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# Prevalence and Risk Factors of Bovine Fascioliasis in Northeastern Peru

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**Abstract:** Bovine fascioliasis in Peru is highly prevalent in almost all regions; however, there are few studies about its prevalence in the region of Amazonas. This research aimed to determine the prevalence and risk factors associated with fascioliasis from four livestock basins in the Amazonas region. A total of 941 bovine feces samples were analyzed and a prevalence of 52% was found. The highest prevalence was registered in females (53.9%), crossbred (58.6%), and producers with less than 50 animals (54.40%). The highest risk factor was for Brown Swiss (2.1), crossbreeds (2.4), heifer (4.1), females (1.4), and bovine that drinks water from streams (2.5) and waterhole (2.4). With the principal component analysis, 5 groups were identified, where the first explains that the area of the farm and the number of animals are related to the prevalence of fascioliasis. Group five indicated a relationship between the drinking water source and the breeds with the highest prevalence of fascioliasis. The results show that there are high prevalence and risk factors that affect livestock productivity and welfare. For this reason, there is a need to improve veterinary and animal health support, as well as training in livestock management, providing adequate sources of nutrition, and improving drug administration.

**Keywords:** Amazonas Region, Extensive Livestock, Fasciola Eggs, Fascioliasis, Odds Ratio

## Introduction

Fasciola spp. it is distributed worldwide and causes fascioliasis. This disease has social and economic importance (Vara-Del Río *et al*., 2007; Utrera-Quintana *et al*., 2022), affecting bovines, sheep (Reigate *et al*., 2021), goats (Pérez-Creo *et al*., 2016) and humans who are the definitive hosts of this parasitosis (Beesley *et al*., 2018). The adult stage of the parasite is located in the bile ducts of herbivorous mammals and to complete its biological cycle it requires snails of the genus Lymnaea as intermediate hosts (Alba *et al*., 2023). Trematode prevalence has increased worldwide due to climatic variations (Suwannatrai *et al*., 2017), resistance to anthelmintics (Vineer *et al*., 2020), and current agricultural practices (Shrestha *et al*., 2020). Fascioliasis infection is chronic, generating losses in the animal industry due to reduced meat and milk production, bovine fertility (Jaja *et al*., 2017), and confiscation of livers (Arias-Pacheco *et al*., 2020), especially in animals raised in extensive systems (Olaogun *et al*., 2023).

Bovine fascioliasis in Peru has a high prevalence, with more than 70% of the infection present in 21 of its 24 regions. This is an agricultural and livestock country, with an Andean region that extends from 500 to 6768 meters above sea level, representing 35.50% of the national territory (Ñaupas, 2004). A relevant aspect of the increase of this parasitosis is the geographical distribution of the intermediate host, which coincides with the areas with the largest breeding population, especially in the Andes of Peru. In addition, raising cattle in an extensive exploitation system (grazing) adds to the increase in

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disease. Murga *et al*. (2018), determined that the type of system used for raising cattle in the region is the extensive system, where more than 60% has natural pastures and 36% with grass for cutting, and the source of the drink is ad libitum. This could reflect poor control in pasture handling by increasing intermediate hosts (Murga *et al*., 2018). Infection by fascioliasis generally occurs during grazing or when feeding the animals with green forage from agricultural purification and when using a non-served water source (Kurnianto *et al*., 2022).

At the level of Peru, there are reports of the prevalence of fascioliasis, for example, in the province of Huancabamba in Piura, 64.91% was reported (Alva *et al*., 2020), in Chachapoyas a 90% incidence of fascioliasis was reported (Diaz-Quevedo *et al*., 2021) and in Cajamarca, more than 40% of trematodes were reported to be resistant to triclabendazole (Fernandez-Baca *et al*., 2022). The last Agricultural Census of Peru registered more than 5 million head of bovines, of which 3.05% (157166) are located in the Amazon region (INEI, 2012) and beef production has increased significantly over the last 10 years. Beef meat is currently in very high demand and Amazon producers are considering exporting to other parts of Peru due to the high quality of the meat produced. However, for the production of quality meat, animals that have well-being and are free of diseases are needed. In this sense, the prevalence of fascioliasis in the country must be monitored and good and efficient programs for the prevention and control of this parasitosis must be carried out. Prevalence data is relevant when designing programs that instill good parenting habits in communities (Cabada *et al*., 2018). In that sense, we estimate the prevalence and risk factors of bovine fascioliasis in Amazonas and its effects on meat production.

## Materials and Methods

### *Study Area*

The research was carried out between January and August 2021 in the highlands of the Northeast of Peru, located in Leymebamba at 2,158 m.a.s.l, with an average annual temperature of 19°C and relative humidity of 82%, Molinopampa at 2,407 m.a.s.l, with an average annual temperature of 19.5°C and relative humidity of 82%, Rodríguez de Mendoza at 1,395 m.a.s.l, temperature annual average of 20°C and relative humidity of 78% and Florida at 2225 m.a.s.l, annual average temperature of 17°C and relative humidity of 71%, region of Amazonas, Peru (Fig. 1)

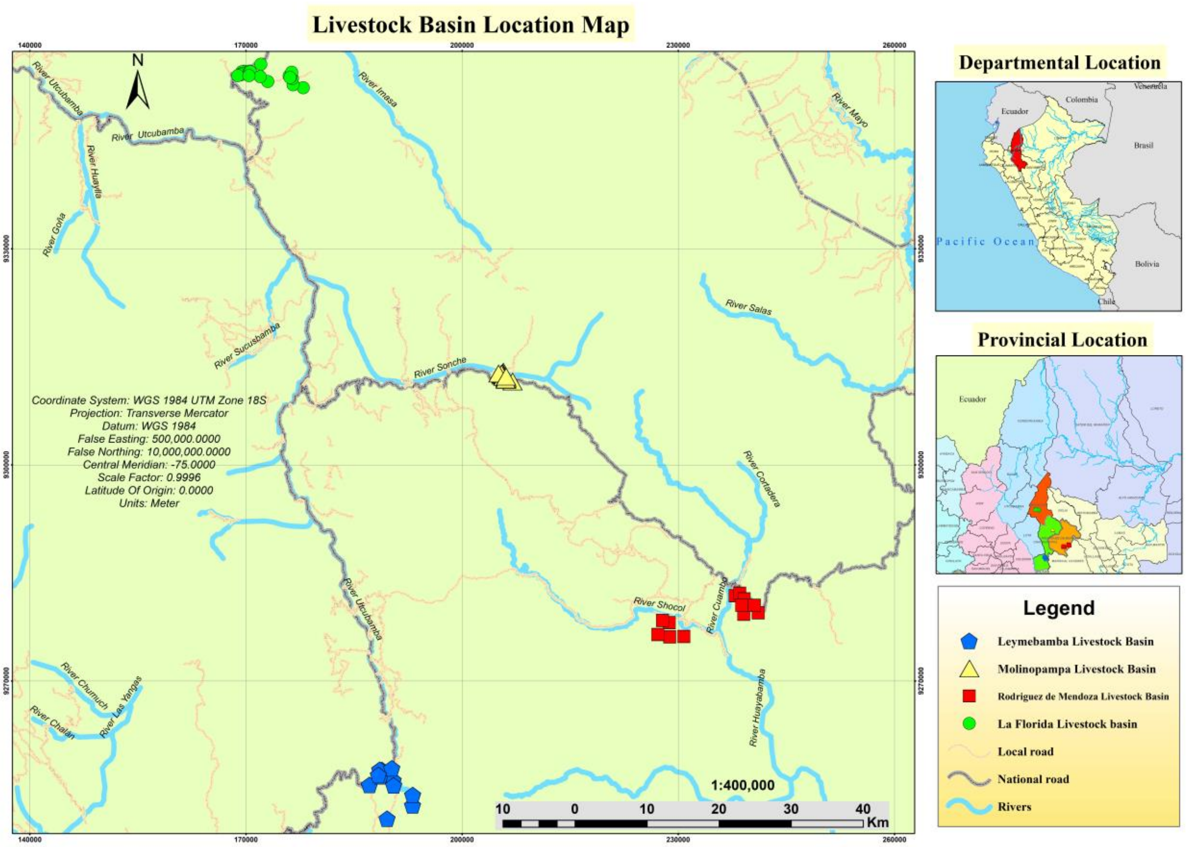


**Fig. 1:** Livestock basin location map

### *Experimental Design*

The research was carried out under a randomized, descriptive, and cross-sectional design. We visited 25 places (place of origin) within the 4 livestock basins. A total of 1734 bovine feces samples were estimated with the finite population formula (Subramani, 2000), at a confidence level of 95%. To obtain epidemiological data on possible risk factors, a questionnaire was applied to 60 producers. The data was based on age, sex, breed, total farm area, the total number of animals per farm, water source, and rearing system.

### *Sampling and Laboratory Analysis*

Fecal samples of 10-15 g were collected from the rectum of 1734 bovines, grouped according to breed (Brown Swiss, Holstein, Simmental, Creole, and Crossbred), animal category (calf, bullfighter [male bovine of 8-18 months of age], bull, veal, heifer, pregnant heifer and cow) and sex (male and female) and transported at 4°C to the laboratory. The presence of eggs was corroborated by the sedimentation technique (Correa *et al*., 2016), at the Laboratory of Infectious and Parasitic Diseases of Domestic Animals of the Universidad Nacional Toribio Rodríguez de Mendoza de Amazonas.

### *Statistical Analysis*

The prevalence of Fasciola spp. it was determined using descriptive statistics. The analysis of the fascioliasis association with livestock basin, place of origin, sex, breed, animal category, total farm area, the total number of animals on the farm, water source, and rearing system, was evaluated with Chi-square with a significance level of 0.05 and with a confidence level of 95% (Eq. 1). Risk factors (Odds ratio) and 95% confidence intervals based on the value of exp (β), were determined with binary logistics regression (Pinilla *et al*., 2020). The probability proportions were determined after applying a questionnaire to the producer of each livestock basin at the time of sampling. The factorial analysis was based on the method of extraction of main components with Varimax. The missing values in coefficients with absolute values below 0.20 were suppressed. The contrast of the correlation coefficients was performed using Kaiser-Meyer-Olkin and the hypothesis contrast occurred with the Bartlett sphericity test (p<0.05). The analyzes were performed at IBM SPSS vs. 26 Eq. 1:

$$Chi\,square = \sum_{i=1}^{r}\sum_{j=1}^{c}\frac{(O_{ij}-E_{ij})^2}{E_{ij}}$$

$r$ = The number of categories of the variable in the rows
$c$ = The number of categories of the variable in the columns
$O_{ij}$ = Number observed in input *ij*
$E_{ij}$ = Expected number at input *ij*

## Results

### *Fasciola Spp Prevalence*

The prevalence of Fasciola spp. in bovines in the four livestock basins was 52% (Fig. 2A). A significant association (Chi-square = 149.68, p<0.05) was found between the prevalence values in the four livestock basins in Molinopampa, Leymebamba, La Florita and Rodrigues de Mendoza (Fig. 2A). At the level of origin place, the highest prevalence found was in Pumahermana, followed by Tingo and Zeta. The level of association was significant for the origin place (Chi-square = 182.63, p<0.05) (Fig. 2B).

The prevalence of Fasciola spp. was associated with bovine sex (Chi-square = 8.34, p<0.05). The highest value was found in female bovines with a prevalence of 53.90% (Fig. 2C). On the other hand, depending on the bovine breed, there is a low association with the prevalence of Fasciola spp. (Chi-square = 36.17, p<0.05) and low level of prediction according to Lambda (Fig. 2D). The Crossbred bovine presented the highest prevalence, followed by the Swiss brown breed. Similarly, a significant association was found between the prevalence and the animal category (Chi-square = 59.58, p<0.05). In addition, heifers, pregnant heifers, bullfighters, and cows showed the highest prevalence compared to the other animal categories (Fig. 2E).

There was a significant association between Fasciola spp. prevalence and farm area (Chi-square = 73.90, p<0.05), with a low level of association and prediction (Fig. 2F). The prevalence of Fasciola spp. according to the farm, the area was higher at 1-50 ha and lower when the farm was over 100 ha. We found a similar result when analyzing the prevalence based on the number of animals on farms (Fig. 2G). Higher prevalence was observed in producers who have less than 50 bovines. A significant association (Chi-square = 25.45, p<0.05) was found between the prevalence of Fasciola and the source water. The highest prevalence was when bovines drinks water from streams, followed by waterholes and irrigation ditches (Fig. 2H). The association was significant between prevalence and the type of rearing system (Chi-square = 10.48, p<0.05). The highest prevalence was when bovines were raised in mixed systems versus extensive systems (Fig. 2I).

### *Risk Factors*

Binary logistic regression and odds ratios for fascioliasis in bovines are shown in Tables 1-4.

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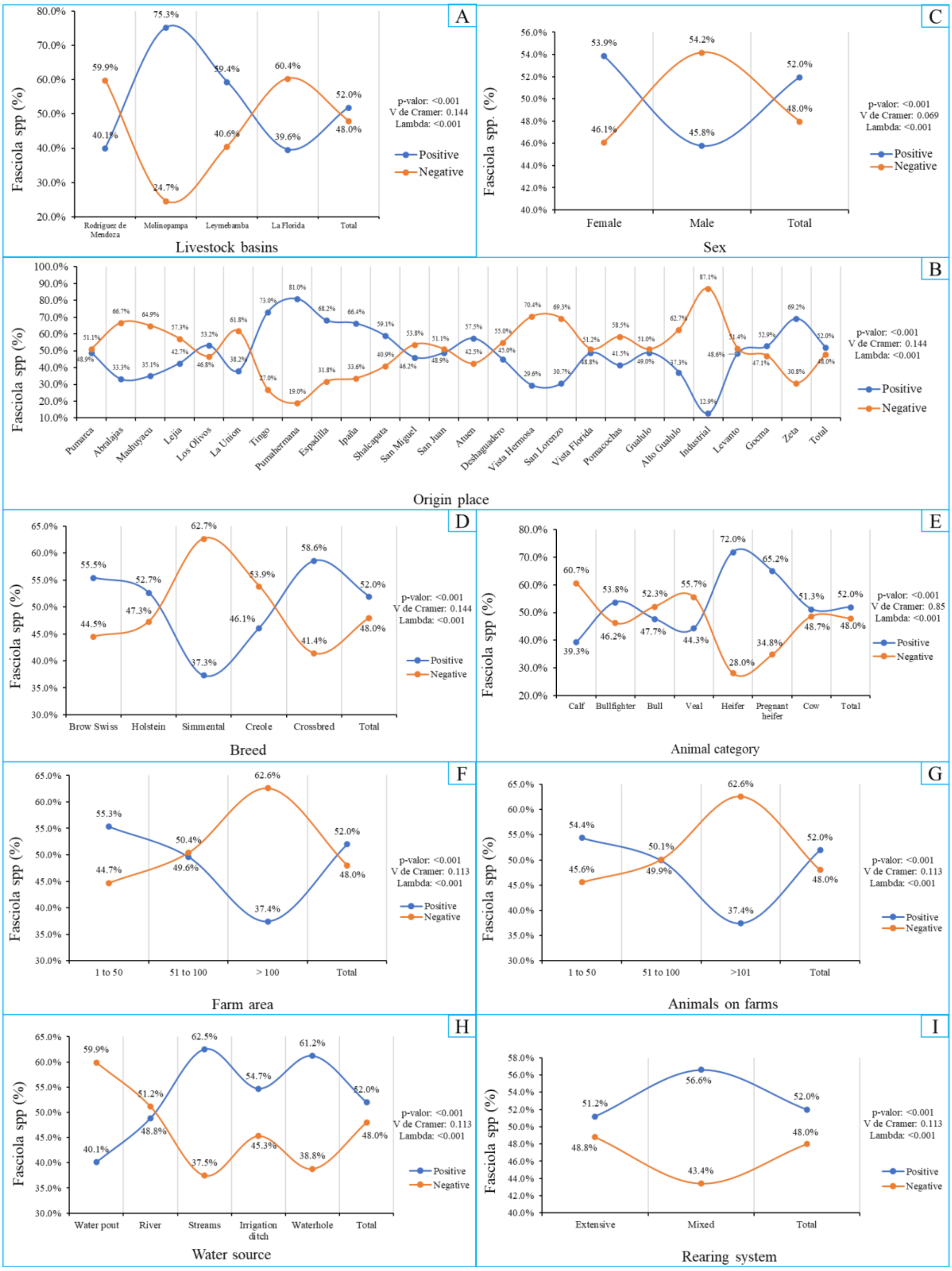


**Fig. 2:** Prevalence and association of Fasciola spp. in bovine; A: Prevalence and association according to livestock basins; B: Prevalence and association according to origin place; C: Prevalence and association according to sex; D: Prevalence and association according to breed; E: Prevalence and association according to the animal category; F: Prevalence and association according to the farm area; G: Prevalence and association according to animals on farms; H: Prevalence and association according to the water source; I: Prevalence and association according to rearing system

**Table 1:** Binary logistic regression analysis for Fasciola spp. infection in bovines according to livestock basins and origin place

| | | | | | CI 95% | |
|---|---|---|---|---|---|---|
| Livestock basins | β | SE | Sig. | Exp(β) | Lower | Upper |
| Rodriguez de Mendoza | -2.01 | 0.10 | 0.045 | 0.760 | 0.582 | 0.993 |
| Molinopampa | 9.86 | 0.60 | 0.000 | 4.157 | 3.131 | 5.518 |
| Leymebamba | 5.20 | 0.27 | 0.000 | 1.997 | 1.538 | 2.592 |
| La Florida | -3.76 | 0.06 | 0.000 | 0.731 | 0.621 | 0.861 |
| Origin place | | | | | | |
| Pumarca | 0.00 | 0.42 | 0.996 | 1.002 | 0.442 | 2.270 |
| Abralajas | 0.33 | 0.21 | 0.113 | 1.384 | 0.926 | 2.070 |
| Mashayacu | 0.19 | 0.13 | 0.155 | 1.210 | 0.930 | 1.575 |
| Legia | 0.06 | 0.09 | 0.492 | 1.065 | 0.890 | 1.275 |
| Los Olivos | -0.03 | 0.07 | 0.646 | 0.967 | 0.837 | 1.117 |
| La Unión | 0.07 | 0.06 | 0.255 | 1.076 | 0.949 | 1.219 |
| Tingo | -0.15 | 0.05 | 0.001 | 0.862 | 0.787 | 0.945 |
| Pumahermana | -0.19 | 0.08 | 0.018 | 0.830 | 0.712 | 0.968 |
| Espadilla | -0.08 | 0.05 | 0.138 | 0.923 | 0.830 | 1.026 |
| Ipaña | -0.07 | 0.03 | 0.041 | 0.936 | 0.879 | 0.997 |
| Shalcapata | -0.03 | 0.04 | 0.432 | 0.969 | 0.896 | 1.048 |
| San Miguel | 0.01 | 0.04 | 0.820 | 1.008 | 0.941 | 1.080 |
| Leymebamba | 0.02 | 0.04 | 0.503 | 1.024 | 0.954 | 1.100 |
| Atuen | -0.02 | 0.02 | 0.345 | 0.980 | 0.940 | 1.022 |
| Dashaguadero | 0.01 | 0.03 | 0.768 | 1.009 | 0.952 | 1.069 |
| Vistahermosa | 0.04 | 0.03 | 0.109 | 1.044 | 0.990 | 1.101 |
| San Lorenzo | 0.04 | 0.02 | 0.025 | 1.039 | 1.005 | 1.075 |
| Vista Florida | 0.00 | 0.02 | 0.986 | 1.000 | 0.967 | 1.035 |
| Pomacochas | -0.07 | 0.03 | 0.040 | 0.935 | 0.878 | 0.997 |
| Gualulo | 0.00 | 0.02 | 0.997 | 1.000 | 0.966 | 1.035 |
| Alto Gualulo | 0.02 | 0.02 | 0.217 | 1.020 | 0.988 | 1.053 |
| Industrial | 0.08 | 0.02 | 0.002 | 1.078 | 1.027 | 1.130 |
| Levanto | 0.00 | 0.02 | 0.974 | 1.001 | 0.967 | 1.035 |
| Gocma | -0.01 | 0.02 | 0.777 | 0.994 | 0.954 | 1.036 |
| Zeta | -0.03 | 0.02 | 0.201 | 0.970 | 0.926 | 1.016 |
| San Juan | 0.01 | 0.02 | 0.671 | 1.008 | 0.972 | 1.045 |

β: Estimated value β., SE: Standard error., Sig: Statistically significant ($p<0.05$)., Exp(β): Odd ratio., CI 95%: 95% confidence interval

**Table 2:** Binary logistic regression analysis for Fasciola spp. infection in bovines according to breed, animal category, and sex

| | | | | | CI 95% | |
|---|---|---|---|---|---|---|
| Breed | β | SE | Sig. | Exp(β) | Lower | Upper |
| Brown Swiss | 5.71 | 0.276 | 0.000 | 2.096 | 1.618 | 2.716 |
| Holstein | 2.62 | 0.451 | 0.000 | 1.876 | 1.171 | 3.006 |
| Creole | 1.40 | 0.37 | 0.162 | 1.435 | 0.864 | 2.380 |
| Crossbreed | 4.33 | 0.475 | 0.000 | 2.379 | 1.607 | 3.521 |
| Simmental | -4.4 | 0.069 | 0.000 | 0.594 | 0.472 | 0.748 |
| Animal category | | | | | | |
| Calf | -2.8 | 0.981 | 0.004 | 0.648 | 0.482 | 0.872 |
| Bullfighter | 2.42 | 0.427 | 0.014 | 1.793 | 1.124 | 2.860 |
| Bull | 1.41 | 0.342 | 0.158 | 1.408 | 0.875 | 2.267 |
| Veal | 1.09 | 0.23 | 0.274 | 1.228 | 0.849 | 1.774 |
| Heifer | 6.26 | 0.905 | 0.000 | 4.050 | 2.613 | 6.277 |
| Pregnant heifer | 4.46 | 0.683 | 0.000 | 2.882 | 1.810 | 4.588 |
| Cow | 2.86 | 0.276 | 0.004 | 1.626 | 1.165 | 2.267 |
| Sex | | | | | | |
| Female | 2.88 | 0.156 | 0.004 | 1.385 | 1.110 | 1.729 |
| Male | -1.7 | 0.083 | 0.085 | 0.843 | 0.695 | 1.023 |

β: Estimated value β., SE: Standard error., Sig: Statistically significant ($p<0.05$)., Exp(β): Odd ratio., CI 95: 95% confidence interval

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**Table 3:** Binary logistic regression analysis for Fasciola spp. infection in bovines according to the farm area, animals on the farm, and water source

| | | | | | CI 95% | |
|---|---|---|---|---|---|---|
| Farm area | β | SE | Sig. | Exp(β) | Lower | Upper |
| 1 to 50 | 4.52 | 0.33 | 0.000 | 2.070 | 1.508 | 2.840 |
| 51 to 100) | 2.80 | 0.30 | 0.005 | 1.651 | 1.162 | 2.347 |
| > 100 | -3.4 | 0.09 | 0.001 | 0.596 | 0.444 | 0.800 |
| Animals on farm | | | | | | |
| 1 to 50 | 3.44 | 0.38 | 0.001 | 1.950 | 1.332 | 2.854 |
| 51 to 100 | 2.37 | 0.34 | 0.018 | 1.631 | 1.087 | 2.446 |
| >101 | -2.8 | 0.11 | 0.008 | 0. 610 | 0.424 | 0.877 |
| Water source | | | | | | |
| River | 2.37 | 0.22 | 0.018 | 1.428 | 1.063 | 1.920 |
| Streams | 3.39 | 0.68 | 0.001 | 2.500 | 1.471 | 4.247 |
| Irrigation ditch | 4.20 | 0.26 | 0.000 | 1.815 | 1.374 | 2.398 |
| Waterhole | 5.00 | 0.41 | 0.000 | 2.365 | 1.688 | 3.314 |
| Water pout | -3.44 | 0.08 | 0.001 | 0.666 | 0.529 | 0.839 |
| Rearing system | | | | | | |
| Extensive | 0.75 | 0.24 | 0.001 | 2.110 | 1.332 | 3.342 |
| Mixed | -0.75 | 0.24 | 0.001 | 0.474 | 0.299 | 0.751 |

β: Estimated value β., SE: Standard error., Sig: Statistically significant ($p<0.05$)., Exp(β): Odd ratio., CI 95: 95% confidence interval

**Table 4:** Rotated component Matrix, KMO, and Barlett test

| | Components | | | |
|---|---|---|---|---|
| Variable | 1 | 2 | 3 | 4 |
| Livestock basin | -0.95 | | | |
| Origin place | -0.86 | | | |
| Farm area | 0.83 | | 0.30 | |
| Animals on farm | 0.79 | | 0.31 | |
| Sex | | 0.94 | | |
| Category animal | | -0.94 | | |
| Rearing system | | | -0.85 | |
| Water source | -0.22 | | -0.24 | 0.75 |
| Breed | 0.28 | | 0.48 | 0.55 |
| KMO test | | | | 0.59 |
| Bartlett's sphericity test | Approx. Chi-squared | | | 6.020.726 |
| | Degrees of Freedom | | | 66 |
| | Significance | | | <0.001 |

Extraction method: A principal component analysis. Rotation method: Varimax with Kaiser normalization. The rotation has converged in 8 iterations

Significant values were found for livestock basins and origin place, breed, animal category, sex, farm area, animals on the farm, and water source. A risk factor for fascioliasis of 4.157 and 1.997 was found in the Molinopampa and Leymebamba livestock basin compared to the La Florida livestock basin. However, the livestock basin Rodriguez de Mendoza showed a protective factor against this parasitism. According to the origin place, the samples from San Lorenzo (1.04) and Industrial (1.08) showed a risk, while Tingo, Pumahermana, Ipaña, and Pomacochas presented a protective factor for fascioliasis (Table 1).

According to the breed, the Crossbred, Brown Swiss and Holstein bovine showed a risk factor for fascioliasis of 2.37, 2.09, and 1.87 times compared to Creole and Simmental which show a protection factor. In the animal category, the heifers, pregnant heifers, bullfighters, and cows presented a risk factor for fascioliasis infection of 4.05, 2.88, 1.79, and 1.63 times and the other categories showed to be indifferent to this disease. Female bovines show to be more susceptible to fascioliasis with a risk of 1.38 times greater than male bovines (Table 2).

According to the farm area, it was observed that the farms with an of 1-50 ha and 51-100 ha showed a risk factor of 2.07 and 1.65, respectively, compared to areas greater than 101 ha. Regarding the animals on the farm, the group of bovines made up of 1-50 and 51-100 showed a factor of 3.44 and 2.37 times of contracting the disease, compared to farms with more than 101 bovines (Table 3).

For the water source, drinking water from streams, waterholes, irrigation ditch, and river show an infection risk factor for this parasitosis of 2.5, 2.36, 1.81, and 1.42, respectively, times more than using water pout as a source of drink (Table 3).

The principal component analysis yielded 4 components, with a total variance explained by component 4 of 71.88% (Table 4).

The correlation coefficient according to KMO was 0.59 with the highly significant Bartlett sphericity test ($p<0.05$), which demonstrated the applicability of the analysis of the variables studied. Component 1 indicated that the farm area and animals on the farm are related to the prevalence of Fasciola spp. Component 2 showed that sex is highly related to the prevalence of the trematode. Component 3 indicated that bovine breeds are related to the presence of liver flukes and component 4 indicated that the prevalence of fascioliasis is related to the water source and breed (Table 4).

## Discussion

A prevalence of 52% of Fasciola spp. was found in the three study livestock basins. In livestock basins Cajamarca, the trematode prevalence was 63.20% (Raunelli and González, 2009). In the Amazonas region, a prevalence of more than 90% of Fasciola spp. in beneficiated animals was reported (Diaz-Quevedo *et al*., 2021), being these reports are superior to our findings. In sacrificed animals, a higher prevalence is reported compared to the analysis of live animals. In native bovine livers, the prevalence was 14% compared to the prevalence of fluke eggs in a live animal fecal examination (4.90%) (Abunna *et al*., 2010). The low prevalence of eggs identified by sedimentation could be due to a low intensity of infection or to its migratory phase stage (Pinilla *et al*., 2020).

Regarding sex, female bovines are the most affected by Fasciola spp. In this research, a higher prevalence was found in females (53.9%) compared to males (45.8%), this same effect was reported in bovines from the district of Vilcashuamán in the Ayacucho region (Peru), the females presented a prevalence of 36.70% and males of 34.0% (Ticona *et al*., 2010) and in Zambian bovine, the females presented a prevalence of 65.20% and males of 36.30% (Phiri *et al*., 2005).

The highest prevalence of Fasciola spp. according to breed was higher in Brown Swiss bovine and lower in Creole bovine. However, the Creole bovine had the highest risk compared to other breeds. The Holstein breed presented a risk factor 1.88 times higher than other breeds and a prevalence of 52.7%. The findings of our research differ from the results reported in previous research, for example, in Holstein breeds, Holstein with Jersey crossbreeding, Jersey and other breeds, according to the univariate analysis of risk factors, no significant influence was found (Chaparro *et al*., 2016). These differences could be due to the existing agroclimatic conditions between provenances or regions, where each bovine breed behaves differently and its susceptibility to parasites; the behavior of the parasite can also be different (Gajadhar *et al*., 2006). In addition, the difference between breeds is explained by the differences in genetic, physiological, and immunological constitutions (Yatswako and Alhaji, 2017).

According to the animal category, heifers and pregnant heifers are the most susceptible to fascioliasis infection. In this research, a higher prevalence was found in heifer (72%) and pregnant heifer (65.2%) compared to the other categories. The higher prevalence in adult animals in this research is corroborated by the 64.50% prevalence of the trematode in animals older than 5 years in Nigeria (Isah, 2019). Furthermore, the result obtained agrees with that reported by Chaparro *et al*. (2016) who point out a significant association of Fasciola spp. with the age of the animal; but differs from Phiri *et al*. (2005), who did not report significant associations between age and fasciola infection; but Ticona *et al*. (2010); Jaja *et al*. (2017), found a higher parasite load in young animals. The difference in the presence of fasciola between animals of different ages and bovine breeds is natural in endemic areas such as the Amazon, where bovines graze on pastures infected with metacercariae (Sánchez-Andrade *et al*., 2002). In addition, in adult animals, where no significance was found for fascioliasis risk, it is described that this may be due to their high immunogenicity against Fasciola spp. which allows it to stimulate immunity in adult bovines (Khan *et al*., 2010).

A significant association between the prevalence of Fasciola spp. and animals on the farm was found, the prevalence being higher in farms from 1-50 animals (54.4%). The use of different pharmacological drugs can contribute to overlapping the infection by Fasciola spp. For this reason, it is recommended that doses against Fasciola spp. should be administered three times a year, especially during the seasons with higher rainfall and humidity, when there is a greater number of eggs of the trematode (Raunelli and Gonzalez, 2009). However, in dry seasons, the treatment interval may be longer, here snail egg laying is lower and transmission is more limited due to restrictive environmental conditions (Raunelli and Gonzalez, 2009). However, the indiscriminate use of drugs generates resistance, for example, in Cajamarca, found that Fasciola spp. obtained from dairy bovine are resistant to Triclabendazole-based drugs (Ortiz *et al*., 2013). For this reason, new sustainable strategies such as the eradication of the intermediate host must be designed to reduce this phenomenon. The proposed and future studies should encompass the roles of climate, drainage, and pasture handling (Chaparro *et al*., 2016).

The farm area and the water source for the bovine are important factors for their development and well-being. This research reveals that the highest prevalence was observed when the area was smaller and when bovines drink in Streams and Waterhole. Furthermore, areas smaller than 50 ha had a risk factor. It has been reported that animals grazing in pastures with the presence of rivers and lakes are prone to a high risk for Fasciola spp. infection (Jean-Richard *et al*., 2014) because metacercariae are found in vegetation on the banks of rivers, lakes, and streams (Qureshi *et al*., 2012). The higher prevalence in smaller areas is related to the higher number of times animals graze in the same areas, where they are forced to forage and consume metacercariae-infested pastures, on the other hand, animals grazing in areas larger than 100 ha can select their food (Qureshi *et al*., 2012).

The extensive husbandry system factor had a lower prevalence (51.2%) compared to the mixed system (56.6%), although the mixed system reported a protective factor for fascioliasis infection. In extensive systems, bovine graze year-round in paddocks, such that in a study comparing the predicted risk between seasonal grazing and annual grazing, in animals that remain in the paddock year-round, differences in the probability of bovine exposure to fascioliasis were found (Selemetas *et al*., 2015). This supports the findings of our research, where a higher prevalence was registered in extensive rearing systems. The high prevalence in extensive systems could be due to limited handling activities such as drainage, Bennema *et al*. (2011); Selemetas *et al*. (2014) explains that poorly drained soils are associated with a higher risk of fascioliasis infection. In these soils, there are optimal conditions for the development of the intermediate host and larvae (Selemetas *et al*., 2014). Finally, as a limitation of this research, we would like to highlight the use of univariate logistic regressions. The results can eventually be biased by shadow factors not being considered in these single independent variable models.

## Conclusion

A high prevalence (52%) and risk factors that affect bovine productivity and welfare were found. For this reason, it is necessary to carry out more studies concerning the risk factors of the transmissible sources of fascioliasis to reduce the negative impact of this parasitosis on the productivity of livestock farms and improve veterinary and animal health support in the Peruvian Amazon.

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## Author’s Contributions

**Clavel Diaz-Quevedo:** Conceived and study design, sample collection, data collection, laboratory analysis and paper written.

**Hugo Frias:** Study design, sample collection, and data collection.

**Nilton Luis Murga Valderrama and Lenin Torres Bernal:** Study design, sample collection, data collection and paper written.

**Ilse Silvia Cayo Colca:** Laboratory analysis, interpreted data, funded acquisition, and project administration.

**José Américo Saucedo-Uriarte:** Data analyzed, statically analyzed, paper written and finalized the paper.

## Ethics

This article is original and contains unpublished material. The corresponding author confirms that all of the other authors have read and approved the manuscript and that no ethical issues are involved.

In addition, the collection of bovine feces samples was carried out following the guidelines of the University Council Resolution No. 647-2019-UNTRM/CU of the Toribio Rodríguez de Mendoza National University on experimental studies with animals and under the guidelines of the Animal Protection and Welfare Law - No. 30407 of the Peruvian government.

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