American Journal Of Biomedical Science & Pharmaceutical Innovation

VOLUME Vol.05 Issue12 2025
PAGE NO. 43-46
DOI 10.37547/ajbspi/Volume05Issue12-11

# Biological Development and Life Cycle of Trematodes

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**Received:** 30 October 2025; **Accepted:** 19 November 2025; **Published:** 28 December 2025

**Abstract:** This article provides a scientific analysis of the biological development, life cycle, and stages of morphological changes in trematodes. The study thoroughly examines the main developmental stages of trematodes, including the egg, miracidium, sporocyst, redia, cercaria, and adult (marita) stages. In addition, the alternation of intermediate and definitive hosts, the influence of environmental factors on the developmental process, and the adaptive characteristics of trematodes are comprehensively discussed.

**Keywords:** Trematodes, developmental stages, life cycle, intermediate host, parasitology.

**Introduction:** The ontogenetic development of trematodes comprises four distinct stages: embryogony, parthenogony, cystogony, and maritogony.

The liver fluke (Fasciola hepatica), also known as the liver parasite, is one of the most widespread trematodes. It commonly parasitizes the livers (bile ducts) of sheep, goats, cattle, pigs, camels, and rabbits, causing various diseases in these animals.

Externally, the fluke has a leaf-like shape, reaches up to 3 cm in length, with a whitish-yellow coloration. The anterior (ventral) surface is convex, while the dorsal surface is slightly flattened. The body is covered by a tegument forming a skin-muscle sac. At the anterior extremity of the convex head, there is an oral sucker surrounding the mouth, and slightly posterior to it, a larger ventral (abdominal) sucker is located.

Digestive System. The digestive system begins with the oral cavity, which leads into a short pharynx connected to two intestinal channels. Each intestinal canal extends posteriorly and gives rise to numerous branches. The ingested liquid food is digested within this branched system.

Reproductive System and Development. Although the reproductive organs of trematodes are typical for turbellarians, they are highly developed in liver flukes. The reproductive system occupies almost the entire body. The testes and ovaries are connected via two seminal ducts that merge into a single genital canal. The muscular genital canal can evert to the exterior and is known as the copulatory organ (cirrus).

Female Reproductive Organs. The female reproductive organs are characterized by a cavity known as the ootype. The canal of a single branched ovary and the ducts of two large, branched yolk glands (vitelline glands) open into the ootype. The yolk glands produce nutrients for the fertilized eggs. The uterus originates from the ootype and opens into the genital atrium. Surrounding the ootype are melic cells that form the egg shell. Within the ootype, the eggs are fertilized by spermatozoa and are surrounded by nutritive yolk cells. Subsequently, each fertilized egg becomes encased in a thick and resistant shell before entering the uterus.

The eggs released from the uterus pass through the host's bile ducts, enter the digestive tract, and are excreted into water via feces. In digenetic trematodes, the embryonic development occurs in an aquatic environment under moist conditions. The eggs undergo a specific developmental stage in water, during which a ciliated larva called a miracidium develops within the egg shell. Once fully formed, the egg shell ruptures, and the miracidium swims out into the aquatic environment.

The miracidium possesses two simple eyespots, a cerebral ganglion, protonephridia, and a muscular layer. Its digestive and reproductive organs are not yet formed. In this regard, the first larval stage of trematodes-the miracidium-has a relatively complex structure and, in many aspects, resembles turbellarians.

Since the miracidium lacks a digestive system, it cannot feed. It survives for 2-2,5 days in water, sustained by

the yolk material surrounding the egg. Consequently, its lifespan is very short, lasting up to approximately 36 hours. During this time, the miracidium swims actively to locate its intermediate host, usually a mollusk, and penetrates its body using the apical papilla and secretions from specialized glands.

If the miracidium fails to find a suitable mollusk within 2,5 days, its yolk reserves are depleted, and it dies. Upon entering the mollusk, the miracidium loses its cilia, eyespots, nervous ganglia, and protonephridia, transforming into a ciliated-free larval stage called the sporocyst. This represents the second larval generation (F2), forming a sac-like sporocyst. From this stage, the asexual (parthenogenetic) phase of trematode development begins.

rocysts, lacking an intestine, feed by absorbing dissolved nutrients directly through their body surface from the host's tissues. Within the sporocyst, several eggs develop, and through parthenogenesis-without fertilization-each sporocyst produces 15-20 third-generation larvae called rediae. The rediae (third-generation larvae) are released from the sporocyst.

Through parthenogenetic development, the egg cells of the rediae give rise to the fourth-generation larvae-tailed cercariae. Cercariae are more developmentally advanced than rediae. Once mature, they exit the mollusk's hepatic cavity into the surrounding water and leave the host via a specialized excretory opening.

Cercariae possess two suckers, a bifurcated intestine, and protonephridia. While swimming in water, they reach aquatic plants. During this stage, the tail is lost, and the cercaria transforms into the adolescaria (metacercarial stage). Cercariae attach to aquatic vegetation or other hard substrates, sometimes even the water surface, using a gelatinous secretion from their cystogenic glands. They form a rounded shape, encased in a protective cyst, losing the tail, and become metacercariae. These cysted larvae are then ingested by the definitive host through water or contaminated food, completing the transmission cycle.

With the completion of the parthenogenetic developmental phase, trematodes enter the systogony (sexual) phase. The metacercariae represent the fifth-generation larvae of trematodes. During the maritogony (sexual) stage, these encysted or free metacercariae, attached to aquatic plants or present in water, are ingested by the definitive hosts, which include all vertebrates such as livestock and humans.

After ingestion, the protective cyst walls of the metacercariae dissolve in the stomach and intestines, releasing the larvae. These larvae then migrate to their specific parasitic sites within the host and gradually develop into adult trematodes (marita). The adults subsequently release eggs into the external aquatic environment, completing the life cycle. The released eggs, containing fully developed miracidia, begin the same developmental stages previously described, perpetuating the trematode life cycle.

Infection with liver flukes leads to a disease known as fascioliasis. This disease causes significant economic losses in livestock. In addition to Fasciola hepatica, other species such as the giant liver fluke, wild amphistomes (two-mouthed flukes), feline liver flukes, and blood flukes (found in human blood, particularly in the kidneys and intestinal veins) infect the livers of domestic and wild animals, causing serious diseases.

The transmission of these diseases involves aquatic animals and worms, which act as intermediate hosts, while vertebrates serve as definitive hosts. Therefore, strict adherence to hygiene rules is always required to prevent infection.

Fascioliasis is an acute or chronic disease affecting domestic and wild ruminants, and humans can also become infected. The disease is caused by trematodes belonging to the family Fasciolidae, which parasitize the liver tissues, bile ducts, and gallbladder.

The acute form of fascioliasis occurs when young flukes parasitize liver tissue for 2–3 months, while the chronic form develops due to adult trematodes residing in the bile ducts and, partially, in the gallbladder. Acute fascioliasis can cause rapid and extensive mortality in affected animals. Severe damage to the liver, one of the body's vital organs, disrupts metabolic processes and overall health.

The family Fasciolidae includes eight species within the genus Fasciola. Among them, two species-Fasciola hepatica and Fasciola gigantica-have been recorded in Uzbekistan and are considered highly pathogenic parasites.

Fasciola hepatica has a leaf-like shape. Adult individuals measure 30–40 mm in length and 12-13 mm in width. The adults are grayish with a slightly brownish tint, whereas young trematodes parasitizing liver tissue are white and milky in appearance, with a body length of approximately 18–19 mm.

Fasciola gigantica has an elongated body with a relatively short width. Adults parasitizing the bile ducts measure 30-70 mm in length and 6-11 mm in width. Juvenile trematodes of this species in liver tissue range from 1-2 mm to 30 mm in length and 0,2–5,0 mm in width. Compared to F. hepatica, F. gigantica is considered highly pathogenic, and infections caused by this species are more severe.

The eggs of fasciolids are ovoid and yellowish-golden in color, with a distinct operculum at one pole. The eggs

of Fasciola hepatica measure approximately 0,12-0,15 × 0,07-0,08 mm, while those of Fasciola gigantica are slightly larger.

Fasciolids develop through the involvement of both definitive and intermediate hosts. Domestic and wild ruminants serve as the definitive hosts, while aquatic snails belonging to the family Lymnaeidae act as the intermediate hosts.

In Uzbekistan, the intermediate host of Fasciola hepatica is the snail Lymnaea truncatula. This freshwater snail is widely distributed in marshes, water reservoirs, and various irrigation facilities.

For Fasciola gigantica, the intermediate hosts include Lymnaea auricularia, L. bactriana, L. subdisjuncta, and L. impura. These snails are commonly found in both permanent and temporary water bodies formed from groundwater, such as ponds, drainage canals, and springs. They are also abundantly present in all irrigation facilities.

The eggs produced by sexually mature fasciolids pass through the bile ducts into the small intestine and are subsequently excreted into the external environment with feces. When deposited in water at temperatures of 15-25 °C, the eggs develop into the first larval stage—the ciliated miracidium-within 10-25 days. The miracidium hatches from the egg and enters the body of the appropriate intermediate host, the freshwater snail, through active penetration.

Inside the snail, the miracidium loses its cilia and transforms into the second-generation larva, the sac-like sporocyst. Cells within the sporocyst give rise, by parthenogenetic reproduction, to the third-generation larvae-rediae. These rediae subsequently produce the fourth-generation larvae-the tailed cercariae. Cercariae develop within the snail over 50-80 days.

Mature cercariae exit the intermediate host into the aquatic environment and begin swimming using their tails. Within minutes, they attach to aquatic plants and cover themselves with a secretion from specialized glands, losing their tails and transforming into the next larval stage-the metacercaria (adolescaria) (Figure 1).

An infected snail can release hundreds of cercariae in a single day. The metacercariae are the infectious (invasive) stage for the definitive hosts and can survive for 4-6 months on aquatic plant surfaces, in marshes, pastures, ponds, or on harvested hay.

Animals become infected with fascioliasis by ingesting these metacercariae attached to contaminated forage. In the digestive tract of the definitive host, the protective cyst wall of the metacercariae dissolves, releasing the larvae, which then migrate via intestinal blood vessels or the peritoneal cavity to the liver. There, they parasitize the liver tissue for 2-3 months, causing the acute form of fascioliasis.

In cases of high infection intensity, all infected sheep, and sometimes large numbers of cattle, can die within 2-3 months.

In animals that survive the acute phase of infection, fascioliasis gradually progresses to a chronic course. Fasciolids that have migrated from the liver parenchyma into the bile ducts reach sexual maturity and can parasitize the host for many years, often persisting for 7-9 years.

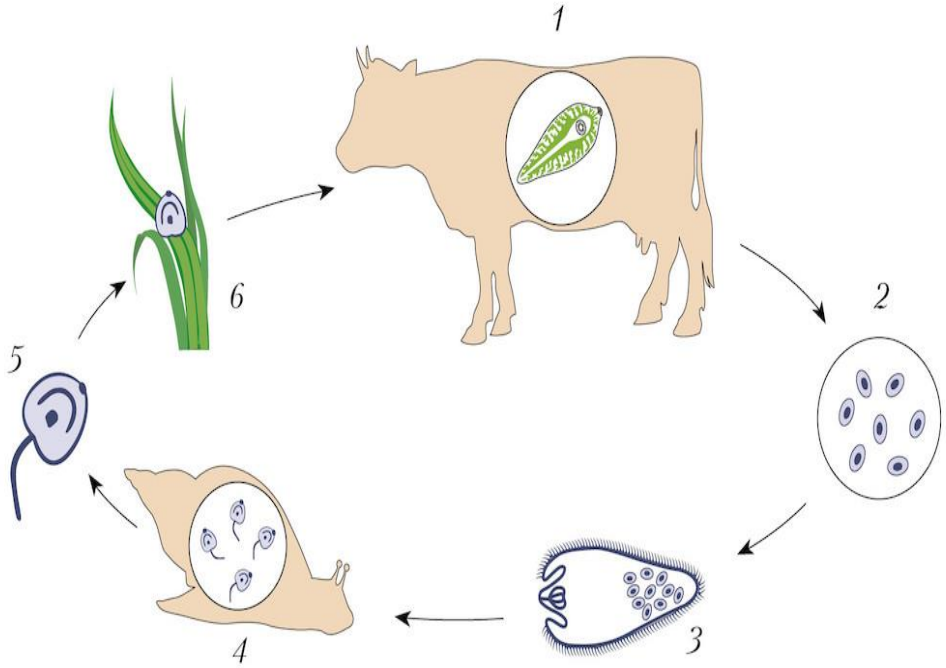


**Figure 1. Development of Fasciola hepatica (based on internet sources):**

1 – Sexually mature trematode in the definitive host; 2 – Parasitic eggs; 3 – Miracidium; 4 – Development of Fasciola larvae in the intermediate host;

5 – Cercaria; 6 – Metacercaria (adolescaria).

Epizootiological Data. Fascioliasis occurs in all regions of Uzbekistan, including irrigated areas, foothills, mountainous regions, and pastures with water bodies.

Fasciola hepatica is a cosmopolitan species in terms of zoogeographical distribution and is widely spread across all countries. Within its range, populations with distinct morphological and biological characteristics exist, including Japanese, American, Australian, and other populations.

In Uzbekistan, F. hepatica is widespread in all regions except Khorezm and the Republic of Karakalpakstan. The prevalence of infection ranges from 3.8-97.8% in sheep, 2.1-33.4% in goats, and 27.3-73.6% in cattle.

Fasciola gigantica is not cosmopolitan and is distributed only in tropical countries. Currently, this species is found in all regions of Uzbekistan. In the Republic of Karakalpakstan and Khorezm region, F. gigantica is the sole causative agent of fascioliasis, whereas in other regions it co-occurs with F. hepatica.

Fascioliasis has been reported in livestock of all ages. Infections typically begin in spring, increase during summer and autumn, and continue through the winter months.

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