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Full Length Research

Risk factors and economic impact of contagious ecthyma (Orf) in small ruminants of Yobe and Borno States, Nigeria

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ABSTRACT: Contagious ecthyma (Orf) is a significant viral disease of small ruminants with substantial economic and animal welfare implications. This study assessed the risk factors, haematological parameters, and economic impact of Orf in sheep and goats in Yobe and Borno States, Nigeria. We employed a mixed-methods approach, combining a cross-sectional survey of 121 farmers, haematological analysis of 12 infected animals, and an economic evaluation. Results revealed high farmer awareness (97.8%) but critical knowledge gaps in herd health management (95.9% unaware) and a complete absence of vaccination. Infected animals showed significant haematological deviations, including anaemia (reduced PCV, Hb, RBC) and systemic stress (elevated WBC). Economically, 36% of farmers incurred losses, primarily driven by mortality. Regression analysis showed that disease exposure, morbidity, and mortality explained 85.9% of the variance in economic losses. The study concludes that Orf poses a substantial burden in the region, highlighting an urgent need for improved veterinary services, farmer education, and vaccine development to mitigate the impact of this zoonotic disease.

Keywords: Contagious ecthyma, economic impact, Nigeria, risk factors, small ruminants.

INTRODUCTION

Small ruminants are vital to the livelihoods of low-income households, serving as a critical source of income and nutrition, often referred to as the "poor man's cow" (Swanepoel *et al*., 2010). However, their productivity is severely constrained by infectious diseases. Among these, contagious ecthyma (Orf), caused by a parapoxvirus, is an emerging, debilitating, and zoonotic disease of global significance (Nandi *et al*., 2011; Tedla *et al*., 2018).

The disease is enzootic worldwide, with morbidity rates that can reach 100% and mortality up to 15% due to secondary complications (Ramesh *et al*., 2008; Kumar *et al*., 2015). Orf virus is highly resilient in the environment, and immunity post-infection is often incomplete, leading to recurrent outbreaks (Bala *et al*., 2018). In Nigeria, several outbreaks have been documented (Adah *et al*., 2012; Adedeji *et al*., 2022; Onoja *et al*., 2024). However, diagnosis is frequently based on clinical signs without laboratory confirmation, and the economic impact of the disease remains largely unquantified (Adedeji *et al*., 2017).

This gap in knowledge hinders the development of effective control strategies. Therefore, this study was conducted to: 1) determine the epidemiological risk factors for Orf in sheep and goats in Yobe and Borno States, 2) assess the body condition score and haematological parameters of infected animals, and 3) evaluate the economic impact of the disease using gross margin and regression analysis.

MATERIALS AND METHODS

Duration of study

The overall length of the study was 12 months (from July 2023 to July 2024). The preparatory phase lasted 3 months and involved data collection through a pilot study to ensure validity. The main data collection took 6 months due to participant recruitment challenges and the need to reach the target sample size of 121 respondents. Data cleaning, analysis, and article preparation took 4 months.

Study area

Yobe and Borno states (Figures 1 and 2) are located in the Northeastern Nigeria, along with the following states: Adamawa, Bauchi, Gombe and Taraba. Yobe State is located in northeastern Nigeria, comprising seventeen Local Government Areas (LGAs) and covering a landmass of approximately 45,502 Km², with an estimated population of 2,321,339 (Waziri, 2012). The State borders the Nigerian States of Bauchi, Borno, Gombe and Jigawa. It also borders the Diffa and the Zinder regions of the Niger Republic (Waziri, 2012). The State is noted for agricultural practices of crop farming, fishing and livestock rearing, which employs over 80% of the State population. The livestock sector plays a significant role in the Yobe economy, providing employment and income for many people, and contributes to the state's food security and nutrition (Babagana *et al.,* 2018).

Maiduguri metropolis is the capital city of Borno State and is in the semi-arid zone of the northeastern part of Nigeria (Waziri, 2012). It is located between latitudes 10°N and 13°N and longitudes 12°E and 15°E. The area has an average temperature of 39 ± 140°C, with an area of 69,436 Km² in the northeastern part of Nigeria. It lies on relatively flat terrain, part of the vast undulating plain which slopes gently toward Lake Chad (Waziri, 2012). Generally, the lowest monthly temperature is about 20ºC but the daily extremes vary in a wide range, reaching up to 47°C in April (Waziri, 2012). The blowing of the North East trade winds and the South West monsoons are the determinants of the climatic pattern of the city (Waziri, 2012). Crop production and livestock farming are the predominant occupations of the people, while other economic activities include trading and craftsmanship. Major crops grown in the region include maize, millet, guinea corn, rice, cowpea, fruits and vegetables (Tijjani *et al.,* 2012).

Study design

Sampling technique

A cross-sectional study was conducted between July and September 2023 in Yobe and Borno States, Nigeria. A multistage sampling technique was employed to ensure a representative geographical distribution. Two Local Government Areas (LGAs) were randomly selected from each of the three senatorial zones in Yobe State (Damaturu, Tarmuwa, Potiskum, Fika, Bade, Jakusko). In Borno State, three LGAs within the Maiduguri metropolis (Maiduguri Metropolitan Council, Jere, and Konduga) were purposively selected due to security constraints, acknowledging this as a study limitation. Two districts were randomly selected from each LGA. A target of six small ruminant farms per district was selected. Farms were included only if they had a herd size of at least 20 animals, to ensure they were of a scale where disease management and economic impact were meaningful to assess. This resulted in a target sample of 71 farms.

Questionnaire survey

The final sample included 121 farmers. While the initial sampling frame targeted 71 farms, the final sample was expanded to 121 to enhance the statistical power and representativeness of the survey data on risk factors and economic impact. This expansion was logistically feasible within the study areas and allowed for the inclusion of more diverse farming operations.

A structured, closed-ended questionnaire was administered through face-to-face interviews. The questionnaire was pre-tested and validated for reliability (Taherdoost, 2016). It collected data on: Farmer awareness of contagious ecthyma, herd demographics and management practices, history of Orf infection (morbidity, mortality), vaccination history and other health management practices, costs associated with disease management (treatment, mortality).

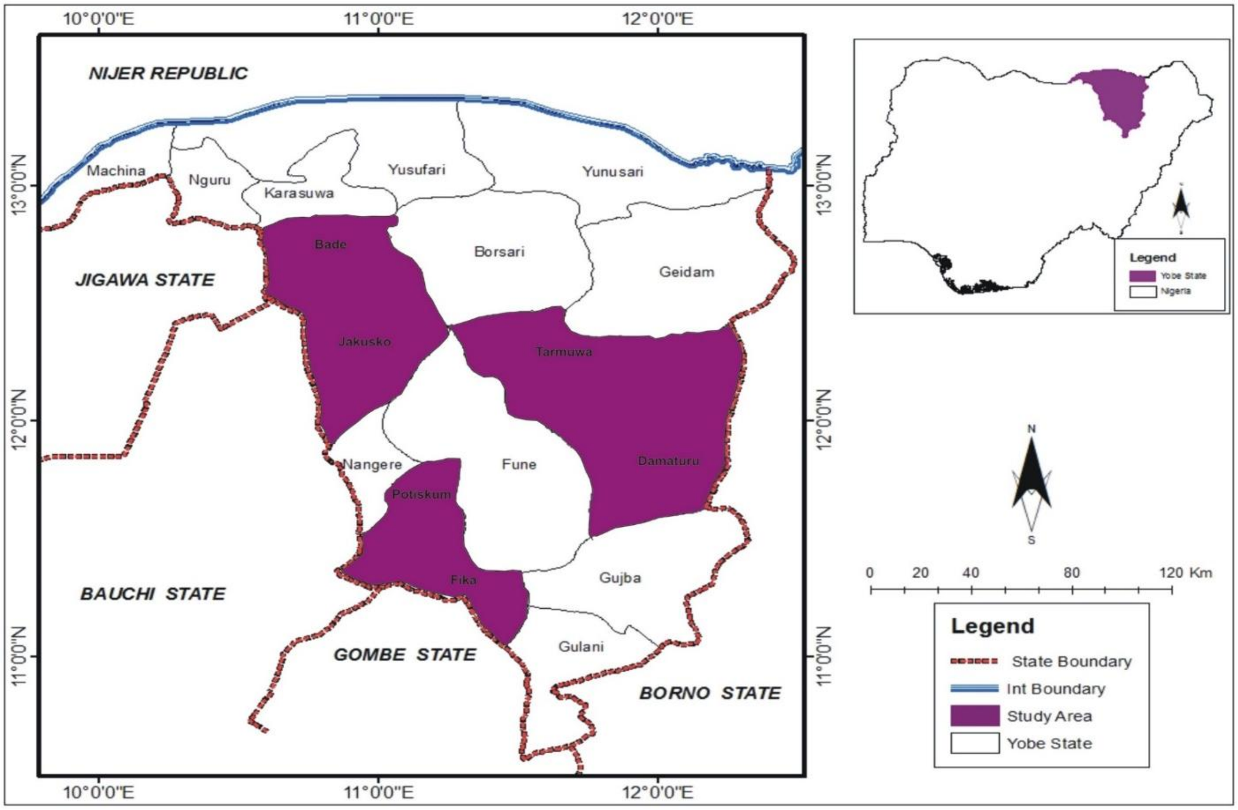

Figure 1. Map of Yobe state showing distribution of LGAs and sampling Locations Yobe state geographic information service (YOGIS).

Figure 2. Map of Borno State showing distribution of LGAs and sampling Location (Maiduguri Metropolis) state geographic information service (BOGIS).

Economic impact of contagious ecthyma of sheep and goats in the study area

Revenue from the sale of diseased live animals

$M_{live,i} = (P_{sheep,d,i} \times N_{sheep,sold,d,i}) + (P_{goat,d,i} \times N_{goat,sold,d,i})$

Where: $M_{live,i}$ = revenue from diseased live animals in flock i, $P_{sheep,d,i}$, $P_{goat,d,i}$ = reduced prices of diseased sheep and goats in flock I, and $N_{sheep,sold,d,i}$, $N_{goat,sold,d,i}$ = number of diseased sheep and goats sold live in flock i (Limon *et al*., 2020).

Income from sale of meat

$M_{meat,i} = M_{sheep,meat,i} + M_{goat,meat,I}$

Where: $M_{meat,i}$ = total revenue from meat sales in flock i, and $M_{sheep,meat,i}$, $M_{goat,meat,i}$ = income from sheep meat and goat meat, respectively, in flock i (Limon *et al*., 2020).

Total economic losses

$TE_{loss,i} = (V_{before,i} – V_{after,i}) + T_{x,I}$

Where: $TE_{loss,i}$ = total economic loss for flock i, $V_{before,i}$ = estimated value of the flock before the outbreak, $V_{after,i}$ = estimated value of the flock after the outbreak, and $T_{x,i}$ = treatment costs incurred during the outbreak (Limon *et al.,* 2020).

Regression analysis of economic losses due to orf disease

Gross margin is computed as:

$GM_i=TR_i−TVC_i$

Where: GM_i = Gross margin for respondent (Naira), TR_i = Total revenue from animal sales by respondent (Naira), and TVC_i = Total variable costs incurred by respondent iii (Naira) (Limon *et al.,* 2020).

The total revenue (TR_i) is computed as:

$TR_i=P_H*N_H+P_T*N_T+P_U*N_U + P_S*N_S$

Where: P_H = Price of healthy animals (Naira), P_T = Price of animals sold after treatment (Naira), P_U = Price of untreated diseased animals (Naira), P_S = Price of slaughtered animals (Naira), and N_H, N_T, N_U & N_S = Number of healthy, treated, untreated animals and slaughtered animals sold, respectively (Limon *et al.,* 2020).

The total variable costs (TVC_i) include treatment expenses and feeding costs:

$TVC_i=C_T*N_T+C_F*(N_T+N_H)$

Where: C_T= Cost of treatment per animal (Naira), and C_F = Additional feed cost per recovering animal (Naira) (Limon *et al.,* 2020).

The net revenue loss (L_i) due to Orf disease is calculated as:

$Li=TR_{Healthy}−TR_i$,

Where: $TR_{Healthy}$ = Total revenue if all animals were sold as healthy, and TR_i = Total revenue (Ref).

Blood sample

Between July and September 2023, blood samples were collected from a total of 12 animals (Ovine: 7, Caprine: 5) which are affected with contagious ecthyma from different farms (4) and abattoir slaughter slab (8) using EDTA tube sample bottle and transported on ice packs in a cold box to the Laboratory for full blood count.

Giemsa staining technique

A thin blood smear was prepared from each of the collected blood samples and allowed to air dry. The smear was fixed by covering it with methanol (methyl alcohol) for 2 – 3 minutes, and subsequent air drying again. The Giemsa stain was diluted with buffered water (a small measuring cylinder was filled to the 19 ml mark with the buffered water, and 1 ml of Giemsa stain was added to the 20 ml mark). The smears were then placed in a small container, supported on each side by the thin piece of stick. The diluted Giemsa stain was poured into the small container and covered with a lid. The smears were allowed to stain for 45 minutes. The stain was washed from the container, and the smear was rinsed with buffered water. Each back of the slide was wiped, cleaned, and placed in a draining rack for the smear to air dry. The slide smears were examined microscopically first with the x40 objective to view the distribution of material and to select a suitable part of the smear to examine with the oil immersion lens (x100 objective) (Garcia and Procop, 2016).

Determination of Pack Cell Volume (PCV)

The blood samples collected in the EDTA sample bottles were mixed and collected into the heparinised capillary tube by capillary action until the tube was three-quarters full. The end of the tube in contact with the blood was sealed with plasticine and centrifuged at the rate of 12000 rpm for 5 minutes. The PCV was read as a percentage (%) using a microhaematocrit reader (MUC, 2022).

Determination Haemoglobin Concentration (Hb)

The haemoglobin concentration was determined by the colourimeter method. About 0.2 ml of blood was pipetted into a test tube containing 5 ml of Drabkin's solution and was vigorously shaken. The mixture was allowed to stand for about 3 minutes, and the colourimeter was switched on for ten minutes to stabilise before use. The mixture was transferred into a clean cuvette and then placed in a colourimeter using a filter of 520 nm wavelength to determine the optical density of the sample. The haemoglobin concentration (g/dl) corresponding to the optical density was read using a standard chart (Drabkin and Austin, 1932).

Determination of Red Blood Cell (RBC)

For the determination of the red blood cell count according to Coles (1986), the following materials were used. Diluting fluid (Hayem's fluid), red cell pipette, and counting chamber (haemocytometer, improved Neubauer type). The red cell pipette with graduation mark (0.5) on the capillary stem below and 101 above the bulb, with a red bean inside the pipette, was cleared and dried. The blood was sucked up to the 0.5 mark, and immediately Hayem's diluting fluid was administered for one minute. The counting chamber and coverslip were dried and cleaned with cotton wool. The coverslip was placed on the counting chamber to fit in. The first few drops of the fluid from the pipette were discarded, and the tip of the pipette was brought in contact with the exposed part of the chamber so as to allow fluid under the cover slip. The cells were allowed to settle for 3 minutes, and the cells in the 5-central square of the chamber were counted under an x40 objective of the light microscope. The number of red cells counted was multiplied by ten (10.000) thousand to give the number of red cells in million per cubic millimetre (or X10/µl) or x1012/L.

Determination of White Blood Cell (WBC)

The white blood cells were counted using a haemocytometer (improved Neubauer type) as described by Schalm *et al.* (1975). A leucocyte diluting fluid pipette was used to draw blood exactly to the 0.5 mark, the tip of the pipette was wiped free of excess blood and then used to draw in the leucocyte diluting fluid (Turk's solution) to mark 11. The pipette was shaken thoroughly to mix well and then allowed to stay for 3 minutes. Three (3) drops of the fluid were discarded from the pipette, and the tip of the pipette was brought close to the chamber. The next drop fell near the coverslip, and the chamber was filled due to capillary action. The counting chamber was allowed for one minute before counting using the x40 objective of the light microscope. The cells in the four corners square were counted, considering those cells inside the squares and from two sides. The number of cells counted was multiplied by 50 to give the total number as cells per cubic millimetre (or x10%µl).

Body condition score

The body condition score was determined by palpation to estimate the muscle and fats covers in the lumbar and sternal region and was classified as emaciated (1), thin (2), average (3), fat (4), and obese (5), according to the methods of Russel (1984) and Villaquiran *et al.* (2007).

Data analysis

Data collected were analysed using descriptive statistics and 95% confidence interval of prevalence with JMP Version 16 (SAS, 2021).

RESULTS AND DISCUSSION

The demographic analysis (Table 1) reveals critical structural challenges in livestock farming, highlighting the sector's vulnerability and potential for targeted interventions. The age composition showed, with 87.6% of farmers above 30 years, suggests an ageing agricultural workforce, a trend corroborated by global studies. A systematic review by Läpple and Kelley (2015) emphasises how farmer age significantly correlates with technology adoption and innovation receptiveness.

The educational profile has nuanced implications for agricultural development. With 25.6% lacking formal education and only 18.2% achieving tertiary qualifications, there is a significant skill gap. Zeweld *et al.* (2017) demonstrate that educational attainment directly influences farmers' adaptive capacity, technological integration, and risk management strategies. This highlights the need for targeted capacity-building programmes and accessible agricultural extension services. Similar research reports that human employment status is another known factor associated with increasing the occurrence of infections in urban areas, such as among veterinarians, slaughterhouse workers, butchers, farmworkers, zookeepers, and others (Paiba *et al.*, 1999; Kassa, 2021).

The economic centrality of livestock farming, constituting 66.9% of primary income, underscores its critical role in rural livelihoods. A comparative study by Steinfeld *et al.* (2006) highlights how livestock represents not just an economic activity but a crucial risk mitigation strategy for smallholder farmers in developing economies.

Veterinary service access emerges as a significant constraint, with only 26.4% experiencing regular professional engagement. This limited interaction potentially exacerbates disease management challenges. A comprehensive study by Perry *et al.* (1999) emphasises how inadequate veterinary infrastructure compromises animal health, productivity, and broader agricultural resilience.

The cooperative membership rate of 29.8% indicates limited collective organisational capacity. Bijman (2016) demonstrates that cooperative membership can significantly enhance market access, knowledge sharing,

Table 1. Socio-demographic characteristics of ruminant livestock farmers in the study area

Variable	Category	Frequency (n)	Percentage (%)
Farm activity	Breeding	100	82.6
	Fattening	11	9.1
	Both	10	8.3
Flock size	1-25	26	21.5
	26-50	63	52.1
	51-75	23	19
	76-100	8	6.6
	>100	1	0.8
Age	<30 years	15	12.4
	30-45 years	47	38.8
	>45 years	59	48.8
Education	No Formal Education	31	25.6
	Primary Education	39	32.2
	Secondary Education	29	24
	Tertiary Education	22	18.2
Primary Income Source	Livestock Farming	81	66.9
	Crop Farming	29	24
	Other (e.g., trade, labor)	11	9.1
Veterinary Services	Regular Access	32	26.4
	Occasional Access	61	50.4
	No Access	28	23.1
Frequency of Vet Visits	Weekly	11	9.1
	Monthly	42	34.7
	Rarely	68	56.2
Cooperative Membership	Yes	36	29.8
	No	85	70.2
Challenges	Disease Outbreaks	79	65.3
	Limited Veterinary Services	51	42.1
	Market Access Issues	45	37.2
	High Feed Costs	63	52.1
	Limited Capital	48	39.7

and negotiating power for smallholder farmers.

Challenges confronting livestock farmers are multifaceted. Disease outbreaks (65.3%) represent the most pressing concern, aligning with global observations of increasing livestock disease vulnerabilities. A WOAH report highlights the escalating economic and public health risks associated with endemic and emerging livestock diseases (Nadeem *et al.,* 2010).

Feed cost affordability (52.1%) reflects broader agricultural sustainability issues. It was observed that there are complex interactions between feed costs, livestock productivity, and environmental sustainability (Herrero *et al.,* 2013).

Capital constraints (39.7%) further compound farmers' challenges, necessitating innovative financial inclusion strategies. A World Bank study by Deininger and Xia (2016) emphasises how targeted financial interventions can transform smallholder agricultural productivity.

Contagious ecthyma disease

The survey (Table 2) reveals critical understandings into the epidemiology and economic implications of contagious ecthyma in livestock farming systems. With 97.8% awareness among farmers, the disease represents a significant concern in the studied region. The finding is in accord with that of Scagliarini *et al.* (2012) in South Africa and Bala *et al.* (2019) in Malaysia.

Geographic distribution demonstrates a concentration in Maiduguri Metropolis (41.3%), suggesting potential localised environmental or management factors influencing disease prevalence. This spatial clustering warrants further epidemiological investigation, as highlighted by Nandi *et al.* (2011) in their comparative study of viral diseases in small ruminants.

Breeding-dominant farms (82.6%) with moderate herd sizes (52.1% between 26 – 50 animals) characterise the

Table 2. Awareness of contagious ecthyma disease virus of sheep and goats among farmers in the study area.

Survey Questions	Description	Frequency	Percentage
Location of the Farm	Bade	11	9.1
	Damaturu	12	9.9
	Fika91	11	9.1
	Jakusko	12	9.9
	Maiduguri Metropolis	50	41.3
	Potiskum	13	10.7
	Tarmuwa	12	9.9
Farm activity	Breeding	100	82.6
	Fattening	11	9.1
	Both	10	8.3
Farm size	1-25	26	21.5
	26-50	63	52.1
	51-75	23	19.0
	76-100	8	6.6
	Greater 100	1	0.8
Animal identification	Yes	12	9.9
	No	109	90.1
New stock	Yes	66	54.5
	No	55	45.5
Presence of injurious weed	Yes	70	57.9
	No	51	42.1
History of viral diseases	Yes	116	95.9
	No	5	4.1
Awareness of CE	Yes	118	97.8
	No	3	2.5
Age group affected	Young	12	9.9
	Adult	30	24.8
	All age group	64	52.9
Sex group affected	Male	14	11.6
	Female	25	20.7
	All sex group	82	67.8
CE affect Milk	Yes	94	77.7
	No	27	22.3
Spontaneous recovery and reoccurrence	Yes	101	83.5
	No	20	16.5
Duration of recovery	2 weeks	20	16.5
	3 weeks	34	28.1
	Greater than 3 weeks	39	32.2
	Not stated	26	21.5
Previous vaccine	Yes	0	0
	No	121	100
Zoonotic potential of Orf	Yes	0	0
	No	121	100

livestock production structure. The absence of systematic animal identification (90.1% no identification) represents a critical gap in disease tracking and management, potentially compromising early detection and intervention strategies. This study is in contrast with the findings of Bala *et al.* (2019), which reported a high percentage of animal identification (84.6%) among small ruminant peasant farmers in Malaysia.

The high spontaneous recovery rate (83.5%) is noteworthy, with recovery durations predominantly ranging

Table 3. Awareness and compliance of herd health management among farmers in the study area.

Description	Respond	Frequency	Percentage
knowledge of HH	YES	5	4.1
	NO	116	95.9
Practice of HH	YES	5	4.1
	NO	116	95.9
Housing	YES	5	4.1
	NO	116	95.9
Feeding management	YES	4	3.3
	NO	117	96.7
Deworming/Deticking	YES	116	95.9
	NO	5	4.1
Vaccination	YES	69	57.0
	NO	52	42.9
Biosecurity	YES	5	4.1
	NO	116	95.9
Waste disposal	YES	111	91.7
	NO	10	8.30
Fly/odor control	YES	9	7.4
	NO	112	92.6
Milking management	YES	0	0
	NO	121	100
Lamb/kid management	YES	116	95.9
	NO	5	4.1
Doe/ewe management	YES	117	96.7
	NO	4	3.3
Drug management	YES	105	86.8
	NO	16	13.2
Diseases monitoring	YES	4	3.3
	NO	117	96.7

from 2 – 3+ weeks. This aligns with veterinary research by Babiuk *et al.* (2008) and Onyango *et al.* (2014), which emphasises the self-limiting nature of CE while highlighting potential economic implications during recovery periods. In spite of its self-limiting CE demonstrate huge welfare and economic impact on various aspects of small ruminants' production (Scagliarini *et al.*, 2012; Adedeji *et al.*, 2017; Lawan *et al.*, 2021).

Milk production impact (77.7%) underscores the economic significance of CE. A study by Haas *et al.* (2019) estimates that such production disruptions can translate to substantial economic losses for smallholder farmers.

The complete absence of vaccination (100% unvaccinated) represents a critical public health and agricultural management concern. Currently, there is no vaccine for the Orf virus in Nigeria (Adedeji *et al.*, 2017). Comparative studies by Kitching and Smale (1985) demonstrate that targeted vaccination programs can significantly mitigate disease spread and economic losses. Lawan *et al.* (2021) emphasise that Vaccination against the contagious ecthyma virus infection is paramount. The farmers are not aware that the Orf virus is communicable to humans (100%) following an occupational exposure with infected animals or feeding troughs, so the complete absence of awareness of the zoonotic potential of contagious ecthyma among farmers in the study area might be due to a lack of awareness as a result of poor veterinary and extension services. In humans, the lesions often manifest on the exposed parts of the skin that often contact animals, especially the hands, fingers, and forearms (Spickler, 2023). The high prevalence in newly introduced stock (54.5%) and injurious weeds (57.9%) suggests additional risk factors for disease transmission and animal health.

Herd health management

The survey (Table 3) reveals profound gaps in comprehensive herd health management practices among livestock farmers. With a staggering 95.9% reporting no knowledge of herd health management, the findings underscore significant systemic challenges in agricultural livestock care.

Table 4. Body condition scoring and blood parameters of sheep and goat infected with Orf in the study area.

Parameter	Sheep (n =7)			Goat (n =5)		
	Result (Mean ± SD)	Reference value/range (RV)	No. of cases lower (L) and/or higher (H) than RV	Result (Mean ± SD)	Reference value/ range (RV)	No. of cases lower (L) and/or higher (H) than RV
BCS	1.7 ±0.5	1.9	2 L	1.4 ±0.6	1.9	3 L
PCV (%)	23.0 ±3.3↓	27 -45	7 L	18.8 ±5.9	22 -38	3L
HB (g/dL)	7.4 ±1.7↓	9 -15	6 L	6.3 ±1.9	8 -12	4 L
RBC (x 10^6/μL)	6.7 ±1.8↓	9 -15	6 L	9.9 ±5.2	8 -18	2 L; 1 H
WBC (x 10^3/μL)	9.3 ±2.8↑	4 -12	1 H	10.1 ±3.9↑	4 -13	1 H

Means with superscript (↓) and (↑) are higher and lower than the lower point of the reference range, respectively.

Paradoxically, farmers demonstrate selective management competencies. While 95.9% engage in lamb/kid and doe/ewe management, and 86.8% manage drug protocols, critical areas like disease monitoring (3.3%), feeding management (3.3%), and housing management (4.1%) show minimal attention.

Vaccination practices present a nuanced picture, with a 57% higher percentage participating in vaccination programs. This moderate engagement suggests partial awareness of preventive healthcare, contrasting sharply with the complete neglect of milking management (0% compliance). So far, there is no Orf vaccine in the study area and in Nigeria as a whole.

Positive indicators include robust waste disposal practices (91.7%) and deworming/deticking efforts (95.9%), indicating targeted interventions in specific health domains. Effective herd health management is a proactive strategy to prevent disease outbreaks and limit their spread, thereby minimising economic losses for farmers (Bala *et al.*, 2019).

Haematological dynamics in Orf-infected sheep and goats

While the mean values of red cell parameters (PCV, Hb and RBC) were significantly ($p<0.05$) below the lower point of the established reference range (Latimer, 2011; Stayt, 2022) in the sheep, they remained comparable to the established reference range in the goat (Table 4). The mean WBC value was significantly higher than the established reference range (although still within the RV) in both species. The mean body condition score (BCS) was comparable ($p>0.05$) in both species to the average of already reported values (ARV) in the local population of small ruminants (Ma'aruf *et al.*, 2021). The individual values of PCV, HB and RBC were lower than the established reference range in 3 out of the 7 sheep. In the goats, 3 out of 5 animals had similar results. As for individual WBC values, one case each for sheep and goat had higher values than the upper point of the RV. Individual BCS were lower than the ARV for 2 out of 7 sheep and 3 out of 5 goats.

The implication/interpretation of the above findings may be associated with an apparent physical bodily change (BCS) and a decline in the haematological values, which are hallmarks of the health status of an animal. Haematological parameters exhibit notable variations across species and age groups. The PCV ranges from 11 – 27%, indicating potential anaemia and systemic stress. A comparative study by Radostits *et al.* (2007) emphasises how viral infections can substantially disrupt erythropoietic processes, potentially compromising animal health and economic productivity.

Species-specific differences emerge prominently. Ovine subjects demonstrated more consistent haematological parameters, while caprine subjects exhibited greater metabolic variability. This observation underscores the importance of species-specific diagnostic and treatment protocols. Research by Kazemi Asl *et al.* (2018), Baraya *et al.* (2022) and Hussain *et al.* (2022) indicates a profound increase in WBC, neutrophils, lymphocytes, monocytes, PCV, leukocytosis and haemoglobin concentration, citing polycythemia due to dehydration. In another finding by Kumar *et al.* (2022), reported that there is a slight increase in haemoglobin concentration and leucocytosis during Orf virus disease. Their findings significantly tally with the findings of this research.

Respondents' sales strategy

Table 5 presents the distribution of respondents based on Orf disease management decisions. The results indicate that 36% of farmers incurred financial losses by selling at reduced prices or losing animals to disease.

Table 5. Sales distribution by disease management strategy.

Management Decision	Frequency	Percentage (%)
Sold Without Treatment	24	20
Sold After Treatment	19	16
Retained Healthy Animals	53	44
Suffered Direct Losses	12	10
Infected animal slaughtered and meat sold	13	10
Total	**121**	**100**

The results indicate that 36% of farmers incurred financial losses by selling at reduced prices or losing animals to disease.

Table 6. Economic Impact Analysis of Orf Disease (Regression Analysis).

Variable	Coefficient (B)	t-value	p-value
Exposure to Orf Disease	44.92	8.53	<0.001
Estimated Morbidity	3.46	2.27	0.026
Estimated Mortality	48.52	13.88	<0.001
Animals Affected	4.52	3.66	<0.001

Adjusted $R^2 = 0.859$** F-statistic = 146.5** ($p < 0.00$).

Survey data

About 46% of respondents reported experiencing Orf infection in their flocks. Among them, 20% sold infected animals without treatment, receiving approximately 80% less than the normal market price, while 16% sold animals after treatment and were able to recover about 60% of the market value. Additionally, 10% sold the slaughtered meat of infected animals, earning roughly 40% of the market value. The data analysed in this study included total flock size per respondent, market prices of livestock (healthy, treated, and untreated), as well as treatment and feeding costs.

Gross margin

Farmers who sold without treatment had the lowest gross margin, averaging NGN 150,000 per respondent. Those who sold after treatment improved revenue but incurred higher costs, yielding an average gross margin of NGN 280,000**.** Healthy animals yielded the highest gross margin (above NGN 400,000), reinforcing the importance of disease prevention.

Economic losses

A regression model was estimated to quantify the impact of Orf disease exposure on economic losses: $Li=\beta_0+\beta_1M_i+\beta_2T_i+\beta_3U_i+\varepsilon_i$, where: L_i = Economic loss for respondent, M_i = Number of mortality cases, T_i = Number of treated animals sold, and U_i = Number of untreated animals sold. Regression results indicate mortality (p<0.001) as the most significant economic loss driver**,** followed by untreated sales (p = 0.026).

The regression model reveals statistically significant predictors of economic losses associated with Orf disease, demonstrating robust explanatory power (Adjusted R^2 = 0.859). This high model fit suggests that the selected variables comprehensively capture the economic dimensions of disease impact.

Mortality emerges as the most economically consequential factor, with the highest coefficient (B = 48.52, p<0.001). This finding aligns with veterinary epidemiological research indicating that animal deaths represent the most substantial financial burden in livestock disease outbreaks. The statistically significant t-value (13.88) underscores the reliability of this relationship.

Disease exposure itself generates considerable economic losses (B = 44.92, p<0.001). Suggesting that mere exposure to disease triggers substantial financial implications beyond direct mortality, and highlights the preventive value of early intervention and biosecurity measures (Smith *et al.,* 2019; Subasinghe *et al.,* 2023).

Morbidity (B = 3.46, p = 0.026) and the number of animals affected (B = 4.52, p<0.001) contribute incrementally to economic losses. While less impactful than mortality, these factors compound the overall economic burden, emphasising the importance of comprehensive disease management strategies.

The model's statistical significance (F-statistic = 146.5, p<0.001) provides strong empirical evidence for understanding the multifaceted economic consequences of Orf disease in livestock systems.

The research uncovers a huge financial burden associated with losses of lambs and kids, yearlings, infertility, mastitis, reduced milk production, devaluation of meat, leather and wool and finally the cost of treatment among farmers in the study area. This might not be unconnected with the nature of the farming system, characterised by a lack of biosecurity and herd health management. Hajkazemi *et al.* (2016) reported that contagious ecthyma is among the 20 viral diseases of sheep and goats that increase poverty, and the socio-economic damage associated with the disease is estimated to be less than the actual amount. the most important reason is underreporting (Hajkazemi *et al.,* 2016; Lawan *et al.*, 2021). The vaccination, even though it offers a temporary and short period of immunity, is the cornerstone in the control of Contagious ecthyma virus infection in sheep and goats and by extension in the prevention of occupational hazards to humans.

Nigeria's small ruminant resources include 47,926,000 and 84,039,000 heads of sheep and goats, respectively (Nasiru *et al.*, 2021). About 25% of the sheep and the sheep and goat population is located in the Northeastern Nigeria (Mustapha *et al.*, 2024). The role of small ruminants in meeting the social and economic needs of farmers in Nigeria cannot be overemphasised (Ahmed and Egwu, 2014; Dossa *et al.*, 2015; Mustapha *et al.*, 2024). This is closely connected to the various roles these animals play in providing relief, especially during production shortfalls or unexpected contingencies, such as ill health, changes in government policies, and so on. It is widely recognised that these animals are the simplest and most easily accessible way to cope with shocks (Ahmed and Egwu, 2014; Dossa *et al.*, 2015; Mustapha *et al.*, 2024).

Limitation of the study

A key limitation of this study is the small sample size (n=12) for the haematological analysis, which constrains the statistical power and generalizability of these findings. This was a consequence of the field-based nature of the study and the challenge of systematically recruiting a large number of clinically infected animals at the time of the survey. Future studies should prioritise prospective designs with larger clinical cohorts to validate these haematological changes.

Conclusions

This study reveals critical insights into small-scale ruminant farming in the study area, highlighting its prominence as a primary income source for most farmers, despite being a neglected sector. The findings underscore the limited awareness among farmers regarding the epidemiology and risk factors associated with contagious ecthyma virus (Orf virus) infection in small ruminants. Additionally, farmers lack understanding of the occupational hazards posed by this zoonotic disease and the importance of herd health management in optimising production and preventing disease outbreaks. The absence of an effective vaccine for contagious ecthyma virus infection exacerbates its chronic impact, leading to compromised body condition scores, altered haematological parameters, and significant welfare and economic losses for small ruminants in the region. These findings emphasise the urgent need for targeted interventions to mitigate the disease's adverse effects on livestock health and livelihoods.

Recommendation

To address these challenges and improve the sustainability of small-scale ruminant farming, the following measures are recommended:

1. Enhance the delivery of extension services to provide farmers with accessible and practical guidance.
2. Implement educational programs focusing on herd health management practices for small ruminants.
3. Raise awareness among farmers about the epidemiology and zoonotic risks of contagious ecthyma virus infection.
4. Prioritise the development and deployment of heat-stable vaccines that offer long-lasting immunity against contagious.ecthyma virus.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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