



REVIEW ARTICLE

The Roles of Climatic and Biological Factors on the Prevalence of Fascioliasis: A Case Study of *Fasciola gigantica*

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ABSTRACT

Fascioliasis, caused by *Fasciola hepatica* and *Fasciola gigantica*, is a climate-sensitive zoonotic disease with the widest global distribution across all continents. As such, it poses a significant threat to the health and well-being of both animals and humans. Beyond its health effects, fascioliasis causes substantial economic losses amounting to millions of dollars in different parts of the world. The life cycle of the parasite is critically dependent on optimal moisture and thermal conditions. However, other biological factors also contribute significantly to the prevalence of the parasite in endemic areas. Based on this background, this paper examines the roles of both climatic and biological determinants in the prevalence of *Fasciola gigantica*. It was found that vegetative cover, temperature, and moisture at optimal levels affect not only the parasite's developmental stages but also its intermediate host snail (*R. natalensis*). Furthermore, other biological factors that greatly influence parasite prevalence include the age and sex of the definitive host, as well as livestock management practices. It is therefore essential to understand the significance and relevance of these factors in order to build effective capacity to contain the spread of this pathogen, which is taking a heavy toll on animal and human productivity.

Introduction

Climate fluctuations and changes affect the present and future geographic range, intensity as well as the transmission pattern of animal diseases (Baylis & Githeko, 2006). Thus, any pathogen whose transmission can be decreased or increased by climatic influence is regarded as the climate-sensitive disease (Grace et al., 2015).

These diseases are affected by climatic elements such as temperature, rainfall and heat stress through their influence on the activities of the pathogens, vectors and their hosts'. Besides, even the ecosystem services linked to disease transmission and animal management are also likely to change due to changes in climate. In this regard, 65 animal diseases have been

recognised as important to livestock keepers in developing countries, out of which 58% classified as climate-sensitive.

In addition, the World Health Organisation (WHO, 2006) reported that these diseases have a high probability of affecting the health and wellbeing of not only animals but humans in the third world countries due to their zoonotic nature. Climate-sensitive diseases are also more prevalent in developing countries that are characterised by high temperature and vulnerable population. Moreover, fascioliasis is among the 15 diseases that are known as important to livestock keepers in sub-Saharan Africa. Although, the majority of livestock (81%) are in developing countries (FAOSTAT, 2013, FAO, 2024), they are under threat from climate-sensitive diseases with annual mortality of 20% of ruminants (Otte & Chilonda, 2002).

Although fascioliasis is a climate-sensitive disease, biological factors are also important contributors to its incidence. In this regard, Yatswako & Alhaji (2017) explained that both intrinsic (biological characteristics) and extrinsic (climatic/environmental) factors determine the outbreak and intensity of fascioliasis in domestic animals. However, Sanusi et al. (2026) noted that information on fascioliasis risk factors remain limited, which necessitates the present study. According to the Food and Agricultural Organisation, developing countries keep 81% of the 38 billion livestock population worldwide (FAOSTAT, 2013). However, the health and productivity of these livestock are under severe threats from diseases including fascioliasis (Grace et al., 2012). As reported by Akhtar et al. (2024) and Steinfeld et al. (2006) globally livestock sector accounts for 40% agricultural GDP, provides nourishment to humanity and employs 1.3 billion people. Because of this, 'one health' approach (Conraths et al., 2011) which

involves collaboration across disciplines in disease control, has been recommended.

This paper therefore elucidates the life cycle of fasciola parasite in endemic regions and also evaluates climatic and biological factors influencing the geographical distribution of fascioliasis with specific emphasis on addressing existing knowledge gap.

Fascioliasis Disease

Fascioliasis is a parasitic disease whose life cycle substantially depends on moisture and thermal conditions (Malone et al., 1998, Mas-Coma et al., 2009, Freitas et al., 2014). This disease has attracted international attention due to its impacts on animal and public health (Afshan et al., 2014, Sanusi et al., 2026). Furthermore, fascioliasis alongside other helminthic diseases, was prioritized in the agenda of the 3rd World Meeting of the Partners for Parasitic Control (PPC) held at WHO headquarters, Geneva 2004 (Mas-Coma et al., 2005b). In addition, fascioliasis is described as a debilitating disease that reduces the productivity of cattle and sheep (Valentia-Lopez et al., 2012, Charlier et al., 2014). Beyond, health effects, fascioliasis constitute substantial economic losses amounting to millions of dollars in different parts of the world (Saleha, 1991, Malone et al., 1998, Fox et al., 2011, GHadad et al., 2025).

Fascioliasis manifests in two forms caused by specific 'etiological agents', which are *F.hepatica* and *F. gigantica*. The former is more prevalent in the temperate areas while the latter is mostly found in the tropical regions (Andrews, 1999). *F.gigantica* is genetically related to *F.hepatica* but diverged many millions of years ago and subsequently dispersed into various parts of Asia and Africa (Irving et al., 2003). Both species share common characteristics regarding liver infections of the mammalian hosts and have the same life cycle. Despite these common

attributes, according to Spithill et al.(1999), the two species differ in the moisture requirements of their respective intermediate hosts and also in host-parasite interactions.. Differences also exist in animal management practices and other development indices between temperate areas where *F.hepatica* thrives and tropical biomes where *F.gigantica* is endemic. Also *R.natalensis* which transmits *F.gigantica* requires higher temperatures and abundant stagnant water bodies, whereas *Galba truncatula* (transmits *F.hepatica*) needs lower temperature and intermittent water bodies (Mas-Coma, 2004). All these variations account for the epidemiological differences between the two species, which warrant separate studies. In Nigeria, only *F.gigantica* occurs, and according to Spithill et al. (1999), it reaches 60% prevalence rate.

It is essential to note that fascioliasis affect not only animals but also human, and is therefore considered a water or food-borne zoonotic disease due to its public health significance (Moe, 2004). In that light, the World Health Organisation (WHO) recognised it as foodborne trematodiasis (FBTs) because it constitutes a major health burden in many countries of the world. For example, Sripa et al. (2010) reported in Thai that human fascioliasis, which leads to liver and bile duct cancer , was ranked fifth among the conditions with the highest disability-adjusted life years (DALYs) in 2004.

Lifecycle of fascioliasis

The life cycle of fascioliasis involves intermediate and definitive hosts couple with favourable environmental factors that are indispensable for the survival of the parasite (Mas-Coma et al., 2014). Tolan (2011) described the developmental stages in the life cycle of

fascioliasis which begin with the release of fresh unembryonated eggs in bile ducts and feces from infected animals and sometimes humans. Under suitable conditions of temperature and moisture, these eggs hatch and produce miracidia that infect vulnerable lymnae (*R.natalenses*) snails. Inside the snails, miracidia undergo the asexual reproduction and release sporocyst, rediae and finally cercariae. The snail then discharges the cercariae which encyst as metacercariae on suitable surfaces such as leaves of grasses and stems (Andrews, 1999, Graczyk & Fried, 1999). After ingestion of the infected vegetation by grazing animals, the *metacercariae* excysts in the duodenum., move to the intestinal surface into the peritoneal cavity and migrate to biliary ducts where they develop into adults (Tolan, 2011).

The continuity of fasciolosis life cycle depends on optimum conditions of climatic conditions notably temperature and precipitation. Also, according to Mas-Coma et al.(2009) environmental factors such as latitude and altitude also influence temperature and thus affect the prevalence of fascioliasis (fig 1). *Fasciola gigantica* being a tropical species require higher minimum temperatures than *F.hepatica* that thrives in temperate areas. The two species overlap in some tropical regions with high altitudes example Kenya, Ethiopia (Malone et al., 1998) and in Egypt (Soliman, 2008). The extreme rainfall event can lead to flooding and provide new habitats for intermediate hosts (Torgerson & Claxton, 1999). *R.. natalenses* that transmit *F. gigantica* thrives in slow-moving water or stagnant water in depressions such as lakes (ponds) or irrigated rice fields (Kendall, 1965, Fabiyi, 1987).

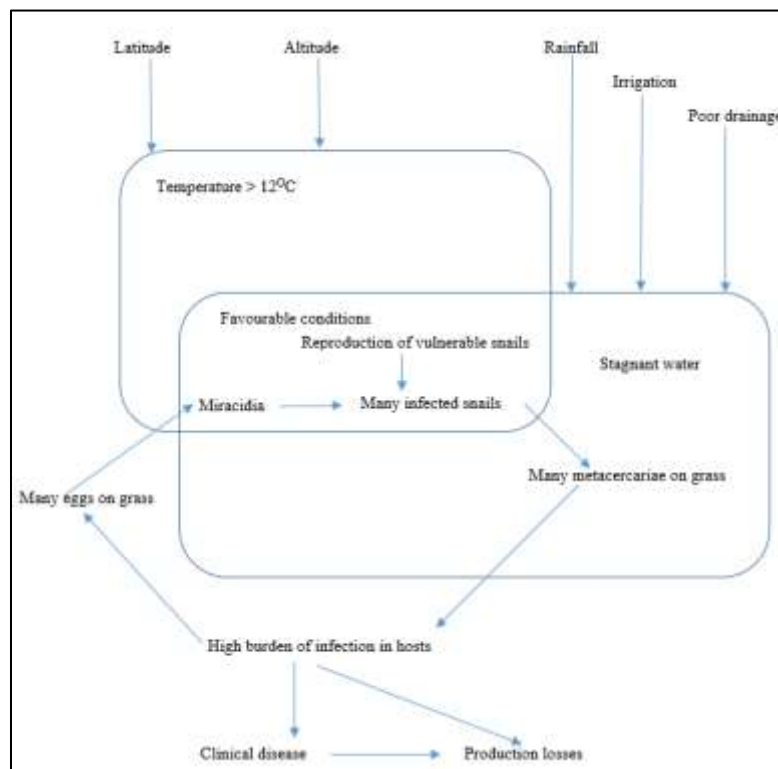


Figure1: Associations of risk factors that enhance the emergence of *F.gigantica* (Togerson and Claxton, 1999 modified).

Intermediate and definitive host of fascioliasis

In the free-living state, after emerging from feces, the development of fasciola parasite process halt unless it is accommodated inside a living organism (as the vector) referred to as intermediate host (Tolan, 2011). The dominant intermediate hosts of *F.gigantica* is *lymnae auricularia sensulato* group. The main subspecies is *R.natalenses* which is found in West Africa and Indian sub-continent, including Bangladesh and Pakistan(Spithill et al., 1999).

The global distribution of fascioliasis

Mas-Coma et al. (2009) explained that fascioliasis is the invertebrate-borne disease with the highest spread across the world, including very high altitude areas, as seen in the Andean countries (Bolivia, Peru, Ecuador, and Venezuela). *Fasciola gigantica* is restricted to areas where the ecological conditions for the

survival of *R.natalensis* the intermediate hosts are suitable. According to Spithill et al. (1999) the Africa countries with the highest prevalence of *F.gigantica* include Egypt, Sudan, Tanganyika, Chad, Nigeria, Zambia, Zimbabwe, Uganda, and Ethiopia. In Asia, high prevalence countries include Indonesia, NE Thailand, Philippines, Vietnam, Pakistan, India, Nepal, and Iran.

Effects of climatic and environmental factors on *Fasciola gigantica* transmission

Climatic elements notably temperature, rainfall, and interactions between them affect the viability of the parasite in its free-living stages (egg and miracidia) and intramolluscan stages [sporocyst, rediae, and cercariae] (Poulin, 2006). Thus, it is vital to comprehend how these elements modulate the activities of the parasites to appreciate the role of climate in determining the geographic range of fascioliasis. The

climatic conditions must remain within an optimum range for the survival and development of both the parasite and its intermediate host' snails.

Effects of Temperature

Higher temperature within the optimum range promotes the development of miracidia in the *F.gigantica* eggs. At 37-38°C development takes only 10-11 days while the number of days extends to 33 at 17-22°C (Guralp et al., 1964). Grigoryan (1958) estimated that 70-80% of eggs hatch at 24-26°C while temperature exceeding 43-44°C cause eggs mortality. Guralp et al. (1964) noted that hatching of *F.gigantica* eggs can occur in batches over 14 weeks. In parts of East Africa such as Kenya, where the average temperatures are lower than other parts of the continent, egg development ranges from 52 to 109 days at 10°C and 22°C (Torgerson & Claxton, 1999). They also noted that nourishment and the quantity of parasite the snail contains would encourage and stimulate their ability to produce eggs

Temperature also influences the physiology and cercarial production by snails (Mas-Coma et al., 2009). Dinnik & Dinnik(1963) and Islam et al. (2014) found out that temperature at 26°C stimulates reproductive processes in snails within a few days. Air temperature is therefore very crucial in affecting the prevalence and geographic range of *F.gigantica*. Likewise, infected snails begin shedding cercariae in 20 to 50 days at 25-27°C (Sharma et al., 1989). This period is prolonged at lower temperatures and may take up to 197 days at high elevations in Kenya (Dinnik and Dinnik, 1963)

Spithill et al. (1999) reported that temperature affects the ability of snails to produce cercariae, which then excyst as metacercariae on suitable objects within 6.4cm of the water body. Suhardono & Copeman, (2008) found that

metacercariae were more viable in water than outside it based on their study in Indonesia. They concluded that the viability of metacercariae was highest at 20°C and decline at 26, 30 and 35°C. Outside water, survival increases under humid conditions and relatively low temperatures. Kimura observed in Japan that metacercariae survived for 120 days at 12-28°C and 30-45% relative humidity on rice.

Effects of Moisture

Moisture is essential for all processes supporting the viability of fascioliasis and its snail hosts (Torgerson and Claxton, 1999). Desiccation has been found by Altizer et al(2006) to be inimical to both. Rainfall is the primary source of moisture. When rainfall exceeds potential evapotranspiration, conditions become suitable for transmission (Mas-Coma et al., 2005). During dry seasons in tropical countries, moisture persists near water bodies such as irrigation sites, streams or lakes.

Moisture is required to disintegrate faecal mass into fluke eggs (Torgerson and Claxton, 1999). *R..natalenses* needs deep water to survive and cannot aestivate for long during a dry spell or drought. Schillhorn Van Veen et al. (1980) reported increased snail populations at the onset of the rainy season in West Africa. In Malawi, the period of rainfall in March/April provides ideal conditions for snail survival.

Given the preceding discussion, moisture is indispensable for the dispersal, free-living and intramolluscan stages of fascioliasis (Andrews, 1999). For example, even under optimum temperature, desiccation (fig 2) threatens metacercarial viability (Spithill et al., 1999). In semi-arid areas such as Nigeria, transmission during the dry season occurs only near water bodies (example streams, dams, lakes, and ponds) as sources of moisture since rainfall is only available during wet season. Extensive

fadama lands (areas liable to flooding) in north-western Nigeria and abundant rainfall in the south and west provide favourable conditions,

with prevalence up to 60% and above (Spithillet al.1999).

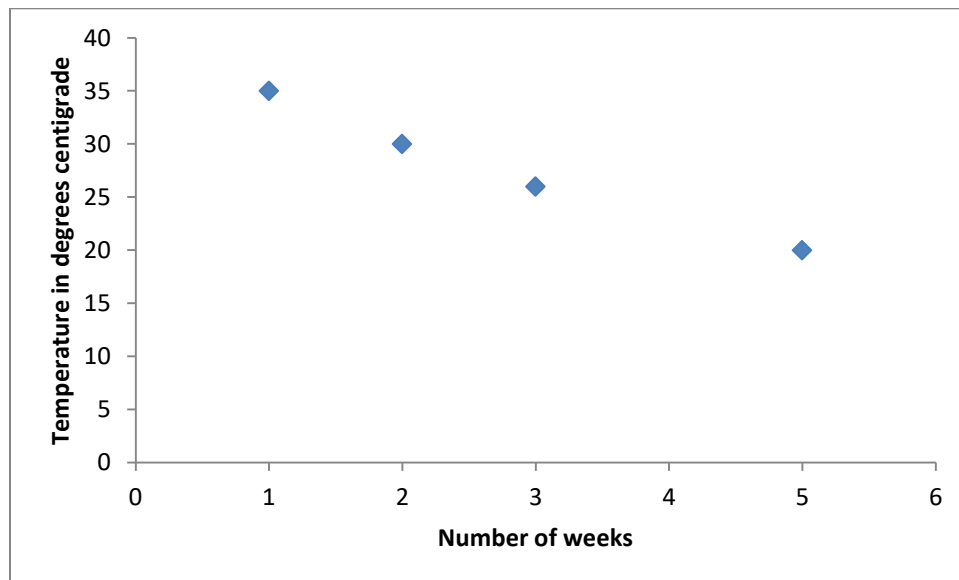


Figure 2: Metacercariae weekly survival rate when subjected to desiccation at different temperatures (Spithillet al.1999).

During the dry periods, snail productivity declines and stagnant water is preferred by the snails for optimal development (Roberts & Suhadono, 1996). If dryness persists, according to Spithill et al. (1999) eggs production in snails continues, but hatching occurs only when moisture condition improves. Furthermore, in extreme dry seasons, in tropical areas, snails can survive up to six months through hibernation and aestivation (Roberts and Suhadono, 1996, Bunza et al., 2008). Copeman (2000) confirmed this in studies of *F.gigantica* and snail hosts' in rice fields in Surade, West Java, Indonesia.

Vegetation

Vegetation influences fascioliasis risk by providing snail habitats and surfaces for metacercarial attachment. It also serves as nourishment for animals and even humans, making it a key vehicle for transmission. This is

measured by an index referred to as Normalised Difference Vegetation Index (NDVI).

NDVI is very useful in epidemiological studies as it represents environmental moisture (Malone et al., 2001, Valentia-Lopez et al., 2012). It is composite mixture of elevation, precipitation, and temperature (Hay et al., 2006), and making it a good indicator of climate risk. NDVI has been incorporated into GIS layers to predict climatic risk and design of control programs for human and animal fascioliasis in East Africa, Europe and South America (Fuentes et al., 2006, Kantzoura et al., 2011, Afshan et al., 2014).

Effects of biological (host-parasite) factors on *Fasciola gigantica* transmission

The climatic factors do not operate in isolation but there are other contributing factors that determine the transmission, intensity and spatial distribution of fascioliasis. These factors are

classified into host-parasite and climatic/environmental factors [including definitive hosts management practices] (Yatswako and Alhaji, 2017).

The preceding section explained the effects of climatic and environmental factors on fascioliasis prevalence while this section describes host-specific factors and their effects on the prevalence of the parasite.

The age of the definitive host

The age of the definitive hosts determines their susceptibility to fascioliasis infection. In this regard, there are two contradictory reports concerning the most vulnerable to infection between the young and old definitive hosts. Some studies report that young hosts are more susceptible to infection due to low immunity which increases with age. It, therefore, means that the more infections the host encounter, the more it develops the ability to acquire immunity over time. This observation got support by (Blood, 2016) and (Noble & Noble, 1982) where fascioliasis infections were more predominant among the weaners than the older host when compared across different age groups. In contrast to the above observation Anon, (1992) concluded that vulnerability to infection was the same across the old and young host and in some cases even higher among older definitive host (Esch, 1977, Elelu et al., 2006, Pfukenyi et al., 2006)

The gender of the host

A strong link exists between gender of the host and fascioliasis infections as a result of the presence of steroid hormones which respond differently to parasitic infection in the definitive host (Esch, 1977). Given this, female hosts were more susceptible to infection than the males as concluded in a study by Rahman & Collins(1992). That was because of the observed increase in 'peri-parturient' (before giving birth)

release of parasite's egg which can suppress the immunity of lactating female definitive host. These findings were also supported by Berger (1971) that the period of parturition and lactation erodes the acquired immunity against fascioliasis infections and other helminths. Conclusively, the definitive female host is, therefore, more vulnerable to infections and its spread across a given pasture owing to their tendency to transmit the infection to their calves as 'adaptive/periodic mechanism (Briskey, 2004).

Practices of animal management

Management systems influence exposure risk of fascioliasis infection. Thus, animals reared by sedentary system of husbandry appeared less susceptible to infection as reported in a study around Lake Chad by Jean-Richard et al. (2014). In contrast to animals under pastoralist systems, such as those practice by Fulani's herders with contact between herds in mostly snail-infected pasture, show higher vulnerability to fascioliasis infections (Elelu & Eisler, 2018).

Conclusion

Liver fluke is a climate sensitive pathogen influenced by both environmental/ climatic conditions and biological factors. In fact, the most notable climatic determinants are moderate temperatures that characterised the most common conditions at endemic locations. These conditions operate efficiently under moist environments especially during the rainy season or around patches of water bodies during the dry season, which support the fascioliasis lifecycle. Likewise, other biological factors such as the age as well as the sex of the animals play a significant role in determining vulnerability to infection. In addition, the management of the animals is also a cogent factor that contributes substantially to infection. Thus, it becomes imperative to consider both climatic and biological factors in designing effective

monitoring and control strategies for fascioliasis pathogen prevalence in endemic localities.

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