* [21]. The latex of *Euphorbia umbellata* is rich in terpene compounds which are highly toxic to *Biomphalaria glabrata* [28]. Quercetin, ursolic acid and myricetin at a concentration of 100 ppm exhibit molluscicidal action too [29]. Alkaloids isolated from *Macleaya cordata* are highly toxic against vectors of Schistosomiasis [30]. Psilostachyin, psilostachyin B and axillaxin isolated from *Ambrosia artemisiifolia* were used in management of golden apple snails [31]. Acacetin-7-rutinoside isolated from *Buddleja lindleyana* exhibit molluscicidal action against *Oncomelania hupensis* [45]. Ferulic acid, umbelliferone, limonene and eugenol obtained from plants *Ferula foetida*, *Syzygium aromaticum* and *Carum carvi* were found to be active against *Lymnaea acuminata* [73].

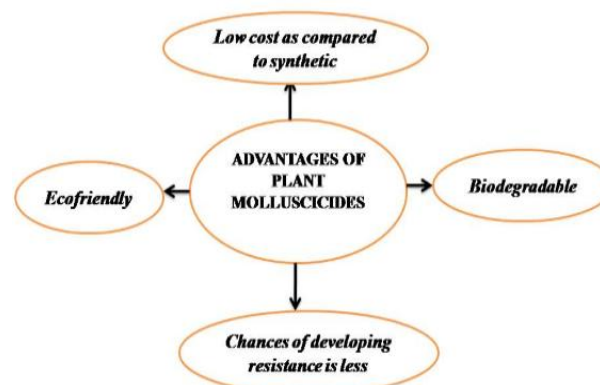


Fig 3: Advantages of plant molluscicides

The essential oil from Azorea plant species *Juniperus brevifolia*, *Laurua azorica*, *Hedychium gardnerianum*, *Psidium cattleianum*, and *Pittosporum undulatum* were shown molluscicidal activity [72]. Cardiac glycosides from leaves *Nerium indicum* also proved to have good molluscicidal compounds [70]. The LC₉₀ values of various plant extracts of *Jatropha elliptica* LC₉₀ 36.43 µg/dl [49], *Bidens pilosa* LC₉₀ 74.1 mg/ml, *Balanites aegyptiaca* LC₉₀ 77.70 120.04, 89.50, 97.55 mg/l [52], *Cymbopogon winterianus* LC₉₀ 97.0 mg/l [53], *Glinus lotoides* LC₉₀ 41.7 mg/l [48], *Phytolacca americana* LC₉₀ 26.1 mg/100 ml [69] were also found to be lethal against molluscs.

Table 1: Examples of plants as molluscicidal: Source of information: PUBMED

S. No.	Plant name	Part involved in study	Tested organism	Reference
1	<i>Tamarindus indica</i> , Fabaceae	Organic extract of ethanol bark	<i>Lymnaea acuminata</i>	[21]
2	<i>Achyranthes aspera</i> , Amaranthaceae	Hydroethanolic leaf extract	<i>Biomphalaria pfeifferi</i>	[22]
3	<i>Anagallis arvensis</i> , Primulaceae	Aqueous leaves extract	<i>Biomphalaria alexandrina</i> snails	[23]
4	<i>Solidago canadensis</i> Asteraceae	Petroleum ether fraction of the ethanolic extract petroleum ether	<i>Pomacea canaliculata</i>	[24]
5	<i>Avicennia schaueriana</i> Acanthaceae, <i>Laguncularia racemosa</i> Combretaceae, <i>Rhizophora mangle</i> Rhizophoraceae	Hydroalcoholic extracts were prepared from the stem and leaves	<i>Biomphalaria glabrata</i>	[25]
6	<i>Croton floribundus</i> Euphorbiaceae	Leaf and stem bark alcoholic extracts of the species	<i>Biomphalaria glabrata</i>	[26]
7	<i>Arisaema erubescens</i> Araceae	Water extract (or powder)	<i>Oncomelania hupensis</i>	[27]
8	<i>Euphorbia umbellata</i> Euphorbiaceae	Latex of the plant	<i>Biomphalaria glabrata</i>	[28]
9	<i>Manilkara subsericea</i> Sapotaceae	Crude extract and ethyl acetate fraction of leaves	<i>Biomphalaria glabrata</i> , <i>M. subsericea</i>	[29]
10	<i>Macleaya cordata</i> Papaveraceae	Leaves	<i>Oncomelania hupensis</i>	[30]
11	<i>Ambrosia artemisiifolia</i> Asteraceae	Aerial parts methanol extracts	<i>Pomacea canaliculata</i>	[31]

12	<i>Moringa oleifera</i> Moringaceae	Aqueous seed extract	<i>Biomphalaria alexandrina</i>	[32]
13	<i>Citrullus colocynthis</i> Cucurbitaceae	Leaf extract	<i>Galba truncatula</i> , <i>Fasciola hepatica</i>	[33]
14	<i>Pueraria peduncularis</i> Leguminosae	Root extract	<i>Pomacea canaliculata</i>	[34]
15	<i>Glycyrrhiza uralensis</i> , Leguminosae, Niclosamide	Aqueous solution	<i>Oncomelania hupensis</i>	[35]
16	<i>Atriplex inflata</i> , Chenopodiaceae	Aqueous solution	<i>Galba truncatula</i> , <i>Fasciola hepatica</i>	[36]
17	<i>Achyranthes aspera</i> , Amaranthaceae	Aqueous leaf extract	<i>Biomphalaria pfeifferi</i> , <i>Lymnaea natalensis</i>	[37]
18	<i>Solanum elaeagnifolium</i> Solanaceae	Methanolic extract of seeds	<i>Galba truncatula</i> , <i>Fasciola hepatica</i>	[38]
19	<i>Agave angustifolia</i> Asparagaceae, <i>Pittosporum tobira</i> Pittosporaceae	Dry powder	<i>Biomphalaria alexandrina</i> snails	[39]
20	<i>Moringa oleifera</i> , Moringaceae	Aqueous extract of flowers	<i>Biomphalaria glabrata</i>	[40]
21	<i>Jatropha gossypifolia</i> , Euphorbiaceae	Ethanol extracts from the stem, leaves, fruit	<i>Biomphalaria glabrata</i>	[41]
22	<i>Solanum nigrum</i> , Solanaceae	Aqueous and solvent extracts of mature leaves	<i>Lymnaea acuminata</i>	[42]
23	<i>Jatropha gossypifolia</i> Euphorbiaceae	Leaf and stem bark powder extracts	<i>Lymnaea acuminata</i>	[43]
24	<i>Cinnamomum camphora</i> , Lauraceae	Leaf extract	<i>Oncomelania hupensis</i>	[44]
25	<i>Buddleja lindleyana</i> Loganiaceae	Leaves	<i>Oncomelania hupensis</i>	[45]
26	<i>Eucalyptus camaldulensis</i> , Myrtaceae	Dichloromethane extracts of eucalyptus	<i>Oncomelania hupensis</i>	[46]
27	<i>Eucalyptus globulus</i> Myrtaceae, <i>Melaleuca styphelioides</i> Myrtaceae	Methanolic extract of leaf	<i>Biomphalaria alexandrina</i>	[47]
28	<i>Glinus lotoides</i> , Molluginaceae	Aqueous and ethyl acetate crude extracts of fruit	<i>Schistosoma mansoni cercariae</i>	[48]
29	<i>Jatropha elliptica</i> , Euphorbiaceae	Ethanol extract of the rhizome	<i>Biomphalaria glabrata</i>	[49]
30	<i>Camellia oleifera</i> Theaceae, <i>Garcinia mangostana</i> Clusiaceae	Solution of crude extract	<i>Bithynia siamensis goniomphalos</i>	[50]
31	<i>Bidens pilosa</i> , Asteraceae	Aqueous extract	<i>Subulina octona</i>	[51]
32	<i>Balanites aegyptiaca</i> , Zygophyllaceae	Aqueous extract	<i>Ethiopian Biomphalaria</i> <i>B. pfeifferi</i> , <i>Lymnaea natalensis</i> , and <i>chistosoma mansoni</i>	[52]
33	<i>Cymbopogon winterianus</i> , Poaceae	Essential oil	<i>Biomphalaria glabrata</i> , <i>Artemia salina</i>	[53]
34	<i>Syzygium cumini</i> , Myrtaceae	Essential oil of leaves	<i>Biomphalaria glabrata</i>	[54]
35	<i>Piper tuberculatum</i> Piperaceae	Piplartine was isolated from <i>P. tuberculatum</i> root extracts	<i>Biomphalaria glabrata</i>	[55]
36	<i>Corymbia citriodora</i> Myrtaceae, <i>Eucalyptus urophylla</i> Myrtaceae	Volatile oil from leaves	<i>Oncomelania hupensis</i>	[56]
37	<i>Phytolacca acinosa</i> , Phytolaccaceae	Broth of <i>Aspergillus fumigatus</i>	<i>Oncomelania, hupensis</i>	[57]
38	<i>Euphorbia helioscopia</i> , Euphorbiaceae	Polar factions	<i>Oncomelania hupensis</i>	[58]
39	<i>Pulsatilla chinensis</i> , Ranunculaceae	Saponins	<i>Oncomelania hupensis</i>	[59]
40	<i>Thymus capitatus</i> , Lamiaceae, <i>Marrubium vulgare</i> Lamiaceae	Essential oils of aerial parts	<i>Biomphalaria alexandrina</i>	[60]
41	<i>Balanites aegyptiaca</i> Zygophyllaceae	Seed oil and glycosides from seed	<i>Monacha cartusiana</i>	[61]
42	<i>Aglaia duperreana</i> Meliaceae	Methanolic extract of the twigs and leaves	<i>Pomacea canaliculata</i>	[62]
43	<i>Adenium arabicum</i> , Apocynaceae, <i>Calotropis procera</i> Apocynaceae	Cardenolide extracts	<i>Monacha cantiana</i>	[63]
44	<i>Acanthospermum hispidum</i> Asteraceae	Essential oil	<i>Biomphalaria peregrines</i>	[64]
45	<i>Yucca desmetiana</i> , Asparagaceae	Methanolic extract	<i>Biomphalaria alexandrina</i>	[65]
46	<i>Scoparia dulcis</i> Plantaginaceae, <i>Helicteres velutina</i> Malvaceae, <i>Poincianella pyramidalis</i> Fabaceae, <i>henopodium ambrosoides</i> Amaranthaceae, <i>Mimosa tenuiflora</i> Fabaceae	Crude extracts	<i>Biomphalaria glabrata</i>	[66]
47	<i>Eucalyptus exserta</i> Myrtaceae	Methanol extract of the bark	<i>Pomacea canaliculata</i>	[67]
48	<i>Hypericum androsaemum</i> , <i>Hypericum foliosum</i> <i>Hypericum undulatum</i> Hypericaceae	Aqueous and hexane extracts	<i>Radix peregra</i>	[68]
49	<i>Phytolacca americana</i> Phytolaccaceae	Polar factions of leaf extract	<i>Oncomelania hupensis</i>	[69]
50	<i>Nerium indicum</i>	Leaves	<i>Pomacea canaliculata</i>	[70]
51	<i>Eomecon chionantha</i> Papaveraceae	Alkaloids	<i>Oncomelania hupensis</i>	[71]
52	<i>Juniperus brevifolia</i> Cupressaceae, <i>Laurus azorica</i> Lauraceae, <i>Hedychium gardnerianum</i> Zingiberaceae, <i>Pittosporum undulatum</i> Pittosporaceae, <i>Psidium cattleianum</i> Myrtaceae	Essential oils	<i>Radix peregra</i>	[72]
53	<i>Ferula foetida</i> Umbelliferae, <i>Syzygium aromaticum</i> Myrtaceae, <i>Carum carvi</i> , Apiaceae	Bait formulations	<i>Lymnaea acuminata</i>	[73]

Table 2: Plant molluscicides: Source of information: IDOSI

S. No.	Plant name	Part involved in study	Tested organism	Reference
1	<i>Azadirachta indica</i>	Bark powder and bioactive compound azadirachtin	<i>Lymnaea acuminata</i>	[74]
2	<i>Annona squamosa</i>	Seed powder and bioactive compound acetogenin	<i>Lymnaea acuminata</i>	[74]
3	<i>Euphorbia splendens</i>	Cold water, boiled water, methanolic, acetone, chloroform extract	<i>Biomphalaria alexandrina</i>	[75]
4	<i>Atriplex stylosa</i>			[75]
5	<i>Guaiacum officinalis</i>			[75]
6	<i>Anagalis arvensis</i>	Ethanolic extract	<i>Biomphalaria alexandrina</i>	[76]
7	<i>Euphorbia tirucalli</i>	Acetone extract of stem bark	<i>Lymnaea acuminata</i> <i>Indoplanorbis exustus</i>	[77]
8	<i>Jatropha gossypifolia</i>	Apigenin extracted from the plant	Freshwater predatory fish <i>Channa punctatus</i>	[78]
9	<i>Solanum surattense</i>	Fruits	Molluscicidal	[79]
10	<i>Calotropis procera</i>	Uscharin, an active compound extracted from plant the latex	<i>Lymnaea acuminata</i>	[80]
11	<i>Ferula foetida</i>	Bait containing ferulic acid, umbelliferone	<i>Indoplanorbis exustus</i>	[81]

Conclusion

Schistosoma and other Molluscs related infection are fatal for humans. Synthetic compounds like polyquaternary ammonium compounds, aromatic hydrocarbons, metal and their salts, niclosamide etc. have limited applications and were also harmful for the environment with very slow biodegradable rate. Moreover, molluscs may develop resistance over them because of their illicit use. Secondary metabolites like alkaloids, saponins, cardiac glycosides, and essential oils/terpenes enable plant to exert natural control over molluscs. Due to their availability, less cost, eco-friendly nature, fast biodegradability and the most important parameter of chances acquiring resistance by the molluscs are less. They seem to be the most reliable methods in controlling the overpopulation of molluscs.

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