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Animal Health

Review

Fasciolosis in Cuba and the World

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ABSTRACT

Background: Fasciolosis is a parasitic disease that not only affects cattle and ovines, but also humans around the world, especially in tropical and subtropical areas. **Aim**: to conduct a review of *Fasciola hepatica*, an assessment of the national and international context, biological cycle, pathogeny, clinical signs, control and prevention, epidemiology, zoonotic effect, seasonality, and economic effects caused by its appearance on livestock farms.

Development: Research evidence shows that the parasite should be included in the group of entities causing emerging diseases. Besides being one of the main causes of liver condemnation in slaughterhouses, *Fasciola sp*. is related to other damage associated to the infection: a decline in meat, milk or wool production, as well as negative effects on body weight, fertility, growth, reproduction, and as the cause of miscarriages and loss of disease resistance. Costs have increased due to anthelmintic treatments, and treatments of frequent secondary bacterial infections that can cause animal death.

Conclusion: The financial losses derived from condemnation of livers affected by *F hepatica* are significant; they depend on the interaction of physiopathological and environmental aspects of the disease (climatic and geographical factors), which can determine the presence of intermediary hosts and the parasite in the environment.

Key words: condemnation, *F. hepatica*, infestation, trematode (Source: *DeCS*)

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INTRODUCTION

F. hepatica is a globally important trematode that causes diseases in multiple mammal species, most of them in developed countries. *Fasciolosis* has been reported to cause $ 23 £ million in economic losses to the livestock raising industry in the United Kingdom alone, which is still an estimated figure. The actual effects on production are not well defined yet; the losses are not only related to liver condemnation in slaughterhouses, but also to reduced daily weight gain from poor food conversion, and a decline in milk and wool production in the animals affected by this parasite (Palacio *et al*., 2017).

Ovines and bovines are the main hosts to fasciolosis around the world; several studies have shown prevalences over 80% in these ruminants (Valderrama, 2016; Carmona, and Tort, 2017). A lower prevalence has been observed in camels, horses, pigs, and guinea pigs. The parasite and its intermediate hosts (snails from family *Lymnaeidae*) adapt to a wide range of environments (Espinoza, Terashima, Herrera-Velit, and Marcos, 2010; Flores *et al*., 2014).

Infections of *Fasciola hepatica* are one of the most significant causes of low milk production and reduced fertility rates in livestock. Additionally, it causes considerable financial losses generated by liver condemnation in slaughterhouses. The impact on animals is considerable, and it is often hard to quantify (Palacio *et al*.,2017).

The development of an effective strategy for integrated control of Fasciolosis requires thorough knowledge of the epidemiology, which is related to the study of the ecology and population dynamics of the intermediate hosts, and their relation to environmental factors (Giménez, Núñez, Chamorro, and Alarcón, 2014).

In Cuba, it is a zoonotic disease in livestock, considered as the most significant economically related disease, mainly affecting cattle and ovines, both in state owned and private farms (Palacio *et al*., 2019).

Aim: to conduct a review of *Fasciola hepatica*, an assessment of the national and international contexts, biological cycle, pathogeny, clinical signs, control and prevention, epidemiology, zoonotic effect, seasonality, and economic effects caused by its appearance on livestock farms.

DEVELOPMENT

Assessment of the local, national, and international contexts

Fasciolosis is a globally spread disease, which is present in all regions where temperature and humidity conditions are appropriate for growth and development of lunged fresh water snails that will be used as intermediate hosts of the parasite. Temperature values of >10 ^{o}C are required for the development of snails miracidia and cercariae (Palacio *et al*., 2017).

It came from Eurasia originally, and spread through North America, Central America, and South America, Australia, Tasmania, New Zealand, and South Africa, as a result of immigration. The arrival of *Fasciola hepatica* from Eurasia is recent. The great genetic uniformity of *Fasciolas* found in geographically distant points, such as Valdivia, in Chile or Leon, in Spain, shows the common origin and recent colonization of the parasite and hosts across the Americas. The same occurs between the genetic isolates of the United Kingdom and the ones from Australia (Selemetas, 2015).

Despite the demonstrated diffusion of *Fasciola hepatica*, brought from Europe by the new settlers in the fifteenth and nineteenth centuries, little is still known about the clonal situation of the species. There is evidence of different behaviors among isolates within Europe, and the reproductive traits (hermaphroditism, possible self-fertilization, and embryonic reproductive multiplication) promoted by the formation of clones. Moreover, in the opposite direction, there are experimentally corroborated hybrids in areas where *Fasciola hepatica* and *Fasciola gigantica* overlap, such as in Korea (Bosco, Rinaldi, and Musella, 2015).

In temperate Europe, *L. truncatula* is the main host species, the very same brought by the Spanish to the high plateaus of The Andes, and other parts of Ibero America (Alison, Matthew, Pinchbeck, and Williams, 2015).

Paleoparasitogical research done in Saale-Unistrut valley, Germany, demonstrated the presence of *F. hepatica* eggs in a prehistoric human skeleton, and in the remains of a bovine from 3.000 BC. This shows that trematodiasis was already endemic in the Old World (Pérez, 2007).

In Mexico, it infects 5-40% cattle heads; on some particular farms, 100% of animals are infected. The parasite is located in all the states of Mexico (Xiang, Hongyu, Jianhua, and Hongbin, 2017).

Research studies conducted in Cuba in 1968-1971 found that, including the total of condemned livers and infected meat, the parasite had caused losses of $ 4 388 210.20 US (Pascual-Linaza, Pfeiffer, and Sanz, 2014). In Cuba, this parasitosis is stimulated by conditions like the presence of susceptible animals, occurrence of infection in any climatic conditions (mostly in the rainy season), water containing metacercariae, inappropriate methods to dispose of feces, the existence of mollusks as intermediary hosts, and occasional inappropriate agricultural and zootechnical practices (Rigoberto, 2012).

Fasciolosis

It is a parasitic disease produced by the presence of trematode *Fasciola hepatica* that lodges in the hepatic parenchyma and biliary conducts of productive animals and man, causing digestive and nutritional disorders (Brito, 2010).

It is also known as liver distomatosis, liver fluke infection, sheep liver fluke infection, rotten liver, etc. (Dupuy *et al*., 2013).

Taxonomic classification of *Fasciola hepatica*

Domain	Eukarya
Kingdom	Metazoa
Phyllum	Plathyhelminthes
Class	Trematoda
Order	Prosostomata
Superfamily	Echinostomatoidea
Family	Fasciolidae
Genus	*Fasciola*
Species	*Hepatica*

Morphology

The adult specimens of *F. hepatica* are flat like a leaf, and measure approximately 30 mm long by 15 mm broad. Their color is gray-pink to brownish. The digestive apparatus is incomplete, and it is formed by a mouth cavity that continues through a pharynx. The esophagus is bifurcated, forming two lateral ramifications, which are directed to the posterior portion of the worm's body, ending in intestinal ceca (Yatswako and Alhaji, 2017).

It is hermaphrodite, with a short uterus. The various components of the egg come together in the proximal segment of the uterus. The yolk sac cells are abundant, in the form of grape bunches, and distributed through all the lateral portions, from which yolk granules containing proliferol and proteins detach (Yatswako and Alhaji, 2017).

The ootype is distinguished at the end of the first third of its body. To the right, on the ventral side, there is an arboreous ovary, whereas the very ramified testicles cover all the central area of the two other posterior thirds. The two efferent conduits meet, and end in a well-developed cirrus bag (Hajimohammadi, Oryan, Zohourtabar, and Ardian, 2014).

The eggs are compact (no air chamber), and operculate. They are 130-150 micra long by 60-90 micra broad. They have an operculum, are yellow, with a cover formed by schlerotinia (proliferol and proteins). The ones disposed of in the feces are not ripe; maturation takes place in water for 9-15 days, at 22-25 ºC (Giménez, Núñez, Chamorro and Alarcón, 2014).

Miracidiae (128 by 25 um) look like adults, with conical papillae in the proximal part, and bodies covered with highly motile cilia. The sporocyst is ovalate, long or sometimes semispherical, with one round and one conical end; the body measures 550 um. The rediae are 1-3 mm long, with germinal masses under several degrees of development. Cercariae have an anterior portion or round elongated resting head when active. The tail provides the worm with high motility; it measures 270-340 um long by 270 broad, the tail is 700 um (Hajimohammadi, Oryan, Zohourtabar, and Ardian, 2014).

Biological cycle

The biological cycle of this parasite needs two hosts: a definitive one (herbivore animals and man), and an intermediary host, which is fresh water snails from genus *Lymnaea* (Silva, Freitas, Dutra, and Molento, 2016).

The eggs abandon the host through the fecal matter. Larvae called miracidiae hatch from the eggs, and are in charge of penetrating the intermediate host inside the snail shell, where they become sporocysts, and later, rediae, until they become cercariae. When cercariae abandon the snail, they attach to aquatic plants, becoming metacercariae, which after being ingested by animals, move through the intestinal wall and enter the abdominal cavity to the liver and penetrate the biliary conducts, where they become adults. Each adult parasite may produce 20 000 eggs per day, then they start reproducing until they reach the host, and close the cycle (Pascual-Linaza, Pfeiffer, and Sanz, 2014).

The free-living stages of the parasite and their intermediary host (*G. cubensis)* are influenced by climate, interacting with precipitations and temperature, which play a major role in the effectiveness of transmission (Giménez, Núñez, Chamorro, and Alarcón, 2014). These conditions are favorable for survival and multiplication of the intermediary host (*Galba cubensis* and *Pseudosuccinea columella*), and transmission of the parasite. The prevalence and economic impact of fasciolosis are linked to climatic and animal nutritional factors, which favor the persistence of the biological cycle of the helminth (Bosco, Rinaldi, and Musella, 2015; Vázquez, Sánchez, Alba, and Pointier, 2015).

<u>Intermediary host</u>

The intermediary host of *F. hepatica* is an amphibian snail of genus *Limnea*, found in humid places like irrigation canals, ditches, shallow, and flowing waters that provide necessary conditions for the development of snails, and permit the infestation of grass, becoming prolific (Brito, 2010).

So far, two species of this family have been described. Previously, only genus *Lymnaea* was recognized, but today each species belongs to different genuses. This group is characterized by having a dextro gyrus and elongated shell with convex turns. They can live within a large variety of habitats, and make abundant populations when the conditions are favorable (Vázquez, Sánchez, Alba, and Pointier, 2015).

In intermediate hosts, successive larval stages are produced, which eventually end up releasing cercariae that swim freely to aquatic plants, tree crusts, and other smooth surfaces or simply, remain suspended in shallow waters where they lose their tails, and become metacercariae (whitish, rounded, and covered with a thick wall), the infecting form of the parasite (Bosco, Rinaldi, and Musella, 2015).

When mammals consume metacercariae contaminated plants and/or water, these larval stages get to the duodenum, move through the intestinal wall, and reach the hepatic parenchyma, to finally reach the biliary conducts, where they become adult in approximately three months. After maturation, eggs are produced, beginning the cycle (Palacio *et al*., 2019).

The life cycle of Fasciola includes an intermediary host snail, and a definitive host, with a complex reproductive biology, which results in a high flow of genes and genetic variability inside Fasciola spp. populations (Cwiklinski *et al*., 2015). Studies have shown that multiple species of Lymnaeid snails may be susceptible to Fasciola infestation, which can also contribute to population understructuring, and the development of several genetic groups in different geographical areas (Vilas, Vázquez-Prieto, and Paniagua, 2012; Beesley *et al*., 2017).

Pathogeny

The greatest damage is caused by young flukes during their migration through the liver tissue into the hepatic conducts. This process destroys liver tissues and causes hemorrhages. The spikes cause additional irritation to the tissue, which reacts with swelling, causes fibrosis and cellular death. The affected livers become large and fragile. Some flukes may end up encapsulated in the tissues, and form nut-size cysts. Besides, the biliary conducts are damaged; they dilate and swell, and may develop incrustations (calcification). Likewise, secondary bacterial infections can take place. They also produce toxic substances that have a negative effect on normal liver development (Beesley, Williams, Paterson, and Hodgkinson, 2004).

When the juvenile forms of the parasite are released into the duodenum, and jejunum, they do not cause significant injuries when migrating through the intestinal wall into the peritoneal cavity, but cause significant eosinophilia. In the peritoneum, there are necrotic and fibrous foci, and as a result of larval migration, ectopic foci can appear, with possible parasite presence in blood vessels in the lungs and brain ventricles (López, 2014; Beesley, Williams, Paterson, and Hodgkinson, 2017).

When perforating the Glisson capsule, leukocytes are infiltrated, and the penetration into the hepatic parenchyma leaves necrosis due to traumatism caused by the parasite. In biliary conducts, the juvenile forms of the parasite produce a chronic inflammatory reaction of such extent that the pathological process will depend on the number of existing parasites (Beesley, Williams, Paterson, and Hodgkinson, 2017).

In the biliary conducts, the traumatism produced by adult parasites in the mucosa causes the appearance of hyperplastic colangitis. The mucosa of those conducts thickens, and becomes hyperplasic, turning permeable. Consequently, it allows the pass of plasmatic proteins to biliary conducts, causing hypoalbuminemia, which is common in chronic Fasciolosis (Fthenakis, Mavrogianni, Gallidis, and Papadopoulos, 2015).

Resulting from epithelial hypertrophy and fibrosis of the wall, the biliary conducts thicken, and may reach a diameter of up to 3 cm. Between the tenth and twelfth week after infection, calcium deposits are formed on the wall. The span of biliary conducts is dilated in some areas, and narrowed in others. The biliary epithelium may suffer ulcers and hemorrhages (Vázquez, Gutiérrez, and Sánchez, 2010).

Clinical signs

From a clinical perspective, two phases are observed: onset and status. The former corresponds to migration of the parasites. Irregular high fever, intense variable pain in the right hypochondrium due to congestion and swelling of the hepatic parenchyma, and ephemeral jaundice can occur. The hematic biometrics is altered, and leukocytes with up to 80% eosinophilia are detected; at times, hyperganmaglobulemia occurs, and hepatic functioning tests are altered as well. In the status phase, the presence of adult parasites in the biliary conducts produce symptoms in the digestive tract, consisting in biliary dyspepsia, flatulence, and alternate constipation with periods of diarrhea. Transient obstructive jaundice, hepatomegalia, fever, and general discomfort can occur. Eosinophilia descends gradually to normal levels (González, Pérez, and Brito, 2007).

Thus, two types of clinical manifestations can be described:

1. **Acute Fasciolosis**: it is produced due to large consumption of metacercariae in a short period of time. Massive migration of juvenile *Fasciolas* through the parenchyma causes traumatic hepatitis, with cellular destruction, hemorrhage, anemia, and death in the most severe cases. The most pathogenic stages are 6-8 weeks, since they are responsible for the large destruction in the hepatic parenchyma with ensuing hemorrhage (Walsh *et al*., 2008).

Escalona (2012) reported that these manifestations mainly occur in ovines. They are fast, and the animal can die in approximately 12 days after the emergence of the first symptoms. This clinical form cannot be diagnosed through coproparasitic tests, since the juvenile stages do not produce eggs (prepatent infection).

2. **Chronic Fasciolosis**: it is the least severe form of the parasitosis, which is produced by the consumption of slightly or moderately contaminated pastures for a long period of time. It allows animals to react and resist the infection. The parasites are established in the biliary conducts, producing thickening, fibrosis, and obstruction (patent stage of infection). While in the mature stage, the eggs are eliminated through the bile, and appear in the feces, which allows for coprological diagnostic of individuals with chronic manifestations (Walsh *et al*., 2008; Escalona, 2012).

This phase represents a silent threat, since the parasites can survive for over a decade, and cause asymptomatic damage, or produce unspecific symptoms. In that context, liver dysfunction due to hepatic damage might be irreversible (Espinoza, Terashima, Herrera-Velit, and Marcos, 2010).

Moreover, it produces a decrease in milk production and quality, along with apparent weight loss, deficient feed conversion, stunting, low fertility, and partial or total liver condemnation in slaughterhouses, producing financial losses in ruminants (Abunna, Asfaw, Megersa, and Regassa, 2010). This form causes, by far, more economic losses than the acute form.

Control and prevention

Deworming of the final host is the main prophylactic method of Fasciolosis; hence, it is important to know all the phases of *F. hepatica* development to implement efficient control strategies based on effective drugs against young and adult worms. A wide range of existing anthelmintics can be found at different prices, efficacy, safety, and availability. Nevertheless, as noted by Espinoza, Terashima, Herrera-Velit, and Marcos (2010), though there are quite a few fasciolicides in the market to control the disease, the costs of treatment hinders widespread use by livestock farmers in developing countries. Besides, the use of molluskcides is necessary to eliminate the intermediary host in biotopes.

Rather than treatments, efficient control programs should be implemented, which can use local epidemiological information. Prevention is the key to secure maximum protection of young animals, which are highly susceptible (Quiroz, Ibarra, Manga-González, and Ochoa, 1997).

Fight against the intermediary host: its goal is to reduce or eliminate lymnaeid populations, which can be achieved through ecological means that modify the conditions of snail biotopes, along with chemicals and biologicals (Wong *et al*., 2010).

- Ecological means (Hajimohammadi, Oryan, Zohourtabar, and Ardian, 2014):

a) Draining of areas with elevated water retention capacity.
b) Suppression of vegetation on the sides of ditches, canals, wells, and other places that can host snails.

- Biological control (Gallego, 2006):

a) Breeding and protection of aquatic birds, like ducks.
b) Utilization of mollusk predators or competitors for food, such as Zonitods and Marisia.

- Chemical means: the utilization of molluskcides, which must be effective, selective, economical, and stable under sun radiation, and organic matter. The most commonly used molluskcides are Copper sulfate, Calcic cianamide, Tritymorpholine, or plant extracts like marine ambrosia used in Africa with promising results (Wong *et al*., 2010).

Knowing the spatial arrangement of larval forms of *F. hepatica* into the mollusk population, the relation between the size of this intermediary host and the average amount of rediae and cercariae hosted, and knowing the relation between mollusk size and the corresponding reproductive value, are important to choose the best moment to apply molluskcides (Wong *et al*., 2010).

In Cuba, as in most countries of the globe, parasitic control relies mostly on the use of proven antiparasitic substances. This strategy is adopted because of the immediate response observed with the utilization of medication. Today, a large variety of anthelmintic products can be used in a rational manner. This combination may be useful to reduce internal parasitism at acceptable levels (Palacio *et al*., 2020).

Epidemiology

Some of the factors that favor the occurrence of the disease are the production of eggs, resistance of metacercariae to the environment, long permanence in the host, and high reproductive capacity of snails. Among the unfavorable factors are bovine resistance, limited life of miracidiae, presence of predators, and relative resistance of snails (Beesley, Williams, Paterson, and Hodgkinson, 2017).

The topographic factors that favor the occurrence of the disease are permanent humid areas with renewable sources of water. On the other hand, some unfavorable factors are dry areas, rapid and still waters, and prolonged dry periods (Quiroz, 2006).

Prepelitchi (2009) found that low temperatures are unfavorable following adequate conditions for the snail that may delay the evolution of juvenile stages, which will reactivate in the next spring. Hence, pasture contamination reduces in the dry season.

Among the human factors that favor the disease are high stocking rate of animals on infested areas, absence of draining, absence of fence wiring, inappropriate use of fasciolicides. The unfavorable conditions are the isolation of the weakest animals from infested areas, proper utilization of fasciolicides, rearing of less susceptible animals (Mas-Coma, Valero, and Bargues, 2009).

The most relevant epidemiological aspects of Fasciolosis, according to Hajimohammadi, Oryan, Zohourtabar, and Ardian (2014) are the following:

1. The geographical distribution is cosmopolitan. The most affected countries are in The Andes (Bolivia, Peru, Chile, and Ecuador), the Caribbean (Cuba), north Africa (Egypt), western Europe (Portugal, France, and Spain), and in the Caspian Sea (Iran and neighboring countries). Considering the limitations in the diagnostic of this parasitosis, the number of cases is much higher than the figures published.
2. The transmission mechanism consists in the consumption of metacercariae adhered to different plants. The spread of *F. hepatica* from its European origin to other continents is linked to the dissemination of the main intermediary host in Europe (*Glaba truncatula*, synonym with *Lymnaea truncatula*) through the trade of animals, the spreading of snails such

as Pseudosuccinea columella in the Americas, and adaptation of other native species of lymneidae to the new colonized areas.
3. Ovines and bovines are the main reservoirs of the parasite, though there are wild animals that can also act as reservoirs.

Zoonotic effects

Fasciolosis infection is accidental in humans, caused by *Fasciola hepatica* (*F. hepatica* and *F. gigantica*). It was the first known trematode (Linnaeus-1758), and it can infect humans in all the continents (except the Antarctica). In contrast, *F. gigantica* is more localized in Africa, the Middle East, and Asia (Bennema *et al*., 2017).

The feeding habits are diverse in the world, defying every logic, which is significant for food-transmitted parasitic zoonosis. In Cuba, France, and other countries, the consumption of wild watercress is the cause of commonly reported cases of Fasciolosis in humans (Mas-Coma, Valero, and Bargues, 2009).

Outbreaks of *F. hepatica* have been historically reported, and the country has a surveillance and care system that permits proper management of the parasitosis at every health care level (Mucheka, Lamb, Pfukenyi, and Mukaratirwa, 2015).

The first case of human infection recorded in Cuba was in 1931; by 1944, more than 100 new cases had been identified, representing 33% of acknowledged infections globally at that time. Aleixo *et al*. (2015) considered this disease as one of the most neglected, regardless of the 91.1 million people that inhabit risk areas, of which 17 million are infected nowadays. Also known as liver distomatosis, this zoonotic entity is commonly observed in herbivores, but much less frequent in humans.

Scattered cases of Fasciolosis continue to be diagnosed, particularly in the central and western regions of the country. The annual incidence is low enough not to be considered a health issue in Cuba (Brito, 2010).

Human infection is thought of as an emerging zoonosis by the World Health Organization (WHO); the most recent reports estimate that 17 million people are infected worldwide (Escalona, 2012).

Seasonality

Cuban Livestock raising has relied on pasture mostly. The development and survival of larval stages in the pasture depend on the local climatic conditions, including precipitations, relative humidity, and temperature (Ticona, Chávez, Casas, and Chavera, 2010; Mucheka, Lamb, Pfukenyi, and Mukaratirwa, 2015). In Cuba, only two well-defined climatic seasons take place (dry and rainy seasons), and the behavior of pasture and animal infestations fluctuates depending on such conditions (Palacio *et al*., 2017).

The existence of *F. hepatica* is linked to the presence of snails from genus Lymnaea, which act as intermediary hosts. Mollusks live in slow flowing fresh water. The biotic potential of snails is stunning: a single individual usually produces up to 25.000 new snails in only three months, particularly when the temperature is close to 22 ºC, combined with proper humidity conditions. In dry warm seasons, the snails can estivate (Selemetas, 2015).

The eggs halt their development in September and October (dry months), and hatch miracidia massively in September and October. Then, the snails increase their population, and a large number of them are attacked by miracidia. As the cycle in the snail takes five to six weeks, a large number of cercariae are released in October and November. In Ecuador, Moscoso Andrade (2014) notes that in the autumn and winter, no new pasture infestations occur, but the untreated animals still harbor Fasciolas in their livers from previous infestations, months or years before. These parasites continue to produce eggs, which halt their evolution when disposed of in winter, and hatch in September and October (Thanh, 2012).

In autumn, the moisture conditions are more favorable for their occurrence, so further pasture infestation can take place. In March-April, the cycle slows down progressively, being less efficient in the emission of cercariae (Palacio *et al*., 2017).

In cold or dry conditions, both the snail and the intermediate stages decrease their metabolic activity, being able to survive for several months, until the conditions are favorable for reappearance. The occurrence of temperatures below 10 °C inhibit snail activity (Selemetas, 2015).

Moreover, in the summer, higher temperature speed up the cycle, producing a spike in evapotranspiration that leads to elevated mortality of different stages of the parasite cycle. Precipitations and a permanently humid environment are determinant in the continuity of the cycle, and occurrence of the disease (Selemetas, 2015).

In the province of Camagüey, recent research studies used linear regression to validate an immunoenzymatic assay (López, 2014). These studies included neuron networks to forecast prevalence in the slaughterhouse, according to variables month, municipality, temperatures (maximum and minimum), and rain average. The climatic variables were the most outstanding, whereas months were the least important (Arteaga, 2014), which is appealing, considering the biological cycle of the parasite (Bennema *et al*., 2014; Mazeri, 2017).

Economic effects

A decrease in the productive parameters that generate this parasitosis is considerable; an infested animal can reduce meat production up to 28%, along with a decline in milk quantity and quality (Espinoza, Terashima, Herrera-Velit, and Marcos, 2010; Wong *et al*., 2010).

This parasite affects the fertility indexes in cattle. Following treatment with fasciolicides, the percentage of gestating animals in the first artificial insemination increases from 38% to 66%. It has been estimated that Fasciolosis causes 0.5 extra services by conception, and the calving interval increases in 20 days, thus raising the costs of feeding, with low weight gain, and lower income for companies (Quiroz, 2006).

In infected ovines, 45 Fasciolas cause 30 grams of weight loss per week. A number of 87-500 trematodes cause a loss of 130-500 grams per week; 350 parasites will lead to severe weight loss and death. A number of 100 Fasciolas is considered to have striking clinical effects for livestock farmers. Another study showed that infected ovines with 10-35 trematodes caused a delay of growth, representing 2.5 kg, and 50-100, 7 kg, compared to the control group (Quiroz, 2006).

Infection also has a detrimental effect on milk production and quality, which depends on the parasitic burden; milk production is reported to undergo a 14% decrease, though 8% can be recovered after treatment. In dairy production, it represents a 5% reduction in cows with a moderate parasitic burden, and milk total solids decrease as well, affecting quality and price. Overall, milk production can decrease 0.5 kg-1.0 kg per day, throughout 305 days of lactation, including a decline in total solids of 0.328% (Espinoza, Terashima, Herrera-Velit, and Marcos, 2010; Fanke, 2017).

Economically, fascioliasis is probably the most prominent helminth infection. It has been reported to be the cause of major economic losses in many parts of the world due to its incidence in production animals, like cattle, sheep, goats, and buffaloes, totaling an estimated three billion US dollars a year, according to several authors (Kialanda *et al*., 2013; Bennema *et al*., 2014).

Slaughterhouses in Costa Rica reported the prevalence of *Fasciola hepatica* (2.33% and 2.55%), and financial losses ($ US 67 438) associated to liver condemnation. These reports emphasize on the negative economic impact of the trematode nationally, as well as the usefulness of damaged viscera condemnation and recording, as diagnostic tools for epidemiological surveillance to determine the state of this parasitosis (Rojas and Cartín, 2016).

A ten-year research done in Nigeria showed prevalences in municipal slaughterhouses in Minna (32.29%), Suleja (26.82%), Bida (30.47%), Kontagora (35.42%), and New-Bussa (36.72%), resulting in a general prevalence of 32.34% of animals affected by *Fasciola hepatica*. The financial losses caused by liver condemnation totaled $ 766 896 USD (Yatswako and Vida, 2017).

Prevalences of *Fasciola hepatica* have been reported in slaughtered cattle from 1.1-4.8% in Iran, 3.3% in Iraq, 25.5% in Pakistan, 10.3% in Brazil, 10.9% in Switzerland, 5.0-8.5% in Scotland, 6.5% in England and Wales, 3.5-26.0% in Kenya, 7.0% in Nigeria, 9% in Audi Arabia (Nasher, 1990), 60.9% in Zambia, 24.3-90.7% in Ethiopia (Sariözkan and YalÇin, 2011), and 11% in Switzerland (Schweizer, Braun, Deplazes, and Torgerson, 2005). The high variation in the prevalence of bovine Fasciolosis in different countries and regions depends on factors like climatic conditions, cattle age and sex, and level of intermediate host contamination in the pasture (Sariözkan and YalÇin, 2011).

A four-year study conducted in a Cuban company estimated financial losses of $ 16 121.30 USD derived from condemnation of livers affected by *Fasciola hepatica*, plus $ 316 078.38 and $ 170 664.60 USD reported as losses due to beef that was not produced, and $ 14 686.18 USD for anthelmintic drug use, leading to a total $ 517 550.46 USD in estimated losses (González, Pérez, and Brito, 2007).

The financial losses produced in the central provinces of Cuba (Cienfuegos, Villa Clara, and Sancti Spiritus) due to liver condemnation were considerable ($ 436 656 USD), which represented 18.0% of 273 450 animals slaughtered (Brito, 2010). Furthermore, a four-year study, (León, Silveira, Pérez, and Olazábal, 2013) estimated that fascioliasis affected one out of three slaughtered cattle heads, causing $ US 16 121.30 in losses due to liver condemnation, apart from the $ US 316 078 38 and $ US 170 664. 60 reported for unproduced beef, respectively.

CONCLUSIONS

The financial losses derived from condemnation of livers affected by *F hepatica* are significant; they are linked to the interaction of physiopathological and environmental aspects of the disease (climatic and geographical factors), which can determine the presence of intermediary hosts and the parasite in the environment.

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AUTHOR CONTRIBUTION

Author participation was as follows: Conception and design of research: DPC, JBV; data analysis and interpretation: DPC, JBV, MBM; redaction of the manuscript: DPC, JBV, MBM.

CONFLICT OF INTERESTS

The authors declare no conflict of interests.