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Original Article

Descriptive cross-sectional study on major bovine diseases and associated risk factors in north-eastern Ecuadorian Amazon

Estudo transversal descritivo sobre as principais doenças bovinas e fatores de risco associados no nordeste da Amazônia equatoriana

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Abstract

Cattle raising is a crucial element of production systems in the tropics and subtropics. However, in recent years, global public health security has been threatened by disease emergence. In Orellana Province, livestock is the most important activity to generate economic income. Nevertheless, there is no available data about Animal Health status. With this objective, a study was performed to describe the major Bovine diseases recorded between 2011 to 2019, and the main Risk factors associated. Data on main Bovine diseases were retrieved from the World Animal Health Information System database. Whereas Bovine population data used to calculate the prevalence rates and confidence intervals were obtained from Ecuador's Ministry of Agriculture. By contrast, the Risk factors identified with an epidemiological questionnaire were applied to 300 livestock farmers. As a result, from 2011 to 2019 in Orellana has been confirmed: 90 cases of Infectious Bovine Rhinotracheitis (31.58%), Bovine Rabies by hematophagous bats *(Desmodus rotundus)*, 83 cases (29.12%), Bovine viral diarrhea with 43 cases (15.10%), Brucellosis by *Brucella abortus* 35 cases, which was (12.28%), and 34 cases related to Enzootic bovine leukosis (11.92%). Overall, the prevalence rates ranged from (0.24 to 15.37%). In addition, farm size, presence of forest, herd, and paddock sizes, cutting frequency of forages, and other animal species were involved as Risk factors (OR = 3.15 to 11.75; 95% CI, 0.01 to 0.69). In conclusion, there are animal diseases with reproductive and neurologic symptomology and high-Risk factors implicated in the transmission. Consequently, space-temporal and seroprevalence epidemiological studies should be performed in Orellana.

Keywords: Ecuadorian Amazon, animal, neurologic, reproductive, risk.

Resumo

A criação de gado é um elemento crucial dos sistemas de produção nos trópicos e subtrópicos. No entanto, nos últimos anos, a segurança da saúde pública global tem sido ameaçada pelo surgimento de doenças. Na província de Orellana, a pecuária é a atividade mais importante para gerar renda econômica. Contudo, não há dados disponíveis sobre o estado de saúde animal. Com este objetivo, foi realizado um estudo para descrever as principais doenças dos bovinos registradas entre 2011 e 2019, além dos principais fatores de risco associados. Os dados sobre as principais doenças bovinas foram recuperados do banco de dados do World Animal Health Information System. Os dados da população bovina usados para calcular as taxas de prevalência e os intervalos de confiança foram obtidos do Ministério da Agricultura do Equador. Por outro lado, os fatores de risco identificados com um questionário epidemiológico foram aplicados a 300 criadores de gado. Como resultado, de 2011 a 2019 em Orellana foram confirmados: 90 casos (31,58%) de rinotraqueíte infecciosa bovina, 83 casos (29,12%) de raiva bovina por morcegos hematófagos (*Desmodus rotundus*), 43 casos (15,10%) de diarreia viral bovina, 35 casos (12,28%) de brucelose por *Brucella abortus* e 34 casos relacionados à leucose enzoótica bovina (11,92%). No geral, as taxas de prevalência variaram de 0,24 a 15,37%. Além disso, tamanho da fazenda, presença de floresta, tamanho do rebanho e dos piquetes, frequência de corte de forragens e outras espécies animais estiveram envolvidos como fatores de risco (OR = 3,15-11,75; IC 95% 0,01-0,69). Em conclusão, existem doenças animais com sintomatologia reprodutiva e neurológica e fatores de alto risco implicados na transmissão. Portanto, estudos epidemiológicos espaço-temporais e de soroprevalência devem ser realizados em Orellana.

Palavras-chave: Amazônia equatoriana, animal, neurológico, reprodutivo, risco.

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1. Introduction

High-impact animal diseases pose a threat to animal production, food chains, and human and animal well-being through their detrimental effects on food security, food safety, animal health and welfare, human health, livelihoods, national economies, and global markets, with poor and vulnerable communities facing the greatest threats (Stroup et al., 2000; Mondal and Yamage, 2014; Ortega et al., 2020).

According to the World Health Organization (WHO) (Meske et al., 2021), of some 1,400 species of infectious disease pathogens in humans, nearly 60% are derived from animal sources, hence the importance of recognizing the role of livestock, companion animals, and wildlife in the interactions between animals and humans.

Food and Agriculture Organization of the United Nations (FAO, 2019, 2021), stated that the livestock sector in Latin America has grown at an annual rate (3.7%) that is higher than the average global growth rate (2.1%). Small producers carrying out livestock activities account for a significant proportion of agricultural operations in Countries of the region (Lord et al., 1977; Caswell et al., 2018). Similar trends have been documented in Ecuador, in which the agricultural expansion is carried out predominantly by small-scale framing systems (Contreras, 2017). Therefore, agricultural expansion in Ecuador relies on smallholders. Consequently, strong connections have been established between poverty and livestock disease (GADMO, 2019), because farmers in the tropical forest of Latin America live in transformed landscapes (Carbonero et al., 2011; Herrera-Yunga et al., 2018). For this reason, is essential to know the current state of livestock diseases and their effects on poverty to improve control actions (Tomley and Shirley, 2009).

The Ecuadorian Amazon (EA) is made up of six Provinces: Sucumbíos, Orellana, Napo, Pastaza, Morona Santiago, and Zamora Chinchipe. It is a mostly sparsely populated tropical lowland rainforest, and is an area of extraordinary biodiversity, among the very highest in the world (González Marcillo et al., 2021), and it is also the largest natural region in Ecuador being approximately 45% of the Nation´s territory. However, according to Bravo et al. (2014), livestock systems have been established, allocating 31% of the Amazon area to grass production, where 70% of the said land is monoculture. Consequently, the conversion of forest to agricultural and livestock systems is the most important reason for land-use change (Rudel et al., 2015). Orellana Province forms Ecuador´s North-Eastern border with Colombia and Peru, and livestock is one of the most represented activities in the agricultural sector (Meske et al., 2021) although high deforestation rates have largely been the result of smallholder livestock farmers' expansion (Rudel et al., 2015), and their is no available data about health animal status. Hence, it is necessary to obtain information about the animal health situation and understand the presence of animal diseases as well as factors related to their spread.

With this objective, a descriptive cross-sectional study was carried out to know the major Bovine diseases in Orellana Province, from 2011 to 2019. Moreover, an epidemiological questionnaire was applied to livestock farmers to determine the risk factors associated. This knowledge is essential for planning, improving, or strengthening control strategies against livestock diseases. Additionality, the obtained results may be a starting point for proposing more comprehensive epidemiological work to determine the disease transmission dynamics in cattle of Orellana.

2. Materials and Methods

2.1. Study location

This study was carried out in Orellana Province, located in the North of the Ecuadorian Amazon. It is divided into four Districts (Cantons): this Province has an area of 21,730 kilometers $(km)^2$ (18.6%). The climate in the Region is characterized by humid tropical rainforests (Bilsborrow et al., 2004; GADPO, 2015; INEC, 2019; González Marcillo et al., 2021). The average rainfall is 2,942 millimeters (mm) annually, with an annual average temperature of 29.7°C (Walz et al., 2010). The Region had an estimated population of 157,520 people in 2018.

Agricultural land use in Orellana Province, according to the estimates by the National Institute of Statistics and Census (INEC-ESPAC) (INEC, 2019), covers a total area of 606,307 hectares (hes), distributed as follows: mountains and forests, 485,039 hes (80%); permanent crops, 43,582 hes (7.2%); other uses, 28,049 hes (4.6%); cultivated pastures, 25.162 hes (4.2%); natural pastures, 19,034 hes (3.1%); transitory crops and fallow, 4,959 hes (0.82%).

2.2. Data collection

This research was carried out using the STROBE statement guidelines (O'Connor et al., 2016; Amarilla et al., 2018) for reporting epidemiological studies. To this end, the major Bovine diseases confirmed between 2011 to 2019 were retrieved from World Animal Health Information System (OIE and WAHIS, 2020) interface and entered into a Microsoft Excel 2016 (Microsoft, Corporation, Washington, DC, USA) spreadsheet. OIE´s mandate is to ensure transparency in the global animal disease situation. Furthermore, these data are submitted to the OIE by the National Authorities of 182 OIE Member Countries that have the legal obligation to report data concerning notifiable animal diseases. Additionality, Mondal and Yamage (2014), Meske et al. (2021), Fanelli and Tizzani (2020), and Seetahal et al. (2018), have used data from OIE-WAHIS for epidemiological studies, so it is a valid and In accepted In methodology In for publication of scientific data. On the other hand, the number of productive agricultural units (PAUs) and cattle populations from 2011 to 2019 in Orellana Province were obtained from the Ministry of Agriculture, Livestock and Fisheries of Ecuador (SIPA-MAGAP, 2020).

2.3. Survey of risk factors

A structured questionnaire including close-ended questions was designed to obtain information concerning to type of production (meat/milk/mixed), management system (semi-extensive or extensive), herd size, predominant breed (Zebu/European dairy breed/crossbred/other breeds), presence of goats (*Capra aegagrus hircus*), sheep (*Ovis aries*), horses (*Equus caballus*), swine (*Sus scrofa*), wildlife, (no/yes), history of abortion (no/yes), abortion disposal method (left in the pasture lot/used to feed pigs (*Sus scrofa)* or dogs *(Canis lupus familiaris)*/buried or burned), animal purchasing (no/yes), paddock size (small/large), cutting frequency (short or large) sharing of pastures (no/yes), flooded pastures (no/yes), and veterinary assistance (no/yes). A sample size of 300 surveys was calculated for a target sampling error of 7% according to Olken and Rotem (1986) and Glenn (1992). The collected information with survey started in 2017 and ended in 2019 and it was administered to the owner or person in charge of the herd. Therefore, obtained data from the epidemiological questionnaires were used to analyze risk factors associated with the prevalence rates.

2.4. Statistical analysis

Descriptive statistical analysis was conducted using SAS v.9.4 (SAS Institute Inc., Cary, NC, USA) to examine cattle disease frequencies and annual patterns according to OIE (2020). The prevalence rates were calculated according to Thrusfield (1988, 2018) and Noordzij et al. (2010), and confidence intervals (CI) in each year using the animal population previously obtained using the Clopper-Pearson exact method (Clopper and Pearson, 1934). The 95% (CI) for the prevalence was based on the normal approximation to the binomial distribution (Brown et al., 2001).

Regarding the surveys, an initial exploratory analysis of the data (Univariable) was conducted for the selection of variables with $P \leq 0.2$ by the chi-square test or Fisher's exact test; subsequently, the variables that passed below this cut-off were utilized for logistic regression (Fagerland and Hosmer, 2012; Mazeri et al., 2013). The fit of the final model was verified with the Hosmer and Lemes how-to test, Fagerland and Hosmer (2012), and collinearity between independent variables was verified by correlation analysis. Therefore, this study calculated the Risk as Odds Ratio (OR). Furthermore, according to Altman (1991), the OR's standard error, and 95% confidence interval (CI), were calculated.

3. Results and Discussions

3.1. Bovine diseases

Estimations for the year 2050, the global population will reach 9.7 billion inhabitants, creating enormous challenges regarding the security of food, housing, and other basics of life while preserving ecosystem health (Garcia et al., 2019). Although, global Public Health security is already been threatened by disease emergence (Maxwell et al., 2017; Garcia et al., 2019). Table 1 shows the cattle disease data in Orellana Province between 2011 to 2019. According to OIE-WAHIS (OIE and WAHIS, 2020), 90 cases were confirmed for Infectious bovine rhinotracheitis (IBR), indicating (31.58%). However, in Orellana, abortion or

Table 1. Confirmed cases, prevalence rates (%), and confidence intervals (95%) on major bovine diseases in Orellana Province between 2011 to 2019.

Item	2011	2012	2013	2014	2015	2016	2017	2018	2019	Total
Cattle population	11575	12744	15430	13424	4701	5132	2960	8633	16841	91440
IBR										
Confirmed cases	2	3	7	10	48	3	5	10	2	90
[1] Prevalence rates	0.17	0.24	0.45	0.74	10.21	0.58	1.69	1.16	0.12	15.37
[2] CI, (95%)	0.10 - 0.28	0.13 - 0.35	0.34 - 0.56	0.63 - 0.85	10.1 - 10.9	0.47 - 0.69	1.58 - 1.80	1.10 - 1.27	0.01 - 0.23	0.83 - 2.58
Bovine rabies										
Confirmed cases	7	10	13	23	11	4	1	4	10	83
Prevalence rates	0.60	0.78	0.84	1.71	2.34	0.78	0.34	0.46	0.59	8.46
CI, (95%)	0.49 - 0.71	0.67 - 0.89	0.73 - 0.95	1.60 - 1.82	2.23 - 2.45	0.67 - 0.89	0.23 - 0.45	0.35 - 0.57	0.48 - 0.70	0.76 - 1.12
BVD										
Confirmed cases	1	-	4	14	18	-	2	4	-	43
Prevalence rates	0.09	-	0.26	1.04	3.83	-	0.68	0.46	-	6.36
CI, (95%)	-0.02 - 0.20	-	0.15 - 0.37	0.93 - 1.15	3.72 - 3.94	-	0.57 - 0.79	0.35 - 0.57	-	0.58 - 1.53
Bovine brucellosis										
Confirmed cases	1	1	3	4	4	-	13	3	6	35
Prevalence rates	0.09	0.08	0.19	0.30	0.85	-	4.39	0.35	0.36	6.60
CI, (95%)	-0.02 - 0.20	-0.03 - 0.19	0.08 - 0.30	0.19 - 0.41	0.75 - 0.96	-	4.28 - 4.28	0.24 - 0.46	0.25 - 0.47	0.37 - 1.21
EBL										
Confirmed cases	1	-	3	12	18	-	-	-	-	34
Prevalence rates	0.09	-	0.19	0.89	3.83	-	-	-	-	5.0
CI, (95%)	-0.02 - 0.20	-	0.08 - 0.30	0.78 - 1.0	3.27 - 3.49	-	-	-	-	0.47 - 2.03

[1]Calculated, as the number of instances of a disease or related attributes in a known population at a designated time, without distinction between old and new cases; [2]CI, confidence intervals. SE, standard error; Statistical differences at (P < 0.05).

respiratory infections in cattle have rarely been reported. In this sense, Givens and Marley (2008) stated that the infected animals are immunosuppressed and serve as a source of infection for unexposed cattle or young animals (heifers and calves). Thus, asymptomatic animals might be implicated in the transmission of IBR in this Province. Although, this hypothesis should be confirmed with serological studies.

Bovine rabies was the second disease that also had high confirmed cases 83 (29.12%), being the disease more frequently reported by livestock farmers (Table 1) in Orellana according to OIE-WAHIS (OIE and WAHIS, 2020). Rabies is an almost globally distributed zoonotic disease caused by a ribonucleic acid (RNA) virus of the Rhabdoviridae family (Rupprecht et al., 2002; Li et al., 2020). It affects all mammals (cattle, horses, and pigs), and it should receive a great deal of attention from local governments, producers, and researchers. The team of researchers developed a hypothesis about these events. Based on recorded rainfall, the animal population, and confirmed disease events, the occurrence of rabies could be related to biological and non-biological factors. Biological factors include the presence of hematophagous bats (*Desmodus rotundus*), the existence of adequate shelter for the bats (Orlando et al., 2019), the availability of food sources, and the presence of the rabies virus in this area. Orellana has a high forest density, allowing suitable conditions for the vectors of sylvatic rabies. The non-biological factors might be the type of production systems; changing patterns in farming, working, and living conditions; access to rabies prophylaxis; and measures being implemented to control bat populations (Rupprecht et al., 2002; Tomley and Shirley, 2009). Both biological and non-biological factors should be considered as necessary conditions for maintaining the chain of transmission in the wildlife cycle of bat-transmitted rabies (Braga et al., 2014; Amarilla et al., 2018; Mello et al., 2019). Therefore, this work can be a point to start to propose to perform a Spatio-temporal study of bovine rabies in Orellana and to know its epidemiological distribution.

As for Bovine viral diarrhea (BVD) which had 43 cases (15.10%), In Orellana Province, its behavior is often unnoticed, and few symptoms have been observed. Scientific evidence suggests that, depending on the time when an individual animal first shows symptoms, the disease is less easy to quantify (Mazeri et al., 2013). Likewise, this virus is mainly spread by persistently infected (PI) cattle infected in utero between 40 and 120 days of pregnancy which shed large amounts of the virus into the environment after birth (Maxwell et al., 2017; Wathes et al., 2020). Therefore, its effects on reproductive performance are much more pervasive and can lead to many subtle reductions in conception rates or failures to conceive (Wathes et al., 2020). Possibly, BVD could be implicated in the low conception rates observed in the herds of Orellana. However, there is no data to support it, so it should be confirmed with further studies.

On the other hand, Bovine Brucellosis caused by *Brucella abortus* is historically a zoonotic disease associated with the consumption of milk, meat, or subproducts of both (Chiebao et al., 2015). *B. abortus* can cause an influenza-like illness and sometimes pneumonia in humans as well as other serious complications, such as meningitis, septicemia, osteomyelitis of the vertebra, and endocarditis (Mondal and Yamage, 2014; Maxwell et al., 2017). According to OIE-WAHIS (OIE and WAHIS, 2020), between 2011 to 2019 in Orellana were 35 cases confirmed by *B. abortus* bacteria (12.28%). It has been referred to as an occupational disease because the workers involved in dairy production are at risk of zoonotic infection (Givens and Marley, 2008; Tomley and Shirley, 2009; McDaniel et al., 2014; Solón et al., 2019). Due to the livestock being developed in PAUs at different technological levels, small livestock farmers might be considered a significant occupational risk factor for transmission, which will be discussed later. Finally, the last cattle disease studied was Enzootic Bovine Leucosis (EBL) (34 cases; 11.92%; Table 1). According to Hernandez (Hernandez et al., 2018; Hernández-Castellano et al., 2019), in the majority of cases, infection is asymptomatic, but 30% of EBL-infected animals will develop a persistent lymphocytosis, and less than 5% will progress to B-cell lymphoma or leukemia in animals older than 3 years, after a long period of latency characterized by the absence of viral replication.

3.2. Prevalence rates and confidence intervals (CI)

To inform decisions regarding disease priorities and suitable control programs, and to monitor disease trends over time, reliable and up-to-date information on disease prevalence is highly desirable (van Roon et al., 2020). However, in this Province of Ecuador, the prevalence rates of many cattle diseases have not been determined. Consequently, their prevalence is inadequately documented, and their epidemiology is poorly understood. Table 1 are shown the prevalence rates and confidence intervals of diseases in cattle, calculated for each year. IBR showed prevalence rates ranged from (0.12 to 10.21 ± 1.87%) in the 2011 to 2019 period, with 15.37% (95%, CI: 0.83-2.58) of cumulative prevalence. Countries such as Peru (Meske et al., 2021) and Uruguay (Guarino et al., 2008; Botto-Nuñez et al., 2020), have reported IBR prevalence's ranged from 51 to 99%, while Carbonero et al. (2018), determined a higher prevalence rate in other Ecuador Provinces than present study (43.2 vs. 15.37%), but this author stressed that probably the age should be considered to interpret the seroprevalence rate since older animals showed higher seroprevalence due to greater exposure to the virus over time.

Furthermore, Table 1 shows rabies cases between 2011 to 2019, with a minimum of 1 and a maximum of 23 confirmed cases (0.34 to 2.34 ± 0.87%. Meanwhile, the cumulative prevalence rate was 8.46% (95%, CI: 0.76 - 1.12). Rabies is listed as one of the Neglected Tropical Diseases Worldwide according to OIE-WAHIS (OIE and WAHIS, 2020), with a significant impact in South America (Mazeri et al., 2013; Meske et al., 2021). In this study, bats (*Desmodus rotundus*) were the wildlife species mainly involved in livestock infection. Therefore, the occurrence of the disease in livestock may be interpreted as a proxy of the risk represented by the circulation of the virus in common vampire bats. Nevertheless, rabies leads to rapid death, resulting in short disease duration. As a result, its prevalence in the general population should be extremely low at any point in time. Furthermore, Bovine rabies in the Province of Orellana occurred throughout the year, without showing seasonality or a relationship with the rainfall regime (Table 1). Consequently, the vector remains active because it does not hibernate or migrate (Walz et al., 2010; Braga et al., 2014; Guamán-Rivera et al., 2020).

In the same way, BVD showed different behavior during 2011 to 2019 (minimum, 1 and maximum, 18 cases) with prevalence rates ranging from (0.09 to 3.83 ± 0.49%), whose cumulate prevalence rate was 6.36% (95%, CI: 0.58 - 1.53). Guarino et al. (2008), Segura-Correa et al. (2016), and Ortega et al. (2020), determined higher Bovine Virus Diarrhea (BVD) prevalence rates than the present study (30.0 vs. 6.36%, on average). In contrast, BVD prevalence rate in Orellana was lower than reported by Herrera-Yunga et al. (2018), 27% and Saa et al. (2012), 36,2 in other Provinces of Ecuador. Although Orellana has different climate conditions than the studies above mentioned (González Marcillo et al., 2021), no correlations between monthly temperature and prevalence rates (r = 0.56; P = 0.12) were detected. Ortega et al. (2020), stated that a higher prevalence rate in dairy cattle than in beef cattle has been observed. Consequently, this can explain in part these results, since in Orellana the livestock is mainly dedicated toward beef cattle.

Bovine brucellosis is another disease of reproductive importance. In this descriptive study, a total of 35 cases were retrieved from OIE-WAHIS (OIE and WAHIS, 2020). The prevalence rates varied between (0.09 to 4.39 ± 0.52%), and its cumulate prevalence was 6.60% (95%, CI: 0.37 - 1.21). Carbonero et al. (2018), reported higher prevalence rates in dairy and mixed cattle than in this study (17.0 vs. 6.60%). Contrary to this, Poulsen et al. (2014), informed slowly higher prevalence rates in two Ecuadorian Provinces from Northern Ecuador than those obtained in this study (7.20 vs. 6.60%). Nevertheless, these results should be cautiously interpreted because they use convenience sampling and the serology was carried out with the Rose Bengal test, which is considered a screening test due to its poor specificity. Anyway, studies in some Countries of South America described lower prevalence rates; 0.04% for Uruguay, 3.15% in Paraguay, 0.06%, in South of Brazil and Chile, 0.2%, and 2.27% in Bolivia, respectively (Mello et al., 2019; Meske et al., 2021).

Whereas EBL showed a maximum of 18 cases in 2015 with 1 case in 2011, as shown in Table 1. Thus, the following prevalence rates (0.09 to 3.83 ± 0.62%) and cumulate prevalence 5%; (95%, CI: 0.47 - 2.03) from 2011 to 2015, although without cases from 2016 to 2019, were observed. Vásconez-Hernández et al. (2017), determined in Pichincha, Ecuador, higher EBL prevalence rates than the present study (8.13 vs. 5.0%), but Orellana had higher prevalence rates than reported in Manabí 0.89%, Chimborazo 3.13%, and Tungurahua 0.007% [26], respectively. On the contrary, Saa et al. (2012), informed higher prevalence rates for EBL in dual-purpose cattle herds from Ecuador than observed in Orellana Province (17.3 vs. 5%), although this data differed from the reported in South America 34%, North America 31%, and Europe 17%, respectively (Ramalho et al., 2020). Probably, poor management factors and the absence of eradication programs might be implicated in its occurrence (van Roon et al. 2020), and another contributing factor to the high distribution of EBL infection could be the abundance of horseflies and blood-sucking insects present in the farms. Orellana has tropical conditions with high temperatures and wet, but there is no data to support the hypotheses, so it should be confirmed with additional epidemiological studies.

3.3. Risk factors

This is the first realized retrospective epidemiological study in the Orellana Province of Ecuador. This work tried to determine the associated Risk factors with the prevalence of diseases in cattle through an epidemiological questionnaire, which was applied from 2017 to 2019. The results of the univariable analysis for the Risk factors are shown in Table 2. The variable selected (P ≤ 0.20) for the multiple analysis were as follows: farm size, presence of forest, herd size, paddock size, cutting frequency, and other animal species. Consequently, the occurrence of diseases in cattle showed to be highly related to farm size (P = 0.021; OR = 11.75), other animal species in the farms (P < 0.001; OR = 11.70), and paddock size (P = 0.04; OR = 9.30). Whereas moderately for presence of forest (P = 0.011; OR = 8.18), cutting frequency of pastures (P = 0.020; OR = 5.25), and herd size (P = 0.05; OR = 3.15).

The identification of the main factors associated with major Bovine disease is a crucial aspect to implement effective measures for disease control programs. The obtained results showed that the farm size was a Risk factor associated with Bovine diseases (OR: 11.75; CI = 0.02 - 0.66). In Orellana, the farm size ranged from 10 to 50 hectares (Aznar et al., 2014; Bronner et al., 2014; Velasova et al., 2017). The farmers dedicated to livestock activities with lower technical and poorer management represent most of the PAUs in this Province, which might explain these results (Heinemann et al., 2002; Bronner et al., 2014; Garcia et al., 2019).

The presence of forests showed to be also another risk factor associated (OR: 8.18; CI = 0.05 - 0.50). It was observed that farmers with lower technical have lower surface cover with trees, so it can alter the environmental balance and tend to the emergence of a new pathogen. In this sense, Botto-Nuñez et al. (2020), have already documented the synergistic effects of grassland and temperature on

Table 2. Odds ratio analysis for risk factors associated with major bovine diseases in the Orellana Province of Ecuador.

Variable	SE	odds ratio (OR)	95% CI	P = Value
Farm size	2.40	11.75	0.02 – 0.66	0.021
Presence of forest	1.80	8.18	0.05 – 0.50	0.011
Herd size	1.00	3.15	0.01 – 0.28	0.05
Paddock size	0.20	9.30	0.01 – 0.06	0.040
Cutting frequency	2.50	5.25	0.24 – 0.69	0.020
Other animal species	2.60	11.70	0.32 – 0.72	0.001

Bovine disease emergence. Meanwhile,stated that high temperature and humidity may cause heat stress in the animals decreasing the immune response and predisposing the animals to infections (McDaniel et al., 2014).

Herd size was another potential Risk factor (OR: 3.15; CI = 0.01 - 0.28). In this case, it might be explained because the extensive livestock is the most productive system in this Province (Mondal and Yamage, 2014; Mello et al., 2019). Therefore, these extensive production systems are associated with smaller herd sizes and herd density (Velasova et al., 2017; van Roon et al., 2020), increasing the infection prevalence (WHO, 2012; Carbonero et al., 2018). Furthermore, paddock size was identified as a Risk factor possibly associated with Bovine disease in this Province (OR: 9.30; CI = 0.01 - 0.06). In Orellana, the livestock farmers have inadequate management of their paddocks, which, on average, it has 3 hectares. Possibly, these bad practices might be limiting forage quality and affecting animal health (Moore and Mott, 1973), which was also associated with cutting frequency (OR: 5.25; CI = 0.24 - 0.69). Some studies have documented the presence of other animals in the productive systems as a high-risk factor (Taddei et al., 2021). Similar results were determined in Orellana (OR: 9.30; CI = 0.32 – 0.72). Usually, in these conditions, pig and poultry breeding as backyard animals and horses or mules (*Equus asinus × Equus caballus*) are coexisting together (Givens and Marley, 2008; Wathes et al., 2020). Consequently, these other species might play a key role in animal disease transmission in this Province (Mazeri et al., 2013).

4. Conclusions

This study describes the major Bovine diseases that threaten Animal and Human Health in the Orellana Province of Ecuador. The present study showed that diseases with reproductive and neurologic symptomology affect the animal population, causing lower yield, loss of money, and a high risk of transmission to livestock farmers. Furthermore, it was identified that the farm size, presence of forest, other animal species as well as inadequate management are possibly involved as Risk factors associated with the transmission of Bovine diseases. Thus, the obtained findings suggest that the implementation of control and prevention measures among farmers, to prevent the dissemination of the agent in the herds, is necessary. Finally, through this work, this research team will propose to realize other space-temporal or seroprevalence studies to document the spread of zoonotic diseases found in this descriptive cross-sectional study.

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