

Knowledge and Attitudes of Farmers Towards Thermal Stress Management in Cattle

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Abstract

The study aimed to examine farmers' knowledge and attitudes towards thermal stress management in cattle. The study was conducted in the cattle corridor of Uganda using a cross-sectional, simultaneous mixed design. Questionnaires and key informant interviews were used. Veterinary officers, purposively sampled, and 481 cattle farmers, randomly sampled, participated in the study. STATA/SE Version 18 and thematic analysis were used to analyse data. Descriptive statistics were used to present findings. A multivariable logistic regression indicated that district of origin, being an internet user, having a positive attitude, and good knowledge of thermal stress had a significant influence ($p < 0.001$) on thermal stress management. Veterinarians noted that thermal stress management was not given priority during the farmers' training. The study findings should support the development of targeted extension initiatives, policy changes, and climate-resilient management techniques. The study sought to enhance farm systems theory by providing evidence that human behavioural components are central sub-systems that determine animal welfare outcomes. This study is distinct because it shifts attention to the human dimension of adaptation, which remains empirically understudied in many developing countries.

Keywords: feed, heat stress, perception, season, water

1. Introduction

Uganda is an agricultural country in which livestock, such as cattle, contribute a major proportion of the sector's enterprise. According to the Uganda Bureau of Statistics (2024), 72.8% of the estimated 9.3 million households keep livestock, of which 24.1% specifically rear cattle. One of the primary issues influencing the productivity, well-being, and health of dairy cattle is the rising temperatures, which have led to major changes in the dairy production industry in recent years (Talbi & Maklouf, 2025). Management of thermal stress is key to improving the productive and reproductive efficiency in cattle in the hot, humid tropics. Likewise, efficient assessment and management of thermal stress are required to mitigate the decline in cattle fertility (Sammad et al., 2020). An assessment of the symptoms of thermal stress and taking appropriate measures before the productive and reproductive efficiencies are negatively affected is a prerequisite for successful cattle production. The use of fans, misters, an optimal shed structure, and ventilation has been identified as effective in mitigating the effects of thermal stress (Ji et al., 2020). However, pastoral farmers in the tropics do not deliberately manage thermal stress. Management practices such as using cattle sheds and providing animals with access to drinking water can help mitigate the effects of thermal stress. Unless such practices are deliberately focused on managing thermal stress, they will still fall short of the required standards. While it is unarguable that extensive systems have numerous advantages for animal welfare, they are certainly not free from welfare issues such as thermal stress. This could be a result of the widespread perception that extensive systems are better for animal welfare (Alemayehu et al., 2020).

An individual's attitudes and experiences can affect how they improve animal welfare. Therefore, it is essential to have a thorough understanding of animal welfare knowledge and attitudes among livestock owners (Alemayehu et al., 2020). In a study conducted in South Africa by Katiyatiya et al. (2014), it was revealed that

57% of the farmers believed that heat stress caused excessive panting in cattle, whereas 48% and 46% said that weight loss and decreased milk output, respectively, had also occurred in cattle due to thermal stress. In the same study, about 70% of the farmers who raised cattle reported that heat stress reduced feed intake and caused animal deaths. Reduced breeding efficiency, which was cited by 26.42% of the farmers as an effect of heat stress, was the least understood. A convenience sample of Americans' opinions revealed that indoor systems without fans and pasture without shade had the least desirable results for animal rearing methods. However, attitudes were more favourable for indoor housing with fans than for pasture without shade (Cardoso et al., 2018). The majority of respondents in a study conducted in India believed that climate change, such as heat waves, negatively affected the productivity and reproductive performance of livestock. Additionally, they supposed that the occurrence of livestock diseases and parasite infestation, and the trend toward decreasing feed and fodder resources and water, were all results of climate change (Singh et al., 2012). In Tanzania, a study conducted by Chinta et al. (2020) revealed that 52.36% of the farmers concurred that extreme heat stress resulted in abortions and the retention of the placenta in dairy animals. Additionally, 46.46% noted an increase in the animal's respiration rate. Also, 59.45% opined that buffaloes were more impacted by heat stress than cattle. The study further noted that crossbred cattle produced less milk while under thermal stress, followed by buffalo and native cattle.

The results of a study conducted in Jordan by Al-dawood (2020) found that 52.4% of the participants had neither heard about nor known what heat stress was. Approximately 25% of the respondents reported familiarity with the concepts and techniques of heat stress. Only 9.52% of the respondents reported routinely managing the exposure of animals to heat. About 46% of people had heard of misting systems, compared to 3.2% of farmers who had heard of fogging systems. Diniso (2021) noted that 92.5% of farmers in the Eastern Cape Province of South Africa reported that climate change had an impact on dairy output. Further noted was that climate change restricted dairy cow productivity (69.8%), and that dairy cows consumed less dry matter in increased temperatures (75.5%). Climate change in the tropics is mainly characterised by increasing ambient temperature, commonly referred to as global warming. This phenomenon exacerbates thermal stress in livestock, including cattle. A study conducted by Dhakal et al. (2013) in Nepal revealed that farmers' perceptions of climate change in the study area were consistent with findings from other studies worldwide. A scientific investigation in Tunisia by Amamou et al. (2018) revealed that all farmers believed that there were climate change-related challenges in dairy farming. The greatest of the challenges were the direct effects of heat waves on milk output and fertility, as well as the indirect effects of feed availability and cost.

Hendricks et al. (2022) noted that the solutions for reducing heat stress that entail pasture access, such as one where cows are given the option to select between pasture or a shaded barn, were perceived more favourably by Australian participants. Fewer people supported the use of gene editing and pasture or zero-grazing (indoor) systems to protect dairy cattle from heat stress. The ability of the farm system to give cows access to pasture, allow them freedom of movement and choice, and match their natural living environment was valued by participants. In the assessment of cattle welfare on Ghanaian farms, Wuntimah et al. (2021) discovered that 95% farmers prioritised freedom from hunger, malnutrition, and thirst and gave less importance to freedom from physical and thermal pain (50%). Although confinement in enclosed spaces contributes to increased thermal stress, farmers do not give attention to its management in intensive cattle production systems. It is vital to note that Ghana is located in a low latitude area with relatively high temperatures and relative humidity that expose cattle to a threat of thermal stress. In the western Lake Tana and upper Beles watersheds of northwest Ethiopia, it was found that the frequency of extension services had a significant impact on the decision to adopt crop management adaptation solutions to climate change (Takele et al., 2019). The same practice would be recommended for livestock production enterprises.

The level of farm management abilities was found to be highly influenced by socioeconomic factors, including gender, educational attainment, experience in the enterprise, farm size, number of people employed, ownership status, training status, and financial support (Rashamol et al., 2018). A participant's ability, willingness and decision to change their practice were typically influenced by several factors, including the training program (Masta, 2022). A study conducted in the Bawku West District of Ghana found that farm household decisions to adopt agricultural technology depended on their socioeconomic situation and institutional efficiency (Abunga et al., 2012). In India, the adoption of ICT-based information systems was significantly influenced by sociodemographic factors such as education, income, and farmers' social category (Ali, 2012).

In the tropics and subtropics, with rising temperatures due to global warming, knowledge of thermal stress will be a critical need for livestock owners. It is possible to support farmers' efforts and provide interventions that are better suited to the local context by learning about their perspectives on climate change and adaptation strategies

(Balasha et al., 2023). This study was conducted in the prominent cattle-producing area of Uganda, well known as the cattle corridor for its concentration of livestock production, mainly cattle. While aspects regarding interventions for thermal stress management have been widely studied, they should be aligned with the factors associated with the adoption and application of the practices. Surprisingly, it is a common practice in developing countries for several life-changing innovations to stall at the innovator and or inventor due to financial and infrastructural constraints (Quinn & Cameron, 2013). Thus, understanding the factors can enhance the uptake of interventions to address thermal stress to improve production and productivity is a worthwhile undertaking. Therefore, this study aimed to establish the knowledge and attitudes of farmers towards thermal stress in cattle in Uganda's cattle corridor.

This study was hinged on the Farm-system Theory as propounded by John L. Dillon in 1992. This theory conceptualises the farm as a purposeful system. The theory is a method of looking at the farm, and offers a list of things that management should be concerned about (McConnell & Dillon, 1997). To improve management, solve problems, and promote sustainable development, farm-system theory views a farm as a complex, interlinked system of parts interacting with external social, economic, and environmental influences. The close physical link between the climatic suprasystem and the farm's technical system makes it crucial for almost all farm systems. The impact of global climate change on markets and international trade might also be substantial at the macro level, as it will affect production and productivity in agricultural enterprises. A study on the knowledge and attitudes of farmers towards thermal stress aligns with the farm-system theory by treating the farm as a holistic, purposeful, and adaptive system rather than merely a collection of inputs and outputs. This alignment occurs because such studies integrate the human element (management/knowledge) with biophysical, environmental, and socio-economic components, acknowledging that farmers are central decision-makers responding to environmental change. Farmers' knowledge and attitudes are part of the technical and human subsystem that illustrate how knowledge gaps may lead to poor thermal stress management decisions. The researcher can methodically investigate the factors that influence thermal stress management behaviour and suggest context-sensitive interventions. Such an approach should improve the resilience and sustainability of cattle production systems by grounding the study in the Farm-System Theory.

2. Materials and Methods

2.1 Study Area

The study was conducted in Uganda's cattle corridor. The cattle corridor is a semi-arid stretch of land that constitutes about 35% of Uganda's land area (Hasahya et al., 2023) and is home to about 90% of the national cattle herd (Nanfuka et al., 2020; Owoyesigire et al., 2016).

2.2 Study Design

The study employed a parallel mixed (quantitative-qualitative) cross-sectional explanatory survey design to investigate multifaceted explorations and on-farm factors associated with the management of thermal stress by cattle farmers.

2.3 Sample Size and Sampling Strategy

2.3.1 Quantitative

Using the number of cattle-rearing households in the cattle corridor as 115,490 (Uganda Bureau of Statistics [UBOS] & Ministry of Agriculture, Animal Industry and Fisheries [MAAIF], 2009), the sample size was determined using the Krejcie and Morgan (1970) formula (Uakarn, 2021) as follows:

$$n = \frac{X^2 N p (1 - p)}{e^2 (N - 1) + X^2 p (1 - p)} \quad (1)$$

where, n = sample size; N = population size; e = acceptable sampling error ($e = 0.05$); X^2 = Chi square, $df = 1$ and reliability level 95% ($X^2 = 3.841$); and p = population proportion (Assumed to be 0.5).

Hence, $n = \frac{3.841 \times 115490 \times 0.5(1 - 0.5)}{0.05^2(115490 - 1) + 3.841 \times 0.5(1 - 0.5)}$, thus $n = 382.8$.

The proportionate by size method was used to determine the number of participants from Kotido, Lira and Soroti. Due to population variability and the need to increase statistical power, quantitative data were collected from 481 participants.

The participants were selected using systematic random sampling after obtaining the sampling frame from the district/city/municipal production of officers in the selected areas.

2.3.2 Qualitative

Qualitative data were collected from veterinary officers as key informants through interviews. The number of respondents selected was determined by the principle of data saturation (Braun & Clarke, 2006). Seven (07) key informants participated in the study and were sufficient to reveal the metathemes (Guest et al., 2006).

2.4 Variables and Measurement

Farmers' knowledge of and attitude towards thermal stress management were the independent (predictor) variables, while thermal stress management practices and socio-demographic factors (location of the farm, marital status, age, type of phone used, gender, level of education, being an internet user, years of experience in cattle production and monthly income) were the dependent (outcome) variables.

Thermal stress management practices were measured using five structured questionnaire items (statements) with 'Yes' and 'No' response options; a 'Yes' response scored 1, while a 'No' response scored 0. A score of ≥ 3 indicated good thermal stress management practices, while a score < 3 indicated poor practices.

Knowledge about thermal stress was measured using 10 structured questionnaire items. Each question had three possible responses, coded 1 to 3, where 1 represented 'Yes', 2 represented 'No', and 3 represented 'Not sure'. A value of 1 indicated good knowledge, 2 indicated a lack of knowledge, while 3 indicated no position as regards the indicators of thermal stress in cattle. An average score of 1 indicated that the farmer had a good understanding of thermal stress; thus, a total score of ≤ 15 for all the items denoted good knowledge.

The attitude towards thermal stress was measured using eight Likert-scale questionnaire statements that assessed farmers' perceptions, beliefs and willingness to adopt management practices. The respondents rated their level of agreement with each of the statements on a 5-point scale: 1 = strongly agree, 2 = agree, 3 = neutral, 4 = disagree and 5 = strongly disagree. The lowest total score was 8, indicating a highly positive attitude, and 40, indicating a highly negative attitude. A total score of ≥ 24 indicated a poor attitude.

2.5 Data Analysis

The data from questionnaires were analysed using multivariable logistic regression to estimate the probabilities for categorical outcomes. Qualitative data from the key informant interviews were analysed using thematic analysis. Major themes (patterns) and subthemes from the interview surveys among veterinarians were identified, analysed, interpreted, presented and discussed using Braun and Clarke's framework (Braun & Clarke, 2006).

3. Results

3.1 Demographic Characteristics of the Respondents

Respondents from Kotido were significantly less likely to have good thermal stress management practices compared to those from Soroti ($p < 0.001$). Having a smartphone, being an internet user, and earning a monthly income above UGX 720 001 significantly influenced thermal stress management. The findings of this study indicated that farmers with income below UGX 360 000 (US\$99.02) had better thermal stress management practices than those earning the amount or above. The quality of thermal stress management reduced as one moved higher in the socio-economic rating.

Table 1. Demographic characteristics of the respondents

Variable	Frequency (%)	Thermal stress management		COR(CI)	p-value
		Good	Poor		
<i>District</i>					
Soroti	177(36.95)	17(9.6)	160(90.4)	Ref	
Lira	208(43.42)	67(32.2)	141(67.8)	0.42(0.12-1.28)	0.127
Kotido	94(19.62)	4(4.3)	90(95.7)	0.09(0.03-0.27)	<0.001
<i>Marital status</i>					
Married	447(93.32)	362(80.98)	85(19.02)	Ref	
Single	19(3.97)	16(84.21)	3(15.79)	0.798(0.22-2.80)	0.725
Widowed	13(2.71)	13(100)	0(0.00)	0	
<i>Age (Mean = 45.44, SD = 14.77)</i>					
18-24	35(8.56)	28(80)	7(20)	Ref	
25-54	265(64.79)	232(87.55)	33(12.45)	0.56(0.23-1.40)	0.222
55-64	63(15.40)	49(77.78)	14(22.22)	1.14(0.41-3.166)	0.797
Above 64	46(11.25)	38(82.61)	8(17.39)	0.84(0.27-2.59)	0.765
<i>Type of phone</i>					
Smartphone	45(9.39)	36(80)	9(20)	Ref	
Feature phone	345(71.61)	271(79.01)	72(20.99)	1.06(0.489-2.307)	0.878
No phone	91(19.00)	84(92.31)	7(7.69)	0.33(0.115-0.964)	0.043
<i>Internet user</i>					
Yes	84(17.54)	50(59.52)	34(40.48)	Ref	
No	394(82.46)	341(86.33)	54(13.67)	0.232(0.138-0.392)	< 0.001
<i>Gender</i>					
Male	392(81.84)	321(81.89)	71(18.11)	Ref	
Female	87(18.16)	70(80.63)	17(19.54)	1.097(0.609-1.978)	0.756
<i>Level of education</i>					
Primary	256(53.44)	202(78.91)	54(21.09)	Ref	
Secondary	69(14.41)	52(75.36)	17(24.64)	1.222(0.654-2.283)	0.528
Tertiary	43(8.98)	37(86.05)	6(13.95)	0.606(0.243-1.512)	0.283
None	111(23.17)	100(90.9)	11(9.91)	0.411(0.206-0.821)	0.012
<i>Years of experience in cattle production (Mean = 17.88, SD = 14.19)</i>					
Less than 5	109(22.76)	88(80.73)	21(19.27)	Ref	
6 to 10 years	86(17.95)	66(76.74)	20(23.26)	1.269(0.636-2.533)	0.498
11 to 20 years	150(31.32)	123(82.07)	27(18.00)	0.919(0.488-1.731)	0.796
More than 20	134(27.97)	114(85.07)	20(14.93)	0.735(0.375-1.440)	0.370
<i>Monthly income (Mean UGX = 185,976.9, SD = 427,096.3)</i>					
≤ 360,000	424(90.79)	351 (82.78)	73(17.22)	Ref	
360,001-720,000	35(7.49)	28(80.00)	7(20.00)	1.2(0.505-2.85)	0.677
≥ 720,001	8(1.72)	12(60)	8(40)	3.2(1.26-8.11)	0.014
<i>Overall knowledge of thermal stress management in cattle</i>					
Good knowledge	203(42.38)	155(76.35)	48(23.65)	Ref	
Poor knowledge	276(57.62)	236(85.51)	40(14.49)	0.547(0.34-0.87)	0.011
<i>Overall attitude towards thermal stress management</i>					
Negative attitude	153(31.94)	127(83.01)	26(16.99)	Ref	
Positive attitude	213(44.47)	167(78.40)	46(21)	6.24(2.26-17.27)	<0.001

Note. COR = crude odds Ratio; CI = confidence interval; SD = standard deviation; p = probability.

3.2 Farmers' Knowledge of Thermal Stress in Cattle

The majority of respondents (90.19%) reported that cattle sought shade when experiencing thermal stress. Also, 49.06% of respondents noted that cattle did not breathe normally while under thermal stress. A substantial

number (66.6%) observed that cattle panted when stressed, and 70.77% stated that cattle produced a lot of saliva. This implies that the respondents did not have a complete understanding of thermal stress, as the frequencies and the proportions varied significantly across items. There was uncertainty about the need for insemination during hot weather, with 41.34% respondents being unsure. Respondents had also noted behavioural changes in cattle related to thermal stress. As such, 58.46% said cattle spent more time lying down, and 64.93% observed that cattle refused to graze when experiencing thermal stress. A proportion of respondents (39.04%) did not attest to the possibility of thermal stress even at low temperatures. Furthermore, 80.58% noted that milk production was affected by thermal stress. A proportion of the respondents (68.48%) reported that cattle grouped during thermal stress.

Table 2. Knowledge of farmers about thermal stress

Variable	Frequency (n)	Percentage (%)
<i>Cattle seek shade when experiencing thermal stress</i>		
Yes	432	90.19
Not sure	39	8.14
No	8	1.67
<i>Cattle breathe normally when under thermal stress</i>		
Yes	189	39.46
Not sure	55	11.48
No	235	49.06
<i>Cattle pant when experiencing thermal stress</i>		
Yes	319	66.6
Not sure	78	16.28
No	82	17.12
<i>Cattle produce a lot of saliva when experiencing thermal stress</i>		
Yes	339	70.77
Not sure	77	16.08
No	63	13.15
<i>Cattle do not need to be inseminated during hot weather</i>		
Yes	173	36.12
Not sure	198	41.34
No	108	22.55
<i>Cattle spend more time lying when stressed</i>		
Yes	280	58.46
Not sure	70	14.61
No	129	26.93
<i>Cattle refuse to graze when stressed</i>		
Yes	311	64.93
Not sure	60	12.53
No	108	22.55
<i>Thermal stress can occur even at low temperatures</i>		
Yes	170	35.49
Not sure	122	25.47
No	187	39.04
<i>Milk production can be affected by thermal stress</i>		
Yes	386	80.58
Not sure	61	12.73
No	32	6.68
<i>Cattle group together during thermal stress</i>		
Yes	328	68.48
Not sure	78	16.28
No	73	15.24

3.3 Attitudes of Farmers Towards Thermal Stress Management in Cattle

The majority (61.38%) of the respondents agreed that it is important to manage thermal stress in cattle. A proportion (53.44%) of the respondents also strongly agreed that cattle must be taken under shade. Only 57.2% of the respondents strongly agreed that cattle should be given water when the environment is hot. Slightly more than half of the respondents strongly agreed that there was a need for shade trees on the farm for use by animals during hot weather 249(51.98%). Most of the respondents agreed that farm employees should be trained about thermal stress management 269(56.16). The majority of the respondents also agreed that animal waste should be kept far away from cattle 201(41.96%), whereas 222(46.35%) of the respondents noted that animals must be grazed in the open to avoid thermal stress. In addition, 213 respondents (44.47%) strongly agreed that cattle should be given high-quality feed.

Table 3. Attitudes of cattle farmers towards thermal stress management

Aspect	Strongly agree n(%)	Agree n(%)	Neutral n(%)	Disagree n(%)	Strongly disagree n(%)	Mean	SD
It is important to manage thermal stress in cattle	294(61.38)	158(32.99)	17(3.55)	8(1.67)	2(0.42)	1.47	0.69
Cattle should be taken to the shade when the environment is hot	256(53.44)	197(41.13)	20(4.18)	3(0.63)	3(0.63)	1.54	0.66
Cattle must be provided with water when it is hot	276(57.62)	167(34.86)	26(5.43)	6(1.25)	4(0.84)	1.53	0.73
There is a need for shade trees on the farm	249(51.98)	196(40.92)	19(3.97)	11(2.30)	4(0.84)	1.59	0.74
Employees must be trained on thermal stress management	269(56.16)	179(37.37)	24(5.01)	5(1.04)	2(0.42)	1.52	0.68
Animal waste should be kept far away from the cattle house	192(40.08)	201(41.96)	59(12.32)	21(4.38)	6(1.25)	1.83	0.89
It is better to graze in the open than in a place with trees	190(39.67)	222(46.35)	33(6.89)	28(5.85)	6(1.25)	1.82	0.88
Cattle should be given high-quality feed	153(31.94)	213(44.47)	68(14.20)	37(7.72)	8(1.67)	2.02	0.96

Note. SD = standard deviation; p = probability.

3.4 Factors Associated with Thermal Stress Management in Cattle

Respondents who were not internet users were 98.5% less likely to have good practices for thermal stress management compared to those who were internet users (AOR = 0.015, 95% CI 0.22-0.85, p = 0.015). Respondents with positive attitudes towards thermal stress management practices were 4.76 times more likely to have good thermal stress management practices compared to those with poor attitudes (AOR = 4.76, 95% CI 1.27-17.74, p = 0.02).

Table 4. Factors associated with thermal stress management in cattle

Variable	COR	p -value	AOR	p -value
<i>Location</i>				
Soroti	ref		ref	
Lira	4.47(2.50-7.97)	< 0.001	4.60(2.52-8.39)	< 0.001
Kotido	0.41(0.13-1.28)	0.127	0.29(0.09-0.94)	0.040
<i>Overall knowledge</i>				
Good knowledge	ref		ref	
Poor knowledge	0.55(0.34-0.87)	0.011	0.33(0.19-0.56)	< 0.001
<i>Overall attitude</i>				
Negative attitude	ref		ref	
Positive attitude	6.24(2.26-17.27)	< 0.001	8.95(2.69-29.73)	< 0.001

Note. COR = Crude Odds Ratio; AOR = Adjusted Odds Ratio; p = probability value (probability of obtaining the observed results).

According to Table 4, the odds of effective thermal stress management were 45% lower among farmers with poor knowledge compared to those with good knowledge (COR = 0.55, 95% CI: 0.34–0.87, p = 0.011). After adjusting for other variables, the odds of effective thermal stress management remain 67% lower among those with poor knowledge compared to those with good knowledge. The findings are highly statistically significant (AOR = 0.33, 95% CI: 0.19-0.56), p < 0.001). Table 4 also indicates that the odds of effective thermal stress management are 6.24 times (COR = 6.24, 95% CI: 2.26-17.27, p < 0.001) higher for individuals with a positive

attitude compared to those with a negative attitude. After adjusting for other factors, the odds of effective thermal stress management are 8.95 times higher for individuals with a positive attitude. This result is also highly statistically significant (AOR = 8.95, 95% CI: 2.69-29.73, $p < 0.001$). Individuals with a positive attitude towards thermal stress management had significantly higher odds of managing thermal stress effectively compared to those with a negative attitude. The positive attitude is associated with a substantially higher likelihood of effective management, with the association being stronger after adjustment for other variables.

3.5 Thematic Analysis of the Key Informant Interviews with Veterinarians

Veterinarians were interviewed as key informants to better understand farmers' attitudes and understanding of heat stress in cattle. The Braun and Clarke framework was used to conduct a thematic analysis of the data. The following five main topics surfaced.

3.5.1 Theme 1: There is Little Knowledge and Focus on Thermal Stress Management by Veterinarians

Sub-themes:

Little focus on thermal stress by extension agents.

Limited understanding of thermal stress by extension agents and farmers themselves.

Indigenous breeds were thought not to be affected by thermal stress.

Narrative interpretation:

Veterinarians indicated they had not conducted any training for farmers on thermal stress management, even though they knew it affected cattle production and productivity. Only farmers who have done advanced farming, such as zero grazing, indirectly manage thermal stress.

Illustrative quotations:

"Thermal stress is an area that is not well studied; people have not studied it, and it is a very big problem. Capacity building of the technocrats in industry, such as vets, production officers, is overlooked; that is the problem." (Vet01S)

"The knowledge gap stands highest; the signs of thermal stress are taken to be for diseases. Thermal stress has been taken as normal yet very abnormal and not given due attention in the training for farmers." (Vet02S)

"Thermal stress is an issue, largely discussed when still at school. One reason for discussing it in school was that some breeds of livestock were not adapted to living in these high temperatures, but it is a major issue in the arid and semi-arid areas." (Vet07M)

3.5.2 Theme 2: Attitudes Towards Thermal Stress Management are Shaped by Several Factors

Sub-themes:

Indigenous breeds have adapted to the tropical conditions, so they do not experience thermal stress.

There is more emphasis on diseases and feeding than on thermal stress.

Most production in the cattle corridor is extensive, reducing the probability of thermal stress occurrence in cattle.

Thermal stress has very little effect on productivity in indigenous and crossbred cattle.

Narrative interpretation:

Some veterinarians and farmers perceived thermal stress as normal. Farmers rearing indigenous breeds believed thermal stress management was unnecessary as the animals had adapted to the high tropical heat. Relatedly, veterinarians had not provided any support to the farmers since the extension service is demand-driven. Management practices such as extensive production systems led to lower thermal stress.

Illustrative quotations:

"Thermal stress was not seen so much in local or indigenous breeds. In exotic breeds, it became more prevalent. Most exotics died partly due to heat stress." (Vet06K)

"Thermal stress is a vice generally difficult to handle since one cannot control the weather. Animals are left to nature. Farmers do not put any science into cattle farming. Veterinarians address issues raised by farmers only because the extension approach in Uganda today is demand-driven." (Vet04L)

"Farmers do not understand thermal stress as a big challenge, so they do not demand for its training from extension workers. Thermal stress is not a key production factor in cattle because it is not experienced throughout the year; the major factors are drought and insecurity." (Vet05K)

3.5.3 Theme 3: Thermal Stress Management Practices are Unplanned and Rudimentary

Sub-themes:

Reliance on trees in rangelands as a source of shade during the hot parts of the day.

An extensive production system to allow animals move away from hot areas during grazing.

Afternoon resting of animals and grazing early in the morning and late in the evening.

Narrative interpretation:

Thermal stress management practices in cattle are unplanned, as they believe that most of the breeds in the tropics have successfully adapted to high temperatures. Cattle are left in the rangeland to seek shade at will; this is prominent in the cattle corridor where the study was conducted. In some pastoral communities, they resort to grazing early in the morning and late at night.

Illustrative quotations:

“During the dry season, farmers take animals for grazing very early, by midday, animals are allowed to be under shade; however, this is a dry season feeding strategy, not a response to thermal stress.” (Vet05K)

“The Government of Uganda has had a lot of restocking initiatives, but the figures of Friesian breeds supplied to the northern cattle corridor have not improved. The key issue here is poor thermal stress management since these breeds originate from cooler climates.” (Vet07M)

3.5.4 Theme 4: Limited Understanding of the Effects of Thermal Stress in Cattle

Sub-themes:

The dry season has repeat cases for artificial insemination.

Cattle refuse to graze mainly due to disease.

Thermal stress does not affect the indigenous breeds.

Reduced milk is due to poor feeding and disease.

Narrative interpretation:

There is limited practical knowledge of thermal stress among farmers and veterinarians. Veterinarians are called to treat animals experiencing thermal stress, and they proceed to treat. Cattle should be monitored for signs of thermal stress. Increased rectal temperature, refusal to graze, and low conception rates are prevalent in both diseased animals and those experiencing thermal stress. This makes it difficult to delineate and isolate the signs of thermal stress.

Illustrative quotations:

“Our field veterinarians often treat cattle for diseases even when they are exhibiting signs of experiencing thermal stress that compromises their physiology.” (Vet02S)

“It is difficult to know whether the reduction in milk yield or abnormal cycling is a result of thermal stress, not disease.” (Vet06K)

“Thermal stress is one of the factors hindering zero grazing, particularly for improved breeds in Teso. Thermal stress occurs here throughout the year, worse in the dry season, farmers cannot realise what they expect from their animals, especially the dairy breeds.” (Vet02S)

“Thermal stress exists and affects production. I am an experienced artificial insemination technician. Dry season has repeat cases for improved breeds; animals switch off reproduction completely.” (Vet01S)

3.5.5 Theme 5: Veterinarians Believed Certain Practices Can Improve Cattle Production and Productivity Amidst Thermal Stress

Sub-themes:

Introduce training for farmers on thermal stress.

Provide water to animals *ad libitum*.

Investment in technology to monitor thermal stress.

Narrative interpretation:

Despite existing gaps, veterinarians expressed optimism about improving farmers' thermal stress management practices. They emphasised the importance of targeted training, strengthened veterinary extension services, and supportive policies promoting climate-resilient livestock systems.

Illustrative quotations:

"The approach to extension service delivery should change from demand-driven to command-driven because some farmers do not know what they want. Farmers must do what the government wants." (Vet03L)

"Trainings, day-to-day routines, advising farmers and showing farmers the videos of farms that are doing well." (Vet06K)

"We are in the information age, and the use of technology is the best fit for the local communities if customised to the local environment". (Vet01L)

4. Discussion

The study found that farmers who were internet users were 98.5% less likely to have good thermal stress management practices. Precision technology using the Internet of Things (IoT) and machine learning helps farmers to better control and remotely manage physiological and technological parameters. IoT helps to track the health and welfare of the animals by collecting, storing, and analysing large amounts of data. Biometric and biological sensors help farmers improve and manage the quantity of their production (Markov et al., 2022). This explains why internet users were more likely to have good thermal stress management practices, as they have easier access to innovative technologies and research findings. A multivariate linear regression analysis of farmer knowledge and attitude revealed a significant influence on thermal stress management ($p < 0.01$). Results from interviews with veterinarians indicated that agricultural extension training packages often fail to adequately address thermal stress. This was attributed to the model of extension service provision being demand-driven. Agricultural extension workers should therefore deliberately train farmers on the productivity challenges associated with thermal stress. An analysis of the correlation between thermal stress management and the socio-economic status of the farmer was not statistically significant. These findings align with those of Slayi et al. (2024) on the contribution of financial constraints on strategies to address heat stress.

A study by Al-dawood (2020) found that 52.4% of participants were unaware of the existence of heat stress. Only 9.5% of participants reported regularly controlling their cattle's exposure to heat. Wuntimah et al. (2021) found that 50% of the farmers placed less importance on freedom from physical and thermal pain. In this study, most farmers were unaware of thermal stress; thus, they did not know how to manage it. The uptake of knowledge can be enhanced through farmer participation in training programmes, agricultural associations and extension services (Ifeanyi-obi & Tolumoyi, 2025; Matthew et al., 2025; Oyedele et al., 2025). Pastoral farmers with limited knowledge of thermal stress management are significantly less likely to manage thermal stress effectively than those with good knowledge. The impact of poor knowledge remained significant in thermal stress management even after adjusting for other factors. This is the basis on which Ifeanyi-obi and Tolumoyi (2025) recommended enhancing agricultural extension services to provide timely information to address production and productivity constraints in agriculture.

Perceptions of heat-stress mitigation strategies, including pasture access, such as allowing cows to select between pasture and a shaded barn, were more favourable among Australian participants (Hendricks et al., 2022). Whereas there is freedom of movement and access to pasture of choice in the extensive systems, such as the cattle corridor, such systems are subject to welfare issues, including but not limited to thermal stress (Temple & Manteca, 2020). Due to the migratory nature of pastoralists in the cattle corridor, the extensive production system is most prevalent. This is because farmers have to move to find pasture and water for their animals throughout the year. This likely exposes cattle to thermal stress, as there are no planned measures to manage it.

Both knowledge and attitude are important factors that influence thermal stress management in cattle. Having good knowledge and a positive attitude substantially increased the likelihood of efficient thermal stress management. Conversely, poor knowledge and a negative attitude were associated with significantly lower odds of efficient thermal stress management. In addition, the veterinarians' viewpoints demonstrate how farmers' reactions to heat stress are interwoven with broader farm system dynamics. According to the Farm-System Theory, attitudes and the prioritisation of management actions are shaped by the technical subsystem (knowledge), goals and values, and managerial subsystems. The cultural, technological, educational, demographic, sociological, climatic and economic suprasystems equally have significant influence on farm management decisions and practices, including thermal stress (McConnell & Dillon, 1997). All these are part of the environmental suprasystem whose influence on the farm cannot be overemphasised. Certainly, veterinarians

report a lack of training packages for farmers on thermal stress, and farmers likewise have limited knowledge and attitudes toward thermal stress management.

According to farm-system theory, the dynamic interplay of biophysical, socioeconomic, and institutional subsystems affects cattle output (McConnell & Dillon, 1997). Veterinarians' limited attention to thermal stress reflects the institutional subsystem's shortcomings, especially in professional capacity building and extension service delivery. Veterinarians recognised the importance of thermal stress, but they mainly approached it as a theoretical problem rather than a real-world management issue. Proactive participation was further limited by the demand-driven approach to extension, which reinforced a system where farmers are reluctant to embrace techniques for challenges they neither fully understand nor prioritise. Overall, the results imply that heat stress is a systemic problem ingrained in institutional, cognitive, and production processes rather than just a technical difficulty. Coordinated strategies that support climate-resilient livestock management as an essential part of providing extension services and that recognise the interconnectedness of agricultural systems are essential.

The inclusion of thermal stress management into routine livestock extension and veterinary service delivery should be prioritised by policy and practice, acknowledging it as a fundamental production limitation alongside disease and nutrition. To do this, veterinarians and extension agents must be strengthened through routine professional development focused on the practical identification, delineation, isolation, and prevention of thermal stress. Extension strategies should evolve to be more proactive and anticipatory, especially when it comes to climate-related concerns that farmers might not immediately identify or need assistance for.

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Authors Contributions

Prof. ODDO and Dr. MC contributed to the design of the study, had an oversight role on data collection, and reviewed the draft manuscript.

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