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Investigation of Risk Factors for Lumpy Skin Disease and Prevention Practices in Dak Lak, Vietnam, 2021–2022

Ngan Hong Thi Le[1], Pawin Padungtod[2], Long Thanh Pham[3]*

1 Dak Lak Sub-Department of Livestock Production and Animal Health, Vietnam

2 Emergency Center for Transboundary Animal Diseases, Food and Agriculture Organization of the United Nations, Country Office for Vietnam, Vietnam

3 Department of Animal Health, Ministry of Agriculture and Rural Development, Vietnam

*Corresponding author email: ptlong.vndah@gmail.com

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Abstract

Lumpy skin disease is a transboundary animal disease primarily affecting cattle, and causing fever, anorexia, skin nodules, mastitis, swelling of peripheral lymph nodes, nasal discharge, watery eyes, and sometimes mortality. The disease was first detected in Vietnam in October 2020 and has spread to 55 out of 63 provinces with around 210,000 cattle and buffaloes infected. Dak Lak was one of the provinces seriously affected by the disease. A retrospective case-control study in three districts of the province was conducted to assess awareness of the disease among local livestock holders and to determine potential risk factors for disease transmission. A total of 276 holdings known to keep cattle or buffalo, including 138 cases (holdings that had at least one animal with clinical signs of the disease) and 138 controls (holdings with no clinically apparent infected animal), were investigated. The study revealed gaps in knowledge and practices among livestock holders on disease control with median scores of 8/20 for knowledge and 5/9 for practices. Vaccination against lumpy skin disease was the only risk factor significantly associated with disease transmission (adjusted odds ratio 0.39, 95% confidence interval 0.21–0.72). We recommend raising the awareness of livestock owners about the risk factors of lumpy skin disease and the importance of vaccination for better prevention and control of outbreaks.

Keywords: lumpy skin disease, case-control studies, vaccination, Vietnam

Introduction

Lumpy skin disease (LSD) is a transboundary infectious disease, mainly affecting cattle (breeds of *Bos taurus* and *Bos indicus*) and water buffalo (*Bubalus bubalis*). It is caused by a poxvirus of the genus *Capripoxvirus*, the family *Poxviridae*.[1] The lumpy skin disease virus (LSDV) is a double-stranded DNA virus having only one serotype but a close antigenic relationship to sheep pox and goat pox viruses.[2] According to the World Organisation for Animal Health, LSDV cannot infect humans, but some wildlife species such as springbok *(Antidorcas marsupialis),* eland *(Taurotragus oryx),* oryx *(Oryx gazelle),* Arabian oryx *(Oryx leucoryx),* guar *(Bos gaurus)*, mainland serow *(Capricornis sumtraensis)* and banteng *(Bos javanicus)* may be susceptible.[3] The disease is characterized by fever, anorexia, skin nodules, mastitis, swelling of peripheral lymph nodes, nasal discharge and watery eyes.[1,4] LSD can cause economic losses through reduced milk yield, damaged hides, low growth rate, costly treatment and control measures, and restricted animal trade. The morbidity rates exceed 85% while mortality rates are low (<3%).[5] The major route of transmission of the virus is by blood-sucking arthropod vectors such as mosquitoes, flies, and ticks or through injection with hypodermic needles contaminated with the virus.[6–9] Vaccination plays a crucial role in reducing the spread of disease in endemic areas; most commercially available vaccines are live-attenuated vaccines produced from the LSDV Neethling strain.[10]

The first outbreak of LSD was detected in Zambia in 1929. By the 1980s, the disease had spread across Africa.[11] In 1989, the disease was first reported outside

Africa in Israel.[12] In 2016, LSD spread into Russia and several South-East European countries.[13] LSD was initially observed in Bangladesh in 2019, followed by more than 20 other Asian countries.[14] According to the World Organisation for Animal Health, by December 2023 the disease was present in 85 countries and territories.

The Department of Animal Health of Vietnam reported the first LSD incursion in the country in October 2020. The disease quickly spread to 55 out of 63 provinces and affected more than 210,000 cattle and buffaloes. As of December 2022, 29,600 animals have been culled.

The first LSD outbreak in Dak Lak Province occurred in June 2021. The disease rapidly spread to all 15 districts in the province with 2,356 cattle and three buffaloes infected. The province culled 829 cattle and two buffaloes, and used 198,067 doses of LSD vaccine (Lumpyvac® attenuated live vaccine; Adiyaman, Turkey) to control the disease.

The objectives of this study are to assess the knowledge and control practices of livestock holders and to identify risk factors of LSD in holdings keeping cattle and/or buffalo in Dak Lak Province.

Materials and Methods

Study Design and Location

This case-control study was conducted in December 2022. Dataset collected was also used to assess LSD knowledge, control practices, and biosecurity measures among livestock holders.

The study was conducted in Krong Bong, Cu M'gar and Ea Sup Districts of Dak Lak Province (Figure 1). Dak Lak has an area of 1,307 km^2 and is in the central highlands of Vietnam with 15 districts and 184 communes (a subdistrict unit). There are 47 ethnic groups in Dak Lak, Kinh people (70%) constituting the majority. Other ethnic groups include Ede, Gia Rai, M'nong, Thai, Tay, and Nung. In 2021, there were approximately 1.9 million residents, 249,500 cattle and 29,200 buffaloes, according to Vietnam General Statistics Office.

Selection of Case and Control Holdings

A list of 13,399 livestock holdings including 283 holdings affected by LSD in the three study districts of Cu M'gar, Ea Sup and Krong Bong from June 2021 to October 2022 was obtained from the Dak Lak Sub-Department of Livestock Production and Animal Health. We selected 276 holdings keeping at least one cattle or buffalo (138 cases and 138 controls) which provided 80% power for detection of an odds ratio (OR) of 2.0 or greater for risk factors that were present in 30% of the control holdings when analyzing the data by unconditional logistic regression.

One LSD outbreak in each commune was confirmed by a real-time polymerase chain reaction assay. Cases were randomly selected from the available pool of holdings having at least one animal demonstrating typical nodular skin lesions of LSD in each district from June 2021 to October 2022. A control holding without clinical signs of LSD was also randomly selected from the same village that the case holding was recruited. In each holding, the livestock owner or the person taking care of the livestock was interviewed using a structured questionnaire form.

Questionnaire

A questionnaire was developed in Vietnamese to collect information about risk factors potentially associated with the occurrence of LSD and to describe the sociodemographic characteristics of livestock holdings in the study area. Data collected were also used to obtain information about LSD knowledge, control practices, and biosecurity measures to protect livestock owners.

The questionnaire consisted of four major sections: holding demographics, information on livestock keeping, knowledge about LSD, and control practices. Additional data on LSD features in each case holding was collected in a separate form. The questionnaire was administered by trained personnel through face-to-face interviews with livestock owners and a local communal animal health worker whenever possible. The questionnaire was pre-tested in five cattle holdings in Buon Ma Thuot City to ensure question clarity.

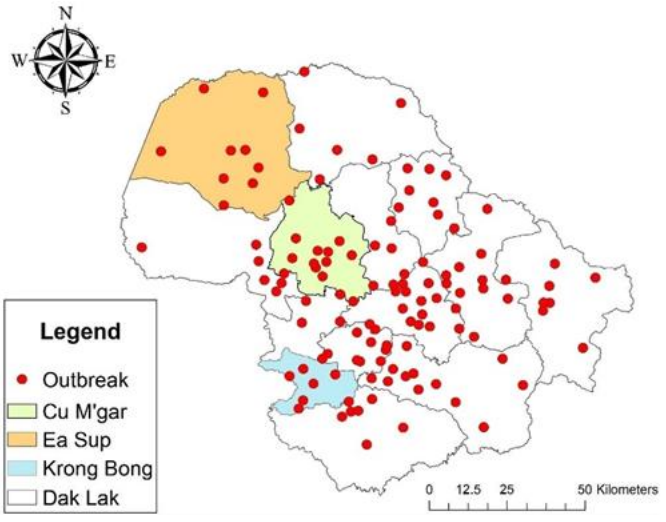

Figure 1. Lumpy skin disease outbreaks in Dak Lak Province, Vietnam, and the three study sites, June 2021–October 2022

Statistical Analysis

Data obtained from the questionnaires were recorded in KoboToolbox (Kobo, Inc.; Cambridge, MA, USA) then exported as a spreadsheet for subsequent analysis using STATA/SE 15.0 (Stata Corp LLC, College Station, TX, USA).

Spearman's rank correlation analysis was used to determine the relationship between knowledge and practices. The Mann–Whitney U test, Kruskal–Wallis test, and negative binomial regression were used to identify associations between demographic factors and knowledge and practice scores. Variables with a *p*-value less than 0.2 in univariable analysis were included in the mixed-effects negative binomial regression using menbreg in STATA/SE 15.0 with the district as a random effect.

For holding's LSD infection risk factor identification, the association of independent variables and outcomes was evaluated using a chi-square test in univariable analysis. Variables with a *p*-value lower than 0.25 and absolute correlation coefficient value (r-value) below 0.7 were included in the initial multivariable logistic regression model.[15,16] Variables changing more than 25% of coefficients of other variables were classified as confounding factors and included in the model if the affected variables were significant. Mixed-effects multivariable logistic regression models were built using meqrlogit in STATA/SE 15.0 with the village as a random effect. A stepwise backward manual elimination technique was used to identify significant predictors in the model. Factors with a *p*-value less than 0.05 were considered statistically significant.

Ethics

The study was approved by the Ethical Committee of the Institute of Malariology, Parasitology, and Entomology Quy Nhon–the Ministry of Health of Vietnam (No 1113/VSR-LSDT, 29 Nov 2022). The purpose of this study was explained to livestock holders by the investigators, and participants were only included in the study after their informed consent was given.

Results

Livestock Holder Demographics

Key demographic features of the survey respondents are summarized in Table 1. The majority of respondents were male (71.4%) and more than 79% were aged 31 to 60 years. Around two-thirds had graduated secondary school or higher. Most participants were involved in farming as their primary job with 31.2% describing themselves as "livestock holder". Over half of respondents belonged to the Kinh ethnic group (55.8%) followed by Ede (22.1%), and Gia Rai (2.2%). Most of the holdings (62%) kept less than 10 cattle and/or buffaloes.

Table 1. Social-demographic features of livestock holders

Variable	n (%)
Gender	
Male	197 (71.4)
Female	79 (28.6)
Age (years)	
18–30	14 (5.1)
31–45	79 (28.6)
46–60	140 (50.7)
>60	43 (15.6)
Education	
None	13 (4.7)
Primary school	64 (23.2)
Secondary school	103 (37.3)
High school	78 (28.3)
College/university	18 (6.5)
Occupation	
Livestock holder	86 (31.2)
Cultivation worker	124 (44.9)
Officer (local government staff)	14 (5.1)
Others	52 (18.8)
Ethnic group	
Kinh	154 (55.8)
Ede	61 (22.1)
Gia Rai	6 (2.2)
Other	55 (19.9)
Herd size (heads of cattle/buffalo)	
<10	171 (62.0)
10–29	80 (29.0)
30–59	20 (7.2)
≥60	5 (1.8)

LSD Awareness and Prevention among Livestock Holders

Knowledge among livestock holders about LSD is summarized in Table 2. In both cases and controls, a majority of respondents (82.6% and 79.7%, respectively) demonstrated awareness of LSD and its associated clinical signs including skin nodules, high fever, anorexia. However, a significantly higher proportion of respondents from cases did not know the causative agent of LSD compared to control (59.4% versus (vs) 47.1%, *p* 0.04). Both cases and controls exhibited knowledge of susceptible species, with similar awareness levels regarding cattle (73.9%) and buffalo (52.2% cases, 57.2% controls). Nevertheless, 22.5% of cases and 23.9% of controls could not identify any susceptible species. While the majority of respondents understood that LSD cannot be transmitted to humans (81.9% cases, 84.0% controls), a considerable proportion lacked knowledge regarding transmission

routes (57.2% cases, 46.4% controls) and how infected cattle shed the virus (72.5% cases, 64.5% controls). To prevent LSD, vaccination was considered crucial by both cases and controls (75.4% vs 76.8%), followed by vector control (23.2% vs 31.9%), and implementing good biosecurity practices (5.1% vs 13.8%).

Table 2. Knowledge of livestock holders about lumpy skin disease in infected versus non-infected holdings

	Cases n (%)	Controls n (%)	*P*-value
Awareness of LSD			
Yes	114 (82.6)	110 (79.7)	0.538
No	24 (17.4)	28 (20.3)	
Clinical signs of LSD			
Subcutaneous hard nodule round shape, diameter 0.5–5 cm	98 (71.0)	96 (69.6)	0.792
High fever	62 (44.9)	57 (41.3)	0.543
Anorexia	57 (41.3)	40 (29.0)	0.031
Depression and reluctance to move	43 (31.2)	36 (26.1)	0.351
Enlarged anterior & inferior parotid lymph nodes	33 (23.9)	30 (21.7)	0.667
Rhinitis	25 (18.1)	25 (18.1)	1.000
Edema under the skin of the waist, neck and genitals	27 (19.6)	22 (15.9)	0.431
Conjunctivitis	17 (12.3)	18 (13.0)	0.856
Excessive salivation	13 (9.4)	18 (13.0)	0.339
Lactation reduction	13 (9.4)	9 (6.5)	0.373
Don't know any	24 (17.4)	31 (22.5)	0.291
The causative agent of LSD			
Virus	47 (34.1)	65 (47.1)	0.027
Parasite	8 (5.8)	6 (4.3)	0.583
Bacteria	2 (1.4)	3 (2.2)	0.651
Don't know	82 (59.4)	65 (47.1)	0.040
Domestic animal species can get LSD			
Cattle	102 (73.9)	102 (73.9)	0.918
Buffalo	72 (52.2)	79 (57.2)	0.434
Pig	3 (2.2)	3 (2.2)	0.992
Goat/sheep	2 (1.4)	2 (1.4)	0.994
Don't know	31 (22.5)	33 (23.9)	0.801
The infected animal can transmit the disease to humans			
Yes	25 (18.1)	22 (16.0)	0.631
No	113 (81.9)	116 (84.0)	
LSD vaccine availability for cattle & buffalo			
Yes	113 (81.9)	112 (81.2)	0.877
No	25 (18.1)	26 (18.8)	
List some routes of the disease transmission			
Through arthropod vectors such as flies, mosquitoes, ticks	52 (37.7)	67 (48.6)	0.068
Through nasal secretions, feces, urine, milk, meat	21 (15.2)	35 (25.4)	0.035
Through semen	11 (8.0)	20 (14.5)	0.084
Contaminated water	4 (2.9)	10 (7.2)	0.094
Don't know	79 (57.2)	64 (46.4)	0.071
How can an infected animal shed the virus?			
Scabs	25 (18.1)	37 (26.8)	0.094
Sperm	18 (13.0)	29 (21.0)	0.086
Nasal discharge	21 (15.2)	26 (18.8)	0.455
Milk	9 (6.5)	16 (11.6)	0.158
Urine	8 (5.8)	8 (5.8)	0.976
Don't know	100 (72.5)	89 (64.5)	0.105
What do you do to prevent the disease in your farm?			
Vaccinate the animal	104 (75.4)	106 (76.8)	0.777
Control arthropod vectors	32 (23.2)	44 (31.9)	0.105
Apply biosecurity in the farm	7 (5.1)	19 (13.8)	0.012
Don't know	30 (21.7)	31 (22.5)	0.885

Controls demonstrated a higher percentage of routine cleaning their livestock premises compared to case holdings (80.1% vs 71.0%), with statistical significance (p 0.033). As shown in Table 3, among controls, 43.5% disinfected their premises monthly, and (18.1%) disinfected weekly, whereas among cases, 37.0% disinfected monthly and 13.0% disinfected weekly. Regarding vector control, 48.6% of controls used insecticides significantly more than the case group (p 0.005). Moreover, most of control holdings (83.3%) vaccinated their animals against LSD more than case holdings (64.5%), with statistical significance (p <0.001). Participation in LSD surveillance programs over last two years was limited, with only 5.1% of cases, and 7.2% of controls involved.

Table 3. Practices of livestock holders for prevention of lumpy skin disease in infected versus non-infected holdings

	Cases n (%)	Controls n (%)	*P*-value
Prohibit visitor(s) coming into the farm			
Yes	34 (24.6)	48 (34.8)	0.065
No	104 (75.4)	90 (65.2)	
Clean the premise regularly	98 (71.0)	123 (89.1)	0.033
Daily basis	44 (31.9)	38 (27.5)	
Every 2–3 times/week	7 (5.1)	29 (21.0)	
Weekly	29 (21.0)	29 (21.0)	
Monthly	16 (11.6)	16 (11.6)	
Disinfect of the premises regularly	76 (55.1)	89 (64.5)	0.111
Daily basis	3 (2.2)	2 (1.4)	
Every 2–3 times/week	4 (2.9)	2 (1.4)	
Weekly	18 (13.0)	25 (18.1)	
Monthly	51 (37.0)	60 (43.5)	
Use of insecticides to control vectors	44 (31.9)	67 (48.6)	0.005
Monthly	5 (3.6)	5 (3.6)	
Quarterly	10 (7.2)	21 (15.2)	
Every 6 months	12 (8.7)	20 (14.5)	
Once per year	7 (5.1)	5 (3.6)	
Waste treatment at the farm	62 (44.9)	78 (56.5)	0.054
Biogas incubation	6 (4.3)	8 (5.8)	
Bio-heat incubation	34 (24.6)	52 (37.7)	
Probiotics	13 (9.4)	14 (10.1)	
LSD vaccination for the animal(s)	89 (64.5)	115 (83.3)	<0.001
Daily monitoring health status of livestock	118 (85.5)	120 (87.0)	0.727
Recording livestock entering/exiting the farm	27 (19.6)	43 (31.2)	0.026
Joined LSD surveillance program for last two years	7 (5.1)	10 (7.2)	0.451

Table 4 presents common practices in LSD infected holdings. Many (83.8%) of the livestock owners treated sick animals by themselves, and 64.6% reported the outbreaks to local veterinarians or authorities. More than half (56.2%) continued raising sick and healthy livestock together on the same premises, while 40% allowed sick animals to graze in community areas.

Table 4. Practices of livestock owners of LSD infected farms

Number of infected farms provided information (n=130)	Yes	%
The cattle/buffalo bitten by flies, mosquitoes, ticks within two weeks of symptoms onset	89	68.5
During one month before the LSD outbreak, there was close contact of animal(s) with infected animals from other farms	55	42.3
When your animal was suspected of having LSD		
Gave a treatment by yourself	109	83.8
Reported to local authorities/local vet	84	64.6
Sold sick animal(s)	15	11.5
Slaughtered	6	4.6
Did nothing	13	10.0
When your animals(s) got sick, did you quarantine them?		
Continued to raise sick animal(s) with healthy animals	73	56.2
Allowed sick animal(s) in the common grazing area	52	40.0
Isolated the infected animal(s) from healthy animals	42	32.3

Associations between Knowledge and Practices and Demographics

Table 5 presents associations between demographic factors and LSD knowledge and practices of livestock holders. The median (interquartile range) scores for knowledge and practices were 8±5 (range from 0–20) and 5±3 (ranging from 0–9), respectively. Correlation analysis showed a moderate positive correlation between knowledge and practices (Spearman's rho 0.45, p <0.001). Older age, Kinh ethnic group, higher education, and larger herd size were significantly associated with higher knowledge scores while district location and Ede ethnic group were significantly associated with practices (p <0.05). The Kinh ethnic group had both knowledge and practice scores significantly higher than the Ede ethnic group, but not for the practice score compared to the Gia Rai ethnic group. Importantly, those aged above 31 years had significantly higher knowledge scores than the younger respondents, but practice scores were not significantly different. In addition, those who graduated from a primary school or higher levels had significantly higher knowledge scores than those without any education, but their practice scores were not significantly different. The owners of holdings having more than 10 animals had significantly higher knowledge scores compared to those with less than 10 animals. However, the practice score was not significantly different between holdings containing different herd sizes. Gender and occupation were not significantly associated with knowledge and practices in the multivariable mixed-effects negative binomial regression analysis.

Table 5. Comparison of knowledge and practice scores with respect to demographics characteristics of study participants (n=275)

Variable	Knowledge			Practice		
	Median ± IQR	*P*-value (Univariable)	*P*-value (Multivariable)	Median ± IQR	*P*-value (Univariable)	*P*-value (Multivariable)
Overall score	**8 ± 5**			**5 ± 3**		
Gender*		**0.416**			**0.628**	
Male	8 ± 5		-	5 ± 3		
Female	8 ± 6			5 ± 3		
District†		**<0.001**	**NA**		**<0.001**	**NA**
Cu M'gar	7 ± 4			5 ± 2		
Ea Sup	10 ± 5			5 ± 2		
Krong Bong	6 ± 1			2 ± 1		
Age group (years) †		**0.035**			**0.099**	
18–30	1 ± 8		Ref.	5 ± 5		Ref.
31–45	8 ± 6		0.005	4 ± 3		0.372
46–60	8 ± 5		0.004	5 ± 3		0.997
>60	7 ± 4		0.003	4 ± 4		0.566
Ethnicity†		**<0.001**			**<0.001**	
Kinh	9 ± 5		Ref.	5 ± 2		Ref.
Ede	6 ± 6		<0.001	2 ± 2		<0.001
Gia Rai	1.5 ± 7		0.008	4 ± 2		0.082
Other	9 ± 10		0.047	5 ± 2		0.362
Level of education†		**<0.001**			**0.018**	
None	1 ± 6		Ref.	4 ± 3		Ref.
Primary school	7.5 ± 6		0.031	5 ± 3.5		0.883
Secondary	8 ± 5		0.006	4 ± 4		0.824
High school	9 ± 5		0.006	5 ± 3		0.531
College/ University	12 ± 9		0.001	5.5 ± 5		0.212
Occupation†		**0.037**			**<0.001**	
Livestock holder	9 ± 7		Ref.	5.5 ± 2		Ref.
Cultivator	7 ± 4		0.800	3.5 ± 3		0.092
Officer	7 ± 6		0.330	5 ± 3		0.304
Other	9 ± 10		0.359	5 ± 3		0.515
Herd size (head)		**<0.001**			**<0.001**	
<10	7 ± 5		Ref.	4 ± 4		Ref.
10–29	10 ± 5		<0.001	5.5 ± 2		0.065
30–59	12 ± 5.5		0.005	6 ± 3		0.124
≥60	17 ± 4		0.019	9 ± 2		0.051

**Mann–Whitney U test. †Kruskal–Wallis test. Ref.: reference. IQR: interquartile range. NA: not applicable.*

Univariable Analysis of Risk Factors

At the holding level, grazing practice, distance from the holding to grazing area, feeding animals mixed forage, cleaning practices, using insecticides, vaccination against LSD and recording livestock entering/exiting the holding were significantly associated with the occurrence of disease by univariable analysis (Table 6).

The odds of getting LSD among free grazing animals during the day time grazing was significantly higher than among fenced animals (OR 1.78, p 0.026). A significantly higher risk of LSD infection was seen in holdings located less than 100 meters from the grazing pasture compared to those more than 200 meters (OR 2.10, p 0.021). In contrast, a lower risk of getting the disease was seen in holdings where animals were fed with mixed forage (OR 0.43, p 0.026). A higher risk of getting LSD was seen at holdings not cleaning livestock premises frequently (OR 1.80, p 0.044), not using insecticides to control vectors (OR 2.02, p 0.005), having no LSD vaccination (OR 2.75, p <0.001), and holdings that did not record livestock entering/ exiting (OR 1.86, p 0.028).

There were no significant associations for district location, herd size, distance from the road or live animal market or another nearby farm, type of drinking water for livestock, breeding practice, whether the origin of the livestock was known or not, and waste treatment practice.

Table 6. Results from univariable analysis of factors associated with LSD infection

Exposure variable	Holdings surveyed	Holdings infected	OR (95% CI)	*P*-value
District				
Cu M'gar	81	42	Ref.	-
Ea Sup	140	68	0.88 (0.51–1.52)	0.638
Krong Bong	55	28	0.96 (0.48–1.91)	0.914
Herd size (head)				
<10	171	83	Ref.	-
10–29	80	44	1.29 (0.76–2.21)	0.340
30–59	20	9	0.87 (0.34–2.20)	0.765
≥60	5	2	0.71 (0.11–4.34)	0.708
Grazing practice				
Fenced	111	47	Ref.	-
Free in day time only	134	76	1.78 (1.07–2.97)	0.026
Free whole day	31	15	1.28 (0.57–2.84)	0.549
Distance to traffic road (meters)				
<100	115	59	Ref.	-
100–200	17	7	0.66 (0.24–1.87)	0.438
>200	142	70	0.92 (0.56–1.51)	0.749
Distance to live animal market (meters)				
<100	2	2	NA	-
100–200	10	6	1.49 (0.41–5.39)	0.545
>200	259	130	Ref.	-
Distance to lake or, pond (meters)				
<100	35	18	Ref.	
100–200	29	21	2.48 (0.87-7.08)	0.090
>200	197	90	0.79 (0.39-1.63)	0.531
Distance to closest farm (meters)				
<100	131	65	Ref.	
100–200	21	14	2.03 (0.77–5.36)	0.152
>200	106	52	0.98 (0.59–1.63)	0.931
Distance to grazing pasture (meters)				
<100	53	34	2.10 (1.12–3.95)	0.021
100–200	25	15	1.76 (0.75–4.12)	0.192
>200	187	86	Ref.	-
Distance to waste treatment area (meters)				
<100	5	1	Ref.	-
100–200	5	2	2.67 (0.16–45.10)	0.497
>200	248	126	4.13 (0.46–37.50)	0.207
Feeding animal with fresh grass				
No	12	5	Ref.	-
Yes	257	132	1.48 (0.46–4.78)	0.514

Table 6. Results from univariable analysis of factors associated with LSD infection (cont.)

Exposure variable	Holdings surveyed	Holdings infected	OR (95% CI)	*P*-value
Feeding animal with dry grass or straw				
No	29	18	Ref.	-
Yes	240	119	0.60 (0.27–1.33)	0.207
Feeding animal with silage feed				
No	242	126	Ref.	-
Yes	27	11	0.63 (0.28–1.42)	0.267
Feeding animal with mixed forage				
No	233	125	Ref.	-
Yes	36	12	0.43 (0.21–0.91)	0.026
Drinking water for livestock				
Drilling well	158	70	Ref.	-
Tap water	5	3	1.89 (0.31-11.60)	0.494
Pond/lake water	105	59	1.61 (0.98-2.65)	0.060
Breeding practice				
Artificial insemination	57	32	Ref.	-
From bull(s) in the holding	44	23	0.86 (0.39–1.88)	0.699
From bull(s) for hiring business	44	18	0.54 (0.24–1.20)	0.131
From bull(s) of another farm	2	1	0.78 (0.05–13.10)	0.864
From bull(s) in public grazing area	107	53	0.77 (0.40–1.46)	0.420
Origin of livestock breeds				
Known	123	62	Ref.	
Unknown	153	76	0.97 (0.60–1.56)	0.904
Quarantine area for new purchased cattle/buffalo				
No	210	112	Ref.	-
Yes	59	25	0.64 (0.36–1.15)	0.138
Floor type				
Cement	211	101	Ref.	-
Soil	63	36	1.45 (0.82–2.56)	0.198
Prohibiting visitor				
No	194	104	Ref.	-
Yes	82	34	0.61 (0.36–1.03)	0.066
Frequent cleaning				
No	64	39	1.80 (1.02–3.18)	0.044
Yes	211	98	Ref.	
Frequent disinfection				
No	111	62	Ref.	-
Yes	165	76	0.67 (0.42–1.09)	0.111
Using insecticides to control vectors				
No	165	94	2.02 (1.24–3.29)	0.005
Yes	111	44	Ref.	-
Waste treatment				
No	136	76	1.59 (0.99–2.56)	0.055
Yes	140	62	Ref.	
LSD vaccination				
No	72	49	2.75 (1.56–4.85)	<0.001
Yes	204	89	Ref.	-
Daily monitoring health status				
No	38	20	Ref.	-
Yes	238	118	0.88 (0.45–1.76)	0.727
Recording livestock entering/ exiting				
No	206	111	1.86 (1.07–3.24)	0.028
Yes	70	27	Ref.	-

LSD: lumpy skin disease. OR: odds ratio. CI: confidence interval. Ref.: reference. NA: not available.

Multivariable Analysis

Results of the multivariable analysis are shown in Table 7. Vaccination against LSD could significantly reduce risk of disease occurrence (adjusted OR 0.39, 95% confidence interval 0.21–0.72).

Table 7. Multivariable analysis of risk factors

Exposure variable*	Adjusted OR	95% CI	*P*-value
Distance to grazing pasture (meters)			
<100	Ref.		
100–200	1.13	0.41–3.13	0.813
>200	0.52	0.27–1.01	0.055
Using insecticides to control vectors			
Yes	0.61	0.36–1.04	0.070
LSD vaccination			
Yes	0.39	0.21–0.72	0.003
Recording livestock entering/ exiting			
Yes	0.60	0.33–1.10	0.098

*LSD: lumpy skin disease. Ref.: reference. OR: odds ratio. CI: confidence interval. *The final model includes five variables of "Distance from holding to grazing pasture", "Using insecticides to control vectors", "LSD vaccination", "Recording livestock entering/exiting holding" and "village".*

Discussion

LSD is an emerging disease in Southeast Asia and the region has become endemic.[7,18] Therefore, more research on LSD in the region is required.[18] Previous studies have recommended some preventive measures against LSD spreading such as restriction of livestock movement, vector control, culling infected animals and vaccination.[1,10,19] However, knowledge, practices and engagement of livestock holders would play an important role in the success of an animal disease control programme.

Our study identified gaps in LSD knowledge in livestock holders with the median scores of 8/20 for knowledge and 5/9 for control practices. We also found that livestock holders with higher education and those older than 31 years were more knowledgeable about animal diseases. Older people likely gained more knowledge from their experience of livestock keeping for many years. In fact, the youth prefer jobs in big cities while the elderly attach their employment to rural settlements.[20] In our study, we found that the respondents from larger-scale farms had significantly higher knowledge scores, but practice scores were not significantly different. Normally, when the farmers invest more in their livestock production, they should have better understanding of farm management, biosecurity and disease preventive measures. However, they were not ready to respond to the outbreak of new diseases such as LSD. The Kinh ethnic group had higher knowledge and better practices compared to the other ethnic groups. The ethnic minority groups in Dak Lak each has their own distinct language and traditions. The impact of language barriers on the knowledge process has been previously documented.[21] Therefore, communication of information on LSD to different ethnic groups should be made in their own language. Improving the literacy of minority ethnic groups and increasing their awareness of emerging infectious diseases should also be taken into consideration.

Non-infected holdings showed better practices in terms of cleaning, controlling vectors, recording livestock movement in and out of their holding, and vaccination against LSD in this study. Generally, better biosecurity practices by livestock farmers could mitigate disease transmission. Our study results also indicated that day time free-grazing and being close to the grazing area were significant risk factors. This finding is consistent with a study in Ethiopia showing that LSD occurrence was significantly associated with communal grazing.[22] Free grazing could facilitate transmission of LSDV through arthropod vectors. A recent study in Thailand reported that 95% of their livestock farms had at least one vector responsible for the disease.[23] Large herd size (exceeding 10 animals) was identified as a factor associated with LSD outbreaks in Kenya, while a study in Kazakhstan concluded that small herd size was significant.[24,25] However, we did not find a significant association between herd size and disease occurrence. Other risk factors from previous studies including district location, and type of drinking water of the livestock were not significant in our study.[26,27]

Vaccination was the only significantly associated factor in our study. Vaccination campaigns have been recommended for the prevention of LSD in both endemic or newly affected areas.[10] The live attenuated homologous vaccine (Neethling strain) used in Dak Lak has demonstrated high efficacy to eradicate LSD in Southeastern Europe.[28]

There were some limitations of our study. First, we did not observe the practices of the farmers directly. Second, we did not include season, climate or veterinary supervision as potential risk factors due to a time limitation. Third, we could only measure the knowledge and practices of the respondents after the outbreak occurred in their households or communities. Finally, livestock in the control holdings were not tested to confirm the absence of LSDV infection. However, clinical observation to confirm the absence of disease could be sufficient considering the infectiousness of LSDV.

Conclusion

Knowledge of LSD among livestock holders in Dak Lak province was low. A communication campaign on LSD prevention is recommended for livestock holders of all herd sizes, targeting minority ethnic communities such as Gia Rai and Ede. Application of the languages of different ethnic communities, literacy improvement for vulnerable groups, and more investment in LSD training for minority ethnic people are potential long-term solutions. Vaccination campaigns are needed to significantly reduce the risk of LSD transmission.

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Data Availability

All datasets supporting our findings are available from the corresponding author on reasonable request.

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Conflicts of Interest

The authors declare that they have no conflicts of interests.

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