

Fascioliasis prevalence in livestock from abattoirs in southern Chile

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ABSTRACT. Fascioliasis is a widely distributed parasitic zoonosis caused by the trematode *Fasciola hepatica* that affects livestock production and generates high economic losses. In Chilean authorised abattoirs, the infected livestock livers are condemned during the veterinary inspection. This study aims to evaluate the prevalence of fascioliasis in Chile from 2014 to 2016 and also monthly from 2002 to 2015 in livestock (cattle, pig, sheep, horse and goat) slaughtered in abattoirs of La Araucanía region, southern Chile. To do this, the available records on abattoirs provided by the sanitary authority were analysed. A descriptive statistics and trend analysis of the data by jointpoint regression was carried out. The Biobío and La Araucanía regions registered the highest levels of parasitosis in the country recording levels of 59.18 and 44.74%, respectively, and presented 50.03% of the liver condemnation rate in cattle. During the study period, a total of 2,239,164 animals were slaughtered and 40.59% infected livers with *F. hepatica* were condemned in the 9 existing abattoirs of La Araucanía region. The abattoirs located in the cities of Temuco (51.43%) and Angol (65.09%) recorded the highest percentages of fascioliasis. The cattle species recorded the highest number of slaughtered animals and liver condemnation (54.52%). The presence of the parasite was recorded annually and monthly and it was possible to observe a slight increase in fascioliasis over the years. This study provides updated information on the fascioliasis prevalence in the country and the dynamics of condemnation in endemic areas such as La Araucanía region, which could contribute to the control and prevention of this zoonosis.

Key words: abattoir, Chile, fascioliasis, livestock.

INTRODUCTION

Fascioliasis is a zoonotic parasitic disease produced by *Fasciola hepatica*, a trematode of the Phylum Platyhelminthes globally distributed and found in every continent except Antarctica (Rojo-Vazquez and Ferre 1999). It seriously affects livestock, particularly sheep and cattle, impacting public health and causing significant productive and economic losses derived from the clinical picture and the condemnation of the liver (Mas-Coma *et al* 2009). The infection is caused by the intake of short-stemmed vegetation and waters contaminated with metacercariae of the parasite (Mas-Coma *et al* 2014). The World Health Organization defines human fascioliasis as a neglected reemerging tropical disease, with endemic and epidemic outbreaks throughout the world (WHO 2013). In cattle, the effects of this pathology in chronic stages are correlated with productivity, generating weight loss, reduced milk production and lower fleece quality (Schweizer *et al* 2005).

In Chile, the disease is mainly associated with cattle and sheep. The most frequent production system involving these species is extensive grazing, which exposes the animal to various parasitic pathogens such as gastrointestinal nematodes and *F. hepatica* (Peña-Espinoza 2018).

The Chilean Agriculture and Livestock Service (SAG) regulates the slaughter of animals for consumption in authorised abattoirs. Through breeding protocols, prior examination and post-slaughter of productive species, SAG ensures the safety of slaughter livestock and their derivatives¹, guaranteeing the organoleptic quality and preventing risks for the consumer. These practices are regulated by Law N° 19.162 of the Ministry of Agriculture² and General Technical Standard N° 62 of the Ministry of Health¹. During the veterinary inspection, transverse incisions are made into the liver to search for adults of *F. hepatica* or pathological lesions in the bile ducts. After detection, the condemned livers are classified as unfit for human consumption, generating a record that is kept by each abattoir¹.

Currently, there is little updated research on the prevalence of *F. hepatica* or fascioliasis that provides information on the situation at both national and regional levels. This study aims to analyse the prevalence of the

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¹ Ministerio de Salud. 2009. Norma General Técnica N° 62 Sobre inspección Médico-Veterinaria de reses y sus carnes. *Biblioteca Del Congreso Nacional*. Available at: <https://www.leychile.cl/N?i=1064158&f=2009-09-14&p=>

² Ministerio de Agricultura. 1992. Ley 19.162, Sistema obligatorio de clasificación de ganado, tipificación y nomenclatura de sus carnes y regula funcionamiento de mataderos, frigoríficos y establecimientos de la industria de la carne. *Biblioteca Del Congreso Nacional*. Available at: <https://www.leychile.cl/N?i=30529&f=2009-07-03&p=>

parasitosis through liver condemnation of infected livestock due to fascioliasis using the available SAG databases from authorised abattoirs, with information corresponding to Chile from 2014 to 2016 and the endemic region of La Araucanía during the period 2002-2015.

MATERIAL AND METHODS

The “Report on the Slaughtered Animals and Pathological Findings in National Abattoirs” was accessed, which contains the records of the main pathologies of interest to public health detected in slaughter animals from authorised abattoirs in Chile from 2014 to 2016. The Ñuble region was included in the statistics of the Biobío region since the law for the creation of the first was promulgated in August 2017³. Also, the “Statistics on SAG Abattoir Inspection” of La Araucanía region were accessed for the period 2002-2015.

The national registry is organised in two main sections: slaughtered animals (or animal gain) and pathological findings in abattoirs by year. The national and regional registry included the total number of animals by species and findings according to pathologies (echinococcosis, tuberculosis, fascioliasis, cysticercosis and trichinosis). The data corresponding to La Araucanía region was registered by month and year. The data did not include livestock traceability and the recordings are made at the end of the animal’s life.

We recorded the number of both slaughtered animals and liver condemnations appearing in the national registry by region (Arica y Parinacota, Tarapacá, Coquimbo, Valparaíso, Metropolitana, O’Higgins, Maule, Biobío, La Araucanía, Los Ríos, Los Lagos, Aysén and Magallanes regions) and productive species (cattle, pig, sheep, horse and goat). The data of La Araucanía was organised by year, month and nine authorised abattoirs, with the productive livestock being grouped into the five categories previously mentioned. La Araucanía region is one of Chile’s 16 administrative divisions, located at the coordinates 38°54’S 72°40’W. The studied abattoirs were Frigorífico Temuco S.A. (Temuco), Faenadora de Carnes Angol (Angol), Faenadora de Carnes Victoria S.A. (Victoria), Comercial Frigosur Rio Toltén Ltda. (Pitrufuén), Sociedad Faenadora y Comercializadora de Productos Alimenticios Araneda Ltda. (Imperial), Sociedad Matadero Chol Chol Ltda. (Chol Chol) and Matadero Industrial Lautaro (Lautaro). Also included were the abattoirs located in Galvarino and Hualpín which ceased functions in October 2005 and December 2006, respectively.

STATISTICAL ANALYSIS

The database was elaborated using a Microsoft Excel worksheet and exported to STATA15 software (StataCorp LLC, College Station, Texas, U.S.A.) for statistical analysis. The basic statistical analysis included the estimation of prevalence and mean of the prevalence over time. The trend analysis of the prevalence through time was done using a Joinpoint Regression (Kim *et al* 2000) and the Trend Analysis Software of the NIH⁴. The graphs were obtained using the GraphPad Prism version 7.00 software (GraphPad Software, La Jolla, California U.S.A.).

RESULTS AND DISCUSSION

The annual record of the statistics and trends of the most commonly detected pathologies in abattoirs at national level allowed us to perform passive monitoring to support the sanitary and zoonotic management in the country. In all the regions with authorised abattoirs of the country, *F. hepatica* was found in livers of productive animals in authorised abattoirs during the years 2014-2016.

In the early 1990s, the distribution and trend of fascioliasis in Chilean abattoirs was 30.1% for cattle (Morales and Luengo 2000). There is a great variation in the prevalence recorded in Latin America where countries such as Brazil, with industrial livestock, report numbers of 18.6% for the state of Rio Grande do Sul and 24.9% for the state of Espírito Santo, with 7.32% being recorded between 2002 and 2011 nationwide (Molento *et al* 2018). In Uruguay, parasitosis exceeds 50% prevalence in productive farms (Sanchís *et al* 2015) while in Mexico, where human fascioliasis is significant (Mas-Coma *et al* 2014), condemnation in abattoirs due to *F. hepatica* reaches 20.99% (Rangel and Martínez 1994). On the other hand, Costa Rica has low prevalence levels (1.82%) of adults of *F. hepatica* after veterinary inspection (Rojas and Cartín 2016). Likewise, in the state of Lara, Venezuela, 8.49% of the animals slaughtered in abattoirs were reported as fascioliasis findings (Quijada *et al* 2005). Despite the differences existing within the Latin American meat industry, during the last decade, *F. hepatica* consistently appeared in those countries.

There are few reports of the prevalence of the parasite in Chile, including human fascioliasis case reports (López *et al* 2004, Morales *et al* 2009, Rosas *et al* 2008, Venturelli *et al* 2003) and a case report on resistance to triclabendazole treatment in the Metropolitana region (Gil *et al* 2014). Fascioliasis, as a problem of veterinary concern, is mainly absent from the epidemiological and public health context, with only one report on the prevalence in endemic areas during the late 1980s (Apt *et al* 1993). The livestock is

³ Ministerio del Interior y Seguridad Pública. 2017. Ley 21.033, Crea la XVI región de Ñuble y las provincias de Diguillín, Punilla e Itata. *Biblioteca Del Congreso Nacional*. <https://www.leychile.cl/N?i=1107597&f=2018-09-06&p=>

⁴ National Institutes of Health. Division of Cancer Control & Population Sciences. USA. 2000. *Joinpoint Trend Analysis Software*. Available at: <https://surveillance.cancer.gov/joinpoint/>

mainly concentrated in the centre and south of the country where the main productive activity is located. It has been given special attention as an endemic area for the parasite (Apt *et al* 1993).

The prevalences (SD) obtained in our study raise the alert for the significant presence of the parasite in the country. The abattoirs located in Biobío 59.18 (4.32) % and La Araucanía regions 44.74 (2.87) %, (figure 1) stand out due to a prevalence similar to that reported in Zambia (64.4%) where the animals exhibit poor body condition (Nyirenda *et al* 2019). The percentage of condemned livers reaches the highest levels in endemic areas of human fascioliasis, particularly in the department of Apurimac (80.1%) in Perú (Espinoza *et al* 2010). Also, abattoirs in other regions of Chile reported a significant presence of the parasite with Los Ríos and Los Lagos regions presenting condemnations of 26.27 (1.39) % and 26.11 (2.57) %, respectively (figure 1).

Our results show a higher prevalence in the southern regions of the country, particularly in the Biobío, La Araucanía, Los Ríos and Los Lagos regions. The elevated livestock population of the area is an important factor that influences the prevalence. Moreover, it is well known that climate conditions and climate changes can affect the parasitism of the species (Hughes 2000). In the case of *F. hepatica*, this impact is conditioned by the freshwater snail, an intermediate host that determines the possibility of completing the life cycle of this zoonotic disease (Reinhard 1957) due to its sensitivity to temperature and soil moisture (Yigezu *et al* 2018). The weather in southern Chile is temperate humid, with rainfall throughout the year. The feeding systems used in the southern regions are predominantly extensive and mixed, where the grazing behaviour of the livestock allows the exposure to the

infective stages of *F. hepatica* (Fox *et al* 2013), unlike the case of more intensive systems used in Metropolitana 24.91 (4.10) %, O'Higgins 0.22 (0.02) % and Maule 6.80 (0.56) % regions. The conditions related to the prevalence are shown in figure 1.

The collected data was obtained from the authorised abattoirs at the end of the productive life of the animals. Therefore, the analysis does not consider livestock traceability making impossible to determine where the animals getting infected are or their movement between regions. Further studies that include traceability are needed to enrich the investigation.

The national record displays a total of 20,005,649 animals slaughtered during the study period, with the liver condemnation rate (SD) in cattle being 50.03 (1.56) % nationwide (figure 2). Previous reports in the early 1990s showed a lower prevalence of 30.1% for the species (Morales and Luengo 2000). The second most infected productive species was equine with 18.3 (1.59) % where the parasitosis was similar to previous reports on fascioliasis in equines. Morales *et al* (2009) reported 12.3%, a similar study found 13.54% (Apt *et al* 1993) and a recent work described 10.4% in racehorses (Muñoz *et al* 2008). In the other species, our results showed that goats reach 1.29 (1.35) % as opposed to the findings of Morales and Luengo (2000) with 14%. The least parasitised livestock species were ovines and porcines with 0.28 (0.05) % and 0.01 (0.01) % respectively, corresponding with a downward trend of this species as reported in previous works (Morales and Luengo 2000), but in disagreement with the 20.61% reported by Apt *et al* (1993). In cattle and equine species, the prevalence observed is related to previous reports but an increase in prevalence is observed.

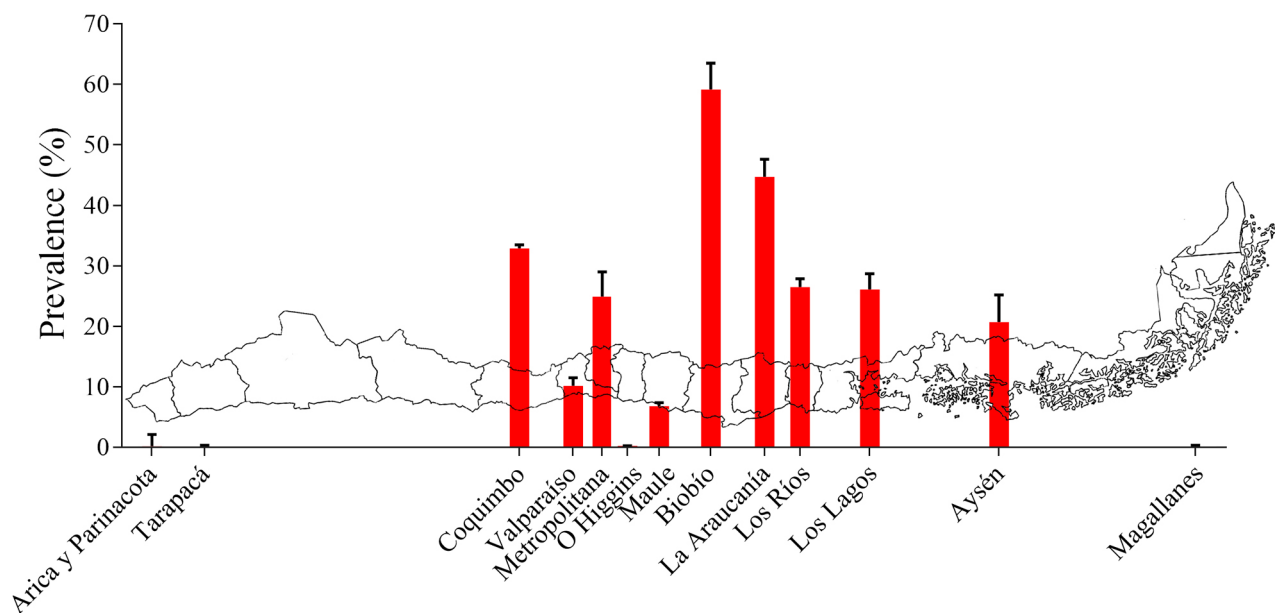


Figure 1. Prevalence of fascioliasis (% red) in Chile abattoirs, during the period 2014-2016. Standard deviation (T) is displayed.

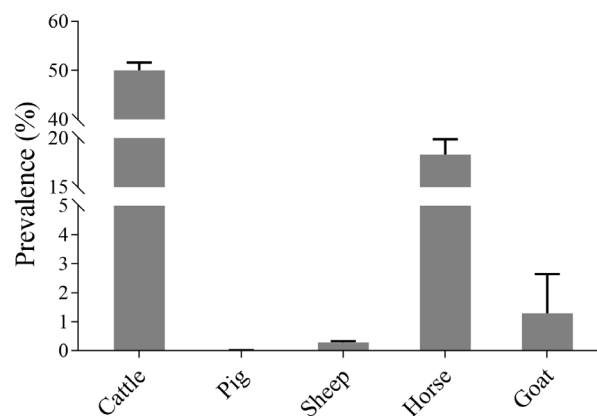


Figure 2. Prevalence of fascioliasis in main productive species slaughtered in Chile abattoirs from 2014 to 2016. Standard deviation (T) is displayed.

Between 2002 and 2015, a total of 2,239,164 animals were slaughtered in La Araucanía region, reporting condemnations of 40.59% due to *F. hepatica* (908,901 animals with findings) (see supplementary material 1). The highest levels of fascioliasis correspond to the abattoirs located in Angol and Temuco (65.09 and 51.43%, respectively) (figure 3). Microclimates are crucial for the distribution of vectors, this particularly concerns diseases transmitted by water-borne vectors such as freshwater snails (Mas-Coma *et al* 1999). The increase in winter temperatures raise the metabolic rate, egg production and feeding frequency of invertebrates (De La Rocque *et al* 2008). The Angol borough has mediterranean climate with mild temperatures and rainy winters and its weather is warmer than in other boroughs of the central valley in the same region, where the abattoirs of Temuco, Victoria (32.49%), Lautaro (3.33%) and Pitrufquén (9.51%) are located (figure 3). This microclimate would explain the prevalence exhibited by the Angol abattoir, considering

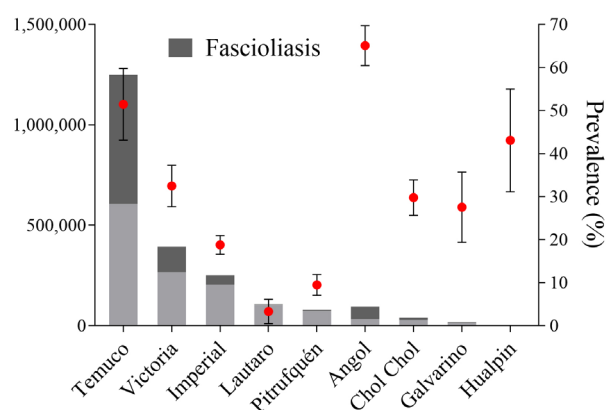


Figure 3. Number of slaughtered animals (columns) and fascioliasis (dark grey), prevalence of fascioliasis (%) (red) and 95% confidence interval (T) by abattoir in La Araucanía region, during the period 2002-2015.

that it recorded only 95,571 slaughtered animals during the studied period.

The rural boroughs of Galvarino and Hualpín range within the lowest quintile of the percentage of the population living with poverty income (Ministerio de Desarrollo Social 2015) and in less than 5 years of operation it registered a high level of condemnation due to *F. hepatica*, recording 27.56 and 43.09%, respectively (figure 3). The uptime of abattoirs and missing data were recorded (see supplementary material 2). La Araucanía is the region with the lowest economic income up to 2017 (Ministerio de Desarrollo Social 2017) with a rural population of 29.1% which is higher than the national average (INE 2017). These factors contribute negatively to control this or any parasitosis, harming livestock and health management. The use of an extensive system and veranadas⁵ conditions animal movement to agroecological areas with greater vegetable mass and annual precipitation (Catrileo 2015), propitiating the distribution and seasonality of the intermediary host (Mas-Coma *et al* 2009). Those conditions allow permanent infection in the areas used for grazing, being associated with the prevalence exhibited.

The dynamic behaviour shows an increase in the number of cattle associated with the increasing demand for the product in the national reports (Cofré 2019, INE 2019), with a marked difference between 2007 (138,978 total animals) and 2008 (191,072 total animals). Our results exhibit three periods, only the first period between 2002 and 2007, characterised by high prevalence indices, was statistically significant ($P=0.0048$) with an annual percent change of 21.7, reaching 60.09% in 2007, the highest record of condemnations for the period studied. The two periods between 2008 and 2015 were not significant, recording 45.19% in condemnations in 2015 (figure 4). This behaviour is probably due to the modification made to the regulation on the veterinary inspection of cattle and their meats, General Technical Standard N°62¹, which was promulgated in July 2002 and entered into force in 2009. The main modification was the certification by SAG-accredited professionals of the control and monitoring of cattle and their derivatives, reforming the requirements of the abattoirs. Therefore, the impact on livestock production and the control of infectious diseases by producers and government services resulted in the improvement of sanitary programs for cattle.

According to our results, slaughter increased the most in December (225,710 total of animals) which is linked to an increase in consumption due to the end of the year celebrations (Cofré 2019). Studies have suggested that the prevalence of *F. hepatica* is conditioned by the ecology of its intermediary host and aquatic vector, a lymnaeid of the genus *Galba* (Artigas *et al* 2011). Considering its habitat

⁵ Yáñez Barrios L. 2018. Región de la Araucanía, Información regional. Oficina de Estudios y Políticas Agrarias, 16. Available at: www.odepa.gob.cl

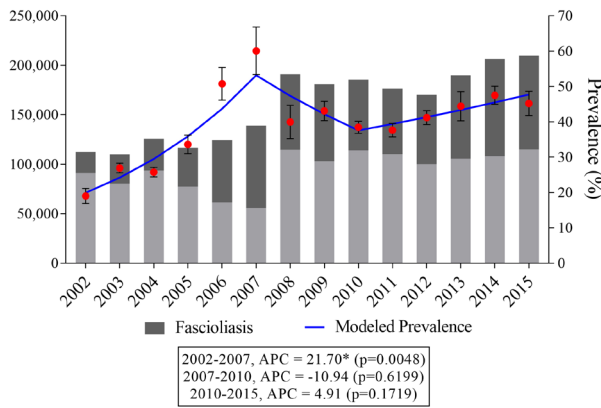


Figure 4. Number of slaughtered animals (columns) and fascioliasis (dark grey), prevalence of fascioliasis (%) (red), 95% confidence interval over time (T) and modeled prevalence (blue), during the period 2002-2015 in La Araucanía region. *Indicates that the Annual Percent Change (APC) is significantly greater than zero (Jointpoint regression).

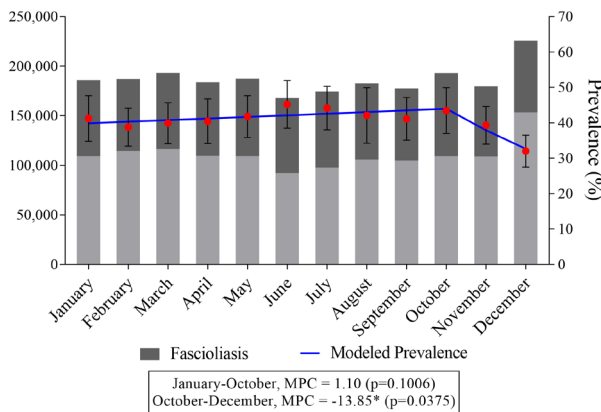


Figure 5. Number of slaughtered animals (columns) and fascioliasis (dark grey), prevalence of fascioliasis (%) (red), 95% confidence interval over time (T) and modeled prevalence (blue), by month in La Araucanía region, during the period 2002-2015. *Indicates that the Monthly Percent Change (MPC) is significantly smaller than zero (Jointpoint regression).

and the climatic conditions of the area, the increase in precipitation and temperature would in turn increase the snail populations (Müller *et al* 1999). Our results show that during the rainy season in the Southern Hemisphere, June (45.20%), July (44.15%) and August (42.09%), there was a lower intake number and high numbers of condemnations (figure 5). This is related with prevalence reports during ideal seasons for their development, in countries such as Venezuela (Quijada *et al* 2005), China (Yuan *et al* 2016), Vietnam (Nguyen and Nguyen 2012) and Cuba (Palacio Collado *et al* 2017), suggesting an even higher probability of becoming infected in the rainy season (Byrne *et al* 2018, Novobilský *et al* 2014). However, the change in monthly percentage through this period was not

significant. On the other hand, the prevalence between the spring months - November and December - shows a statistically significant ($P=0.0375$) lower index (39.32 and 32.00 %, each) (figure 5), probably associated with preventive deworming which takes place at the beginning of the spring as part of government programs. It is important to emphasise the permanent indices throughout the year. The half-life of *F. hepatica* has been reported to be more than two years in livestock (Mas-Coma *et al* 2014); the constant elimination of eggs from the definitive host (Robles-Pérez *et al* 2015) and the invariable presence of the intermediary host in the area (Mas-Coma *et al* 1999) causes constant reinfection.

The most relevant among the productive species was cattle which registered findings of fascioliasis in the abattoirs of Temuco (51.43%) and Victoria (32.49%). The importance of cattle species and the parasitic prevalence of *F. hepatica* had been previously reported at national level (Morales and Luengo 2000). Smaller productive species such as pigs, sheep and goats are traditionally home slaughtered for private consumption although it is an illegal activity without health certification² that is not included in official abattoir records.

The prevalence observed is related to the definitive host tolerance to the infection (Rojo-Vazquez and Ferre 1999). The greatest percentage was reported in cattle (54.52%) because it exhibited low receptivity and delay in response to the implantation process in the liver (Boray 1999, Boray *et al* 1969). In more receptive mammals, such as goat (4.84%) and sheep (4.68%), there is a high parasitic activity and noticeable pathogenicity, producing acute symptoms that in most cases are lethal (Boray 1999, Boray 1985). On the other hand, we recorded low prevalence in pig (0.39%) and horse (3.65%) which confirms that they respond more quickly to hepatic invasion (figure 6) (Boray *et al* 1969).

In conclusion, fascioliasis is the main cause of condemnation in slaughtered livestock at national and regional levels, with cattle reporting the highest prevalence.

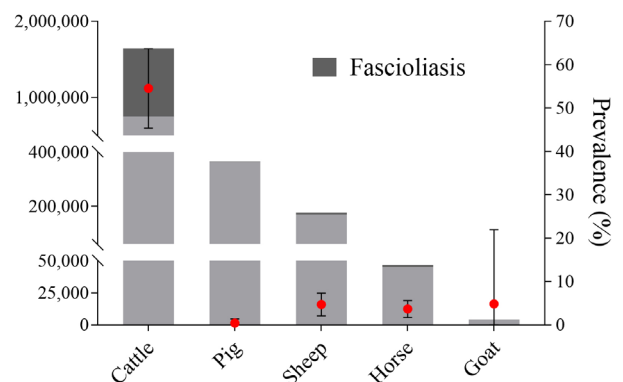


Figure 6. Number of slaughtered animals (columns) and fascioliasis (dark grey), prevalence of fascioliasis (%) (red) and 95% confidence interval (T) by main productive species in La Araucanía region, during the period 2002-2015.

The weather as well the productive system are associated with the prevalence found between the centre and the south regions of the country. The Biobío and La Araucanía regions show the highest rates in Chile and, in particular, La Araucanía region presents a high prevalence of *F. hepatica*. The presence of the intermediary host favoured by the climatic conditions of the area ensures the cycle of the parasite, reporting constant prevalence with a low variation during the chronological year. The dynamic behaviour of the parasitosis reports a slight increase in the prevalence through the years studied. Our results indicate a constant and evident prevalence of the parasite to the detriment of the productive economy and the organoleptic quality of the product due to the inflammatory process. The analysis of condemnation records at national and regional levels is a representative methodology to determine prevalence and monitoring of the disease and is useful for the epidemiological control and management of *F. hepatica*.

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