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Current epidemiological situation of bovine viral diarrhea and infectious bovine rhinotracheitis in Colombia

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ABSTRACT

Viral diseases such as bovine viral diarrhea (BVD) and infectious bovine rhinotracheitis (IBR) impact livestock production, causing significant economic losses in dairy and beef cattle, due to reproductive and respiratory issues. This research aims to identify risk factors contributing to the occurrence of IBR and BVD in the department of Huila, and to determine biosecurity measures for effective management in livestock production. The sampling was made on 360 cattle across 24 municipalities with blood samples tested for BVD and IBR antibodies using ELISA. Of the 360 samples analyzed, 52.7% tested positive for BVD, 55.6% for IBR, and 31.1% for both. Key risk factors identified included estrus detection, contact with neighboring animals, and limited access restrictions for BVD. In contrast, IBR risk factors involved animal purchases, contact with neighboring herds, and infrastructure like footbaths. Protective factors including regular pregnancy diagnostics, tool disinfection, and animal isolation protocols. This descriptive research highlights the importance of managing IBR and BVD in livestock, identifying a lack of awareness and farming practices especially in prevention, sanitation, and biosecurity as critical issues impacting production.

Keywords: ELISA, risk factors, protective factors, biosecurity.

Situación epidemiológica actual de diarrea viral bovina y rinotraqueítis infecciosa bovina en Colombia

RESUMEN

Las enfermedades virales como la diarrea viral bovina (DVB) y la rinotraqueítis infecciosa bovina (RIB) afectan la producción ganadera, causando pérdidas económicas significativas tanto en el ganado lechero como en el de carne debido a problemas reproductivos y respiratorios. Esta investigación tiene como objetivo identificar los factores de riesgo que contribuyen a la aparición de RIB y DVB en el departamento del Huila, y determinar medidas de bioseguridad para un manejo efectivo en la producción ganadera. El muestreo se realizó en 360 bovinos en 24 municipios con muestras de sangre analizadas

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para anticuerpos de DVB y RIB mediante ELISA. De las 360 muestras analizadas, el 52,7% dio positivo para DVB, el 55,6% para RIB y el 31,1% para ambos. Los factores de riesgo clave identificados incluyeron la detección de celo, el contacto con animales vecinos y las restricciones de acceso limitadas para DVB, mientras que los factores de riesgo de RIB involucraron la compra de animales, el contacto con rebaños vecinos e infraestructura como baños de pies. Los factores de protección se identificaron como diagnósticos regulares de preñez, desinfección de herramientas y protocolos de aislamiento animal. Esta investigación descriptiva resalta la importancia del manejo de IBR y BVD en el ganado, identificando la falta de concientización y prácticas agrícolas especialmente en prevención, saneamiento y bioseguridad como problemas críticos que impactan la producción.

Palabras clave: ELISA, factores de riesgo, factores de protección, bioseguridad.

INTRODUCTION

Viral diseases have affected livestock production for centuries, and more zoonotic diseases have been detected in recent years to have a negative impact on their performance. Bovine viral diarrhea (BVD) and infectious bovine rhinotracheitis (IBR) have been reported to cause several economic losses worldwide, both in dairy and beef livestock (Rondón 2006). These diseases can impact the herds depending on the immunity status, management, and nutritional status, also they can cause miscarriage, embryo and embryo death, weight loss, and negative impact on dairy production.

First, BVD is caused by pestivirus with a single-stranded, positive-sense RNA genome from the family Flaviviridae. This virus has two biotypes (cytopathic and non-cytopathic) based on its behavior in cell culture and two genotypes (I and II) based on its genetic sequence. The severity of clinical conditions may vary according to the infecting strain, this could cause severe mucosal damage and lethal effects on the fetus (La Polla *et al.* 2022).

On the other hand, IBR is caused by bovine herpesvirus type 1 (BHV-1), a member of the subfamily Alphaherpesvirinae. It affects individuals of all ages and causes several economic impacts on production due to respiratory and reproductive issues. Transmission occurs directly through contact between infected animals and their aerosols. The incubation period for this disease is 3 to 7 days, and the virus has been detected at least 2 weeks after infection in nasal and ocular secretions. Indirect transmission may occur via fomites, including contaminated equipment, tools, and materials used by veterinarians and other individuals involved in the production process. Additionally, venereal transmission can occur during mating when there is contact with the genital secretions of infected cattle or during artificial insemination with contaminated semen (Nettleton & Russell 2017).

This investigation aims to establish the seroprevalence of IBR and BVD in dual-purpose production systems in the department of Huila and to identify the factors that may contribute to the increased prevalence of these diseases, as well as to identify the possible factors contributing to the occurrence of IBR and BVD, which significantly impact cattle producers' income and their operations in the department of Huila, Colombia.

MATERIALS AND METHODS

This study was conducted as a cross-sectional collaboration between University Corporation of the Huila Region (Corhuila), Colombian Agricultural Research Corporation (Agrosavia), Committee of Huila Cattlemen (CGH), and the Governorate of Huila. Additionally, all the activities carried out in this study were approved through the ethics, bioethics and scientific integrity committee of Colombian Agricultural Research Corporation (Agrosavia), under Act N.° 2 of 2021.

A total of 360 cattle over 24 months old were randomly selected from the 150 farms associated with livestock organizations. The sampling was conducted in 24 municipalities of Huila, distributed across four regions as follows: the central region (Altamira, Garzón, Gigante, Pital, Tarqui, and Suaza), the northern region (Aipe, Algeciras, Baraya, Campoalegre, Colombia, Palermo, Rivera, Tello, Villavieja, and Yaguará.), the western region (La Plata, Nátaga, Paicol, and Tesalia), and the southern region (Acevedo, Pitalito, San Agustín, and Timaná).

Blood samples were collected via jugular vein puncture. The samples were centrifuged at 3.070 Relative Centrifugal Force (RCF) for 5 minutes to separate the sera and preserved at -20 °C to avoid degradation.

Epidemiological surveys were used to collect information on sanitary, socioeconomic, and animal management conditions for each farm, including a monthly follow-up over the course of one year. Additionally, a clinical examination was performed on every animal included in the study.

Bovine viral diarrhea detection

The ELISA analysis was performed using the commercial kit Ingezim BVD DAS (INGENASA, Madrid, Spain). This assay is based on Double Antibody Sandwich ELISA technique using monoclonal antibodies (MAb), which are specific for p80/p125 BVDV protein.

The samples and kit components were thawed at room temperature. Then, 100 µl of the samples were dispensed into each well in duplicate, as established in our laboratory's standardized protocol under ISO 17025 accreditation, to ensure the validity of the results. This approach was not explicitly required by the manufacturer but was implemented based on our internal validation process.

The plate was incubated at room temperature for 18 hours. After incubation, the washing was performed as follows: the plate was inverted to discard the contents while preventing cross-contamination between wells, 300 µl of washing solution were dispensed, the plate was shaken for 30 seconds, the contents were discarded, and the process was repeated six times according to the kit insert. After the washing process, 100 µl of conjugate 1 were added to each well and incubated for 1 hour at 37 °C.

The plate was washed 6 times according to the manufacturer's recommendations. Conjugate 2 was added by 100 µl to each well and then incubated at room temperature for 30 minutes. Another washing was performed. Finally, 100 µl of stop solution were added to each well. The plate was read in the Microplate reader BMR-100 (BOECO Germany) at 450 nm within 5 minutes after the addiction of stop solution.

Infectious bovine rhinotracheitis detection

The detection was performed using the commercial kit Ingezim IBR 2.0 (INGENASA, Madrid, Spain). This kit uses the indirect ELISA method to detect specific antibodies against bovine herpesvirus 1 (BoHV1).

The samples were added by duplicate by 100 µl to each well including the kit controls. Then the plate was incubated at 37 °C for 45 minutes. After the incubation, the plate was washed 4 times following the manufacturer's instructions. Additionally, 100 µl of conjugate were added to each well and incubated for 45 minutes at 37 °C. The plate was washed 5 more times according to the instructions. The substrate solution was added by 100 µl and incubated by 15 minutes at room temperature. Finally, 100 µl of stop solution was added to the plate. The plate was read in the Microplate reader BMR-100 (BOECO Germany) at 450 nm within 5 minutes after the addition of stop solution.

Statistical analysis

The study aimed to investigate the relationship between socioeconomic and demographic factors and the presence of the viruses bovine viral diarrhea and infectious bovine rhinotracheitis.

Binary logistic regression models were developed, using ELISA test results as the dependent variable (0: negative, 1: positive for one of the viruses). The prevalence was compared using the Chi-Square test across the different variable levels, including age groups and regions. Determinant factors, including vaccination status, farm size, and animal density, were compared, and odds ratios (OR) were calculated to examine disparities. The existence of these factors was verified through a combination of survey responses and on-site validation during a one-year productive follow-up. Vaccination status was confirmed both through the survey and by cross-referencing vaccination records during the follow-up period. To avoid interference from vaccine-induced antibodies, sample collection timing was carefully planned in relation to vaccine administration, minimizing the risk of false positives. Statistical significance was determined at a 95% confidence level ($P < 0.05$), enhancing the validity of the selected environmental factors.

The study utilized R version 4.3.3 to conduct descriptive analyses, which facilitated the identification of logistic regression models and environmental variables associated with the infections. This approach allowed for identifying significant determinants, indicating their association with either the presence or absence of viruses.

RESULTS AND DISCUSSION

Of the 360 samples analyzed, 190 (52.7%) showed antibodies for BVD. Meanwhile, 200 of the 360 samples (55.6%) tested positive for IBR. Additionally, 112 of the 360 samples (31.1%) tested positive for both diseases. In the same vein, 278 out of 360 animals (77.2%) tested positive for either of the two diseases. The age group of 66-85 months showed the highest number of seropositive animals, with 82.3% testing positive for at least one of the two diseases. This was followed by the age groups ≥106 months and 46-65 months, with 80% and 78.3%, respectively. On the other hand, the age of eight individuals could not be determined and, therefore, they could not be included in the age groups. Similarly, the distribution of positive cases for each disease was comparable(table 1).

Regarding the geographical distribution of the disease, the region with more animals analyzed was the northern region: 49.1% (177/360); followed by the southern region: 18.0% (65/360); then, the western region: 16.6% (60/360), and the central region: 16.1% (58/360). Similarly, the highest seroprevalence for either of the two diseases was in the central region with 86.2%, followed by the northern region (81.9%), western region (70%), and southern region (63.1%). However, for bovine viral diarrhea, the highest seropositivity was observed in the western region at 60%, followed by the northern region (54.8%), southern region (47.7%), and central region (44.8%) (table 2).

Regarding BVD, the risk factors found using binary logistic regression analysis were the tools cleaning before the procedures, estrus detection, contact with neighboring animals, and restriction on animal access (table 3). In contrast, for IBR the risk factors identified were purchasing animals for production, contact with neighboring animals, and the presence of infrastructure like footbaths and housing facilities. However, activities such as regular pregnancy diagnostics, disinfecting work tools, consistently analyzing the reproductive potential of males, implementing protocols for cow synchronization, and isolating sick animals in the production process are considered protective factors

TABLE 1. Distribution of positive cases for BVD, IBR, and BVD or IBR diseases by age groups

Variable		n	BVD			IBR			BVD or IBR		
			+	%	I.C. 95%	+	%	I.C. 95%	+	%	I.C. 95%
Age	0 to 45	59	27	45.8	(0.33-0.58)	25	42.4	(0.30-0.55)	40	67.8	(0.56-0.80)
	46 to 65	115	61	53.0	(0.44-0.62)	63	54.8	(0.46-0.64)	90	78.3	(0.71-0.86)
	66 to 85	124	74	59.7	(0.51-0.68)	77	62.1	(0.53-0.71)	102	82.3	(0.75-0.89)
	86 to 104	24	11	45.8	(0.26-0.66)	10	41.7	(0.22-0.62)	17	70.8	(0.52-0.90)
	106 or more	30	13	43.3	(0.26-0.61)	20	66.7	(0.49-0.84)	24	80.0	(0.65-0.94)
			χ^2:5.10; gl:5; p:0.404			χ^2: 9.86; gl: 5; p: 0.079			χ^2: 6.51; gl: 5; p: 0.259		

Source: own elaboration.

TABLE 2. Cattle distribution by geographic region in the department of Huila and the corresponding positive cases for BVD, IBR, and BVD or IBR diseases

Variable		n	BVD			IBR			BVD or IBR		
			+	%	I.C. 95%	+	%	I.C. 95%	+	%	I.C. 95%
Region	Southern	65	31	47.7	(0.36-0.60)	21	32.3	(0.21-0.43)	41	63.1	(0.51-0.75)
	Central	58	26	44.8	(0.32-0.57)	42	72.4	(0.61-0.84)	50	86.2	(0.77-0.95)
	Northern	177	97	54.8	(0.47-0.62)	106	59.9	(0.53-0.67)	145	81.9	(0.76-0.88)
	Western	60	36	60.0	(0.48-0.72)	31	51.7	(0.39-0.64)	42	70.0	(0.58-0.82)
			χ^2:3.69; gl:3; p:0.297			χ^2: 22.6; gl: 3; p: 0.001			χ^2: 14.01; gl: 3; p: 0.003		

Source: own elaboration.

TABLE 3. Logistic regression of independent variables for risk factors with the seroprevalence of bovine viral diarrhea

Variable		N	β	gl	P	OR	IC OR 95%	
							ICI	ICS
Region	Central	58	-	-	-	-	-	-
	Northern	177	0.30	1	0.188	1.49	0.82	2.71
	West	60	0.37	1	0.100	1.85	0.89	3.83
	Southern	65	0.36	1	0.750	1.12	0.55	2.28
Self-medication	No	56	-	-	-	-	-	-
	Yes	303	-0.66	1	0.030*	0.52	0.52	0.28
Estrus detection	No	155			-	-		
	Yes	204	0.44	1	0.041*	1.55	1.02	2.36
Synchronization procedures	No	231			-	-		
	Yes	128	0.27	1	0.216	1.32	0.85	2.03
Pregnancy diagnosis	No	64	-	-	-	-	-	-
	Periodically	132	-0.40	1	0.190	0.67	0.37	1.22
	Sporadically	164	0.16	1	0.597	1.17	0.65	2.09
Purchase of fattening animals	No	286	-	-	-	-	-	-
	Yes	74	0.06	1	0.805	1.07	0.64	1.78
Contact with neighboring animals	No	148	-	-	-	-	-	-
	Yes	210	0.52	1	0.017*	1.68	1.10	2.56
Work tool disinfection	No	28	-	-	-	-	-	-
	Yes	329	-0.05	1	0.895	0.95	0.44	2.06
Male evaluation	No	147	-	-	-	-	-	-
	Yes	59	-0.21	1	0.494	0.81	0.44	1.48
Housing facilities	No	56	-	-	-	-	-	-
	Yes	304	-0.21	1	0.477	0.81	0.46	1.44
Isolation of sick animals	No	64	-	-	-	-	-	-
	Yes	295	-0.25	1	0.362	0.776	0.45	1.33
Introduction of external animals	No	331	-	-	-	-	-	-
	Yes	29	-0.35	1	0.337	0.707	0.33	1.52
Restrict access to the herd	No	126	-	-	-	-	-	-
	Yes	234	0.72	1	0.001*	2.046	1.32	3.18
Implement quarantine	No	146	-	-	-	-	-	-
	Yes	211	0.22	1	0.502	0.865	0.57	1.32

Source: own elaboration.

(table 4). Finally, the risk factors for the occurrence of either of the two diseases are: keeping animals in the northern and western regions, implementing reproductive protocols for cow synchronization, and restricting the access of other animals. Meanwhile, the protective factors are pregnancy diagnosis, selling breeding animals, introducing external animals, and implementing quarantine (table 5).

The seroprevalence observed in this study for IBR was 55.6% (200/360), while for BVD it was 52.7% (190/300). Previous studies in Colombia have reported seroprevalence rates for BVD ranging between 30% and 35% (Ochoa *et al.* 2012; Rivera *et al.* 2018) and between 50.0% and 58.0% (Motta Giraldo *et al.* 2013; Rivera *et al.* 2018).

On the other hand, regarding geographic areas, it is evident that for the presentation

TABLE 4. Logistic regression of independent variables for risk factors with the seroprevalence of IBR

Variable		n	β	gl	P	OR	IC OR 95%	
							ICI	ICS
Region	Central	58	-	-	-	-	-	-
	Northern	177	-0.56	1	0.089	0.57	0.30	1.09
	West	60	-0.90	1	0.022*	0.41	0.19	0.88
	Southern	65	-1.70	1	0.000*	0.18	0.08	0.39
Self-medication	No	56	-	-	-	-	-	-
	Yes	303	0.09	1	0.762	1.09	0.62	1.94
Estrus detection	No	155	-	-	-	-	-	-
	Yes	204	0.04	1	0.844	1.04	0.69	1.59
Synchronization procedures	No	231	-	-	-	-	-	-
	Yes	128	0.55	1	0.015*	1.74	1.11	2.71
Pregnancy diagnosis	No	64	-	-	-	-	-	-
	Periodically	132	-0.82	1	0.009*	0.44	0.24	0.81
	Sporadically	164	-0.11	1	0.729	0.90	0.49	1.64
Purchase of fattening animals	No	286	-	-	-	-	-	-
	Yes	74	0.79	1	0.005*	2.20	1.27	3.82
Contact with neighboring animals	No	148	-	-	-	-	-	-
	Yes	210	0.65	1	0.003*	1.91	1.25	2.93
Work tool disinfection	No	28	-	-	-	-	-	-
	Yes	329	-0.95	1	0.036*	0.39	0.16	0.94
Male evaluation	No	147	-	-	-	-	-	-
	Yes	59	-0.74	1	0.019*	0.48	0.26	0.89
Housing facilities	No	56	-	-	-	-	-	-
	Yes	304	0.96	1	0.001*	2.61	1.44	4.73
Isolation of sick animals	No	64	-	-	-	-	-	-
	Yes	295	-0.69	1	0.019*	0.50	0.28	0.89
Introduction of external animals	No	331	-	-	-	-	-	-
	Yes	29	-0.32	1	0.412	0.73	0.34	1.56
Restrict access to the herd	No	126	-	-	-	-	-	-
	Yes	234	0.39	1	0.076	1.48	0.96	2.29
Implement quarantine	No	146	-	-	-	-	-	-
	Yes	211	-0.31	1	0.152	0.73	0.48	1.12

Source: own elaboration

TABLE 5. Logistic regression of independent variables for risk factors with the seroprevalence of both BVD and IBR

Variable		n	β	gl	P	OR	IC OR 95%	
							ICI	ICS
Region	Central	58	-	-	-	-	-	-
	Northern	177	-0.32	1	0.452	0.72	0.31	1.68
	West	60	-0.98	1	0.038*	0.37	0.15	0.94
	Southern	65	-1.30	1	0.005*	0.27	0.11	0.67
Self-medication	No	56	-	-	-	-	-	-
	Yes	303	-0.22	1	0.536	0.80	0.39	1.63
Estrus detection	No	155	-	-	-	-	-	-
	Yes	204	0.23	1	0.362	1.26	0.77	2.06
Synchronization procedures	No	231	-	-	-	-	-	-
	Yes	128	0.77	1	0.008*	2.15	1.22	3.79
Pregnancy diagnosis	No	64	-	-	-	-	-	-
	Periodically	132	-1.03	1	0.008*	0.36	0.17	0.77
	Sporadically	164	-0.06	1	0.877	0.94	0.43	2.07
Purchase of fattening animals	No	286	-	-	-	-	-	-
	Yes	74	0.64	1	0.072	1.89	0.94	3.79
Contact with neighboring animals	No	148	-	-	-	-	-	-
	Yes	210	0.65	1	0.11	1.91	1.16	3.15
Work tool disinfection	No	28	-	-	-	-	-	-
	Yes	329	-0.34	1	0.505	0.71	0.26	1.93
Male evaluation	No	147	-	-	-	-	-	-
	Yes	59	-0.70	1	0.44	0.49	0.25	0.98
Housing facilities	No	56	-	-	-	-	-	-
	Yes	304	0.15	1	0.66	1.16	0.60	2.24
Isolation of sick animals	No	64	-	-	-	-	-	-
	Yes	295	-0.70	1	0.69	0.50	0.23	1.06
Introduction of external animals	No	331	-	-	-	-	-	-
	Yes	29	-0.81	1	0.47*	0.45	0.20	0.99
Restrict access to the herd	No	126	-	-	-	-	-	-
	Yes	234	0.75	1	0.003*	2.13	1.29	3.51
Implement quarantine	No	146	-	-	-	-	-	-
	Yes	211	-0.63	1	0.020*	0.53	0.31	0.91

Source: own elaboration.

of BVD alone, there is no statistically significant difference, while for IBR, the western and southern regions behave as protective factors (OR: 0.41 and 0.18, respectively) compared to the central regions. Similarly, for the presentation of either of the two diseases, the western and southern regions were protective factors (OR: 0.37 and 0.27, respectively) in comparison with the southern region. These results highlight how the specific climatic characteristics of different regions in Huila may influence the prevalence of diseases such as IBR and BVD. In the central region, where a temperate climate predominates, the conditions may favor the survival and transmission of certain pathogens due to lower humidity, which could allow viruses to remain viable for longer in the environment. In contrast, the temperate climate of the west and the cold climate of the south appear to offer some degree of protection, possibly due to lower animal density and different management practices associated with these climates (Murcia–Mono *et al.* 2025).

In the epidemiological survey, 13 sanitary and socioeconomic conditions were identified as being related to the seroprevalence observed in the diseases ($P < 0.05$). Self-medication was identified as a protective factor for BVD in this study (OR: 0.52), based on field observations about metaphylactic measures implemented to safeguard the health of their animals. A survey conducted with 23 veterinarians in North America revealed that 95.65% of respondents recommend metaphylaxis (Terrell *et al.* 2011). Additionally, Schlochtermeier (2018) mentions that metaphylactic treatment in large groups of animals reduces both morbidity and mortality and is also effective in administering parenteral products to young cattle at high risk of developing bovine respiratory syndrome (BRS). At the national level, the use of popular antimicrobials such as tulathromycin, enrofloxacin, oxytetracycline, and sulfamethazine, among others, is well known and has demonstrated favorable efficacy.

Generally, the spread of antigens is due to poor farming practices (González–Stagnaro 2011), such as personnel spreading the viruses between infected and non-infected animals. In this study, estrus detection was considered a risk factor (OR: 1.55). The implementation of Good Agricultural Practices (GAP) is crucial as antigens can persist in areas and objects, facilitating their spread. Therefore, we infer that rather than the estrus detection itself, the lack of implementation of the aseptic practices followed during the detection process could increase the prevalence. Studies show the importance of sanitary management in promoting health, improving production, and preventing animal diseases (Benavides & Rosenfeld 2009). Walz *et al.* (2010) emphasized the need to eliminate contact between livestock and neighboring fences, properly disinfect equipment, and restrict the entry of outsiders into production areas. Furthermore, there are various methods for detecting estrus in cows, ranging from visual observation and record-keeping to the use of pressure-sensitive devices, chalk or paint at the base of the tail, and estrus detection patches (Guáqueta 2009).

On the other hand, synchronization protocols were identified as a risk factor for the occurrence of IBR alone (OR: 1.74) and for the concurrent occurrence of both BVD and IBR (OR: 2.15). Romero–Salas *et al.* (2013) concluded that, on dual-purpose cattle farms, natural breeding contributes to the transmission of IBR; therefore, the adoption of artificial insemination could help reduce its prevalence. Villar (2015) mentions that artificial insemination or mixed natural breeding are risk factors (OR: 7.89) for bovine viral diarrhea compared to farms that only use natural breeding. However, Abad–Zavaleta *et al.* (2016) stated that farms that do not perform artificial insemination or embryo transfers have a higher risk of IBR and BVD, results that differ from Villar (2015).

One of the advantages of synchronization protocols is to avoid direct contact of fluids between animals, and thus the disease, making it essential to maintain good livestock practices, such as the asepsis of reproductive tools (González–Stagnaro 2011). However, despite the divergences in the research findings, the need for rigorous biosecurity measures and good livestock practices is evident.

Synchronization protocols seem to be a valuable tool to reduce disease transmission, but they must be complemented with strict hygiene and rigorous health control of breeding animals to maximize their effectiveness. Additionally, continuous training for producers in risk identification and management is crucial to reduce the spread of these diseases. The implementation of specific protocols adapted to local conditions and the constant evaluation of their effectiveness are essential for efficient health management in the dual-purpose livestock farming in Huila.

Various pathogens, such as the IBR virus, can affect pregnant cows, causing embryonic death, mummification, abortions, infertility, and the birth of stillborn or weak calves that die shortly after birth (Magaña–Urbina *et al.* 2005). Early disease detection is crucial for identifying and isolating infected animals to prevent further transmission. However, common diagnostic methods, such as rectal palpation, can pose a risk of disease spread if not performed under proper biosecurity measures.

This study focuses solely on early detection methods, excluding reproductive management practices. Our findings highlight the need for producer training in proper waste disposal and biosecure animal handling during diagnostic procedures. While early diagnosis is essential for disease control, implementing best practices is equally important to minimize transmission risks.

There are common methods for pregnancy diagnosis that allow for early detection of the disease and proper isolation to prevent further infections. In this study, pregnancy diagnosis is considered a protective factor (OR: 0.44) for the occurrence of IBR.

The purchase of fattening animals was identified as a risk factor in this research (OR: 2.20), due to the possible acquisition of persistently infected animals and the limited control in diagnostics for the detection of IBR. Delgado *et al.* (2022) noted that the main factor in the spread of the disease is the lack of control when acquiring an animal. In 2022, a study on respiratory diseases in cattle in Villavicencio determined that the purchase of fattening animals is a risk factor (OR: 1.44), associated with the transportation of animals (Ballesteros González & Briñez Castiblanco 2022). Taylor *et al.* (2010) indicated that purchased animals, typically transported to their place of origin, may be exposed to different management variables, including stress, which could act as a "necessary but not sufficient" association for the occurrence of respiratory diseases in cattle. Therefore, it is recommended to follow a strict health protocol when integrating new animals into herds to preserve the health of the animals already present on the farm (Narváez Morales & Sangucho Lema 2021).

There are preventive measures to control IBR when the first symptoms of the disease manifest. In this research, the separation of sick animals is considered a protective factor (OR: 0.50). This suggests that the isolation practices implemented by farmers are effective in reducing the presence of the disease. When clinical signs suggesting infections in the herd are observed, it is recommended to take preventive isolation measures (Obando & Rodríguez 2005).

Similarly, Alvarez *et al.* (2007) mentions that if a lower prevalence is observed, concentrated in adult animals, it is possible to perform individual serology on all animals and proceed to eliminate the seropositive animals after vaccinating them every six months, which allows the eradication of the disease in production.

Currently, good livestock practices provide producers with the opportunity to establish proper sanitary and commercial conditions for the export of their products. These practices not only strengthen export capacity but also implement various prevention and control programs aimed at protecting the herds from any eventuality that could put them at risk. This research has identified that the disinfection of equipment is a significant protective factor (OR: 0.39), attributable to the good practices promoted by farmers regarding effective disinfection protocols on farms to prevent the spread of diseases (Benavides & Rosenfeld 2009).

Semen evaluation is crucial in bovine reproduction, allowing the identification of bulls with subfertility or infertility. These evaluations should be performed periodically, including three fundamental steps: physical evaluation, libido assessment, and semen collection and analysis (Lozano & Arias 2008). In the present study, productions that perform exams to determine the male's potential are considered protective factors for the occurrence of IBR (OR: 0.48). When analyzing semen quality and detecting any abnormalities, the bull can be treated or removed from the production system. Additionally, viruses such as the one causing IBR can affect semen quality, as this antigen may be present in subclinical infected bulls.

The IBR virus (BHV-1) can affect reproductive tissues, compromising semen quality and bull fertility. This virus may cause inflammation of testicles and epididymitis, interfering with spermatogenesis and sperm motility, which significantly reduces semen quality. Therefore, semen evaluation can serve as an indicator of IBR infection (Bierema *et al.* 2009; O'Toole *et al.* 2011).

On the other hand, even when BVD may affect reproductive health, it has not been reported a direct affectation to the semen quality being these effects less evident. The common impacts of these diseases are reflected in abortions, fetal malformations, and more vulnerability to secondary infections, but not in the bull reproductive health (Miller *et al.* 2008; Robson *et al.* 2015).

The statistical limitations, such as sample size, may have affected the ability to accurately diagnose semen quality and identify an association with BVD. Additionally, the variability in exposure and the different clinical manifestations of the disease may have hindered the identification of a correlation in this study.

Animal health guarantees the well-being and genetic expression of herds, and its control should be based on the proper structuring and monitoring of a health program. Maintaining animal health is essential to ensure the stability of production in agricultural enterprises, controlling the emergence of infectious and contagious disease outbreaks (Sánchez–Villalobos 2014). The infrastructure of farms plays a crucial role in managing epidemiological outbreaks; adequate facilities allow for the timely isolation of infected animals, preventing the spread of diseases. However, in this research, housing facilities were identified as a significant risk factor (OR: 2.61) for the occurrence of IBR. We infer that this is due to the limited available space in productions for isolation, which could facilitate faster spread. This study included facility observations conducted by professionals who periodically visited the farms to ensure the reliability of the data. During these follow-up visits, the professionals assessed the isolation facilities. However, specific questions regarding isolation facilities and procedures were not included in the survey. Given the impact of isolation practices on disease transmission, it is important for future investigations to include specific questions to better evaluate this determinant.

Various studies have shown results contrary to our findings. For example, González *et al.* (2009) reported a seroprevalence of 58.9% in productions with closed system infrastructures and 81.5% in productions with open systems, demonstrating a significant association between infection and open field systems. Likewise, Ferrara *et al.* (2024) mentioned that house accommodation is a protective factor (OR=0.16) compared to keeping animals in a partial grazing system. Although the results obtained in this study indicate a situation contrary to the literature review, we conclude that having housing facilities on the farm does not necessarily serve as a protective factor, but rather the combination of its size and the biosecurity measures implemented is what truly matters.

Infectious agents enter the herd through individuals with chronic infections, so any biosecurity plan must begin within the farms. Thus, it is necessary to maintain the fences in pastures in optimal conditions to control the entry and exit of animals, thereby minimizing contact with neighboring herds (Hoet & Boscán 2005). Therefore, preventing the entry of foreign cattle into the production system was a protective factor in this study (OR: 0.47). However, this result was completely contradictory for those herds where the entry of both vehicles and visitors is restricted (OR: 2.13).

Furthermore, quarantine was also considered a protective factor (OR: 0.53) for the occurrence of either disease, as they are transmitted through direct contact between sick and susceptible animals (Hoet & Boscán 2005).

CONCLUSIONS

Bovine viral diarrhea (BVD) and infectious bovine rhinotracheitis (IBR) are not officially controlled diseases in Colombia, yet they are critically associated with the bovine reproductive complex. Given their significant contribution to reproductive pathologies and their consequential impact on livestock production systems, their management remains a priority in veterinary health programs. This study evaluated various socioeconomic, demographic, and sanitary determinants, identifying 13 factors significantly associated with the epidemiology of these diseases. Specifically, IBR was correlated with six protective factors and four risk factors, whereas BVD was associated with one protective factor and three risk factors. The primary challenge identified was the limited awareness and implementation of Good Agricultural Practices (GAP). This includes deficiencies in primary prevention strategies, such as immunization protocols, environmental sanitation measures, and adherence to biosecurity protocols, which are essential to mitigating the prevalence and impact of these diseases.

The surveys were complemented by direct measures carried out during follow-up visits. In this way, the data obtained through the surveys were validated with the results of field measurements, allowing for greater robustness in the conclusions.

However, we recognize that this approach may still have limitations, such as the possible variability in respondents' perceptions and in facility conditions over time. Therefore, it is suggested that future studies follow a similar approach but incorporate advanced technologies or additional tools to make more accurate and objective measurements of these factors.

Finally, it is important to carry out agricultural extension through training for livestock producers on topics related to good livestock practices, sustainable livestock, animal health, animal welfare, One Health, among others, which is essential for production to reach levels of productivity and competitiveness in the region. This should be developed through professionals with experience and methodology according to the population to be targeted.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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DECLARATION OF USE OF ARTIFICIAL INTELLIGENCE

We declare that we did not use artificial intelligence.

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