IJMPES International Journal of
Medical Parasitology & Epidemiology Sciences

http://ijmpes.com
doi 10.34172/ijmpes.3112
Vol. 3, No. 3, 2022,54-56
eISSN 2766-6492

Review Article

Effective Factors in the Chemical and Biological Control of *Fasciola* spp. With an Emphasis on the Effects of Macrofungi

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Abstract

Fasciola hepatica and *Fasciola gigantica* are among the most interesting and at the same time important subjects of parasitology. The relative ability of these zoonoses in performing laboratory operations and their high prevalence in animals have made fascioliasis a suitable research subject. Today, consistent and continuous control measures are widely recognized as planned management strategies for fascioliasis. These programs may include scheduled grazing of animals and killing of snails and the use of antiparasitic drugs. In the past, various medicinal plants have been tested against fascioliasis. Usually, mushrooms are known as valuable food and contain various active chemical substances with nutritional and therapeutic properties. *Ganoderma applanatum* and *Cantharellus cibarius* are species of macrofungi that have great medicinal and therapeutic value. These mushrooms show a wide range of medicinal properties (antibacterial, anticancer, antihypertensive, immune system modulator, antioxidant, and antiandrogenic properties). In the biological control method of various Fasciola species, macrofungi and predatory fungi are mostly used, and due to the naturalness of their compounds, they have extremely less side effects and risks compared to chemical synthetic compounds, and because of this alternative biological control, they will be suitable for other fascioliasis control methods in the future.

Keywords: *Fasciola* spp., Biological control, macrofungi, *Ganoderma applanatum*, *Cantharellus cibarius*

Received: September,2 2022, **Accepted**: September, 18 2022, **ePublished**: September 29, 2022

Introduction

Fasciola hepatica and *Fasciola gigantica* are among the most interesting and important subjects of parasitology (1). The life cycle of the worm is complex, and humans, cattle, and sheep are known as the final hosts. In addition, *Lymnaea* snails and aquatic plants are known as intermediate hosts and carriers of the infectious form, respectively. The high prevalence of Fasciola in animals and the complex life cycle of this parasite have made fascioliasis a suitable subject for research. On the one hand, fasciolids, similar to other snail-transmitted worms, have provided wide ecological dimensions for the study of fascioliasis in nature; on the other hand, the strange ability of the parasite to adapt to new conditions, apart from ecological limitations, is astonishing (2,3).

The classification of *Fasciola hepatica* and *Fasciola gigantica* parasites is as follows:

Class: *Trematoda*
Order: *Digenea*
SubOrder: *Prosostomata*
Family: *Fasciolidae* Railliet (1895)
Sub Family: *Fasciolinae* (Stiles & Hassal, 1898)
Genus: *Fasciola* Linnaeus (1758)
Spece: *Hepatica* Linnaeus (1758)

The Effect of the Ecosystem on the Intermediate Host Snail

There should be no doubt that without a suitable ecosystem, one can witness the transmission of the disease in a region or not. Even regardless of the effect of physiographic elements, the presence of other parasites in the area affects the snail's ability to accept the parasite (4). In France, it has been reported that even some snails of the Planorbis group (*Planorbis leucostoma*) are able to transmit the parasite provided that it is simultaneously infected with *Paramphistomum daubneyi* (5).

Application of Geographical Information System and Remote Sensing in the Fight Against Parasitic Diseases

In 1970, Barnett Cline used meteorological information to achieve epidemiological goals, and today, using satellite information to predict disease status is one of the common methods in disease epidemiology (6).

Many pathogens have a close relationship with the environment, and many others have a more independent habitat than others. For example, many parasites, especially geohelminths and snail-transmitted parasites, are highly dependent on environmental changes. For instance, in the case of parasites transmitted by snails,

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following a drought or a watery year, the population of snails decreases or increases, and this directly makes the transmission conditions easier or more difficult for the parasite. Years before the use of satellite information and computers, experts could estimate the status of some diseases such as malaria for the next year by knowing some variables such as the amount of rainfall (7,8).

Different Methods of Fascioliasis Control and Prevention

To describe the control of human fascioliasis, it should be studied in short-term and long-term strategies. In short-term health education, preventing the consumption of raw fresh aquatic plants (especially watercress and water mint) should be taken into consideration (9).

The following can be mentioned in the long-term strategy:

1. Preventive Treatment in Vertebrate Animals: It is performed with different antiparasitic drugs such as triclabendazole at specific time intervals.
2. Controlled Grazing: Changing and rotating pastures destroy parasites and reduce the risk of parasitic infection in animals.
3. Snail Control: It is conducted with different snail-killing poisons such as by bilucide (Bayer-73) and copper sulfate.
4. Vaccination: So far, it has not been very successful regarding *Fasciola*.

Biological Control of Fascioliasis: Macrofungi and predatory fungi are mostly utilized in this biological control method, and due to the naturalness of their compounds, they have extremely less side effects and risks in comparison to chemical synthetic compounds.

Nowadays, consistent and continuous control measures are widely recognized as planned management strategies for fascioliasis. These programs may include scheduled grazing of animals and killing of snails and the use of antiparasitic drugs. Triclabendazole is currently the most widely used fasciolicide in the world due to its good efficacy against immature and mature *Fasciola*. Other fasciolicides such as albendazole, closantel, chloroquine , and rafoxanide are effective against adult *Fasciola* but represent different effects against the larval stages of *Fasciola* (10). In this century, due to the resistance of *Fasciola* to triclabendazole, a large body of research is necessary to find effective antiparasitic compounds in *Fasciola*. Various medicinal plants have been previously tested against fascioliasis, including *Allium sativum, Lawsonia inermis, Opuntia ficus, Lantana camara, Bocconia frutescens, Piper auritum, Artemisia Mexicana,* and *Cajanus cajan* (11).

It has been found that these plants inhibit the movement and activity of mature *Fasciola* and cause perforation and destruction of *Fasciola* internal organs such as the uterus and cecum, especially at higher medicinal doses. Usually, mushrooms are known as valuable food and contain various active chemical substances with nutritional and therapeutic properties (12).

Ganoderma applanatum and *Cantharellus cibarius* are species of macrofungi that have great medicinal and therapeutic value. These mushrooms demonstrate antibacterial, anticancer, and antihypertensive, immune system modulator, antioxidant, and antiandrogenic properties. Currently, there are very few studies and reports on the anti-parasitic ability of Cantharellus and Ganoderma mushrooms (13).

Cantharellus cibarius shows good and strong antiparasitic properties against trypanosomes, while *G. applanatum* represents good antiparasitic effects against protozoan Eimeria species. To further study the anti-parasitic effects of the two aforementioned fungi, the ethanolic extracts of these two macrofungi were tested on the eggs and miracidia of different *Fasciola* species. This is a new finding, and its purpose is to interrupt the cycle of parasite transmission in inanimate nature and outside the body of *Fasciola* hosts (14).

Discussion

Today, the need to find new methods of inhibition and control instead of drugs is more defined due to the drug resistance of *Fasciola* to the old anti-parasitic compounds (15). Adult and immature forms of the *Fasciola* parasite found in vertebrate hosts such as humans are often the main cause of the problem of drug resistance. This drug resistance may be largely due to the overuse of some major anti-*Fasciola* drugs. Special attention to the other stages of the *Fasciola* parasite, which are often not considered in drug susceptibility testing studies, may provide an effective strategy for discovering new drugs against *Fasciola* species (16). Today, *Fasciola* eggs and *Fasciola* miracidia are used as target stages of the parasite for bioassays for anti-*Fasciola* drug discovery (17).

So far, the lethal effects of this parasite's eggs have been investigated in various medicinal plants against *Fasciola*. Some of the effective plants against *Fasciola* eggs are black seed, Zingiber officinale, Momordica charantia, and Moringa oleifera (18).

It was revealed that the butanol subunit of *Momordica charantia* prevents the exit of miracidia from *Fasciola* eggs by inhibiting blastogenesis (19). In recent years, other studies have been conducted against snail intermediate hosts in trematode infections such as *Fasciola*.

Conclusion

Macrofungi and predatory fungi are extensively utilized in the biological control method of various *Fasciola* species. Due to the naturalness of their compounds, they have less side effects and risks when compared to chemical synthetic compounds, and this alternative biological control will be reasonable for other fascioliasis

control methods in the future.

Competing Interests
None.

Ethical Approval
Not applicable.

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