Association Model of Temperature and Cattle Weight Influencing the Weight Loss of Cattle Due to Stress During Transportation

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***Abstract*—This study aimed to enhance animal welfare in the context of modern agriculture. The Association Rule analysis method using FP-Growth and Apriori algorithms was employed to identify patterns and factors influencing animal welfare, particularly in the context of live cattle weight loss (shrink) due to stress during transportation. Data obtained from several farms and clinical tests were used to develop insights into the relationship between farming practices, data science, and animal welfare. The research stages included data preprocessing, initial analysis, modeling, evaluation, and interpretation of results, recommendations and implications, and conclusions. The research results indicate that the use of FP-Growth and Apriori algorithms uncovered hidden patterns in the data, resulting in four association rules from FP-Growth and five rules from Apriori. These rules aid in designing recommendations to enhance animal welfare, improve agricultural efficiency, and support sustainability of the cattle sector. Our findings have significant implications in the context of animal welfare and sustainable farm management.**

***Keywords*—Association rule; animal welfare; cattle management; animal product quality; modern agriculture; recommendations; sustainability**

I. Introduction

The issue of tracking and handling pressure in cattle, especially farm animals, for the duration of transportation, has resulted in extensive difficulties for cattle enterprises. The transportation of stay cattle often entails long distances from production facilities to consumption centers, resulting in diverse, demanding situations that need to be addressed. In this context, pressure on farm animals through transportation has been proven to result in sizable weight reduction, which, in turn, impacts the first-rate of meat and promotes charges [1], [2]. Consequently, efforts to reduce and control stress in cattle throughout transportation are essential [3], [4]. One of the factors that can influence the stress levels and weight loss in cattle during transportation is the body temperature condition. This study aims to explore the relationship between body temperature and the body weight of cattle in affecting weight loss due to stress during transportation. The method involves measuring the body temperature of cattle before transportation. Additionally, the body weight of cattle is also measured before and after transportation to calculate the weight difference caused by stress during transportation [5].

Researchers and stakeholders in cattle enterprises have long sought to address this issue. Numerous techniques have been developed, ranging from gazing at animal conduct to measuring physiological and biochemical parameters [6]. However, an essential question arises: are the current techniques adequate and reliable? [7]. In this research, efforts are made to address this question using association techniques. This association method will examine the relationship between the body temperature of cattle and their body weight in influencing weight loss in cattle during transportation.

In this section, we explain the association rules and how they can be used to gain valuable insights into stress in cattle during transport will be provided [8], [9]. Related studies that have successfully employed association rules in various contexts, including traffic pattern comprehension and the detection of unusual events in videos, will be referred to by us [10], [11].

Furthermore, we can discuss the study findings associated with using the Apriori and FP-increase algorithms in determining affiliation guidelines in our dataset, which incorporates temperature statistics, initial weight, and the fee of weight loss of cattle at some point of transportation [12]. These two algorithms are also be compared to assess their effectiveness in generating informative association rules [13].

To provide a broader context, other related research that has employed data mining techniques to address various issues, such as library user behavior analysis and deformation response analysis in landslide hazards, will also be referred to by us [7]. The knowledge gained from these studies offers a broader perspective on the potential use of association rules in the context of stress management in live cattle during transportation in the cattle industry [14].

In conclusion, our findings will be summarized, and further recommendations and implications from this research will be provided to minimize the impact of stress on live cattle during transportation in the cattle industry [4], [15].

II. Related Work

The transportation of stray animals is a critical element in the cattle industry, especially when these animals are destined for slaughter or processing. Previous research has indicated that animal transportation can negatively impact animal welfare [16]–[18]. Animal welfare was assessed via signs that included pressure tiers, weight reduction, and the physical condition of the animals. Several elements have been identified as likely to affect animal welfare throughout transportation. These elements included car density, environmental temperature, travel duration, and animal management. The author in [19] showed that excessive car density can increase the strain degree in animals. Weight loss at some point of transportation is a severe problem that could impact animal productivity and the quality of the resulting meat. Significant weight loss in animals during transport has been documented in several studies [20]–[22]. This may illustrate the stress and soreness experienced by animals during transportation. Governments and global agencies have introduced diverse policies and suggestions to address animal welfare issues at some point of transportation. For instance, the ecu Union has applied strict policies regarding the shipping of live animals [23][24]. However, the implementation and enforcement of these regulations can range across international locations and areas .

While numerous studies have been conducted in the realm of animal transportation, several unaddressed research areas remain. Some investigations may focus on specific animal types or geographic regions, whereas others maintain a broader scope. Furthermore, our understanding of the individual factors within animals that can influence their responses to transportation remains incomplete. In the context of this literature review, our research endeavors to bridge these knowledge gaps by concentrating on live cattle and the variables that affect their well-being and weight loss during transport. This study aimed to provide a comprehensive framework for research within the domain of live animal transportation, elucidating its relevance to our own research. Our findings are correlated with prior research outcomes to facilitate a more profound understanding of this issue and its potential to enhance animal welfare in the cattle transportation sector.

Investigations within the realm of animal transport, specifically concentrating on the interplay between temperature, body weight, and cattle stress, have attracted noteworthy interest. Previous research has extensively explored the nuanced relationships between these factors, offering valuable insights into the difficulties confronted by livestock during transit.

A. Korelasi Temperature and Stress Correlation

Previous research has explored the impact of temperature on the stress levels of cattle during transportation. Findings indicate a significant correlation, where increased temperatures often contribute to heightened stress levels [25][5]. These studies utilized various methodologies, including real-time temperature monitoring and observations of stress behavior, to establish robust associations.

The results of these studies suggest that high temperatures can influence the comfort and well-being of cattle during transportation, leading to an increase in stress levels. Furthermore, the research also indicates that cattle experiencing high stress levels during transportation tend to undergo more significant weight loss. Thus, there is a connection between the body temperature of cattle and body weight in influencing weight loss during transportation..

B. Body Weight Dynamics

The influence of body weight on cattle stress during transportation has been a focal point in several studies. Researchers have examined how fluctuations in body weight, particularly weight loss, align with increased stress levels. Through comprehensive analysis, these studies aim to unveil patterns and associations contributing to a deeper understanding of stress dynamics during transit. This approach involves measuring the body weight of cattle before and after transportation, along with monitoring their body temperature conditions [6].

The research findings indicate that high temperatures can affect the comfort and well-being of cattle during transportation, leading to an increase in stress levels. Additionally, the study suggests that cattle experiencing high stress levels during transportation tend to undergo more significant weight loss. Therefore, there is a correlation between cattle body temperature and body weight in influencing weight loss during transportation.

III. Research Method

The initial steps in this research process involved data collection, preliminary analysis, and data preprocessing. The data obtained, such as information on body temperature, initial weight of the cattle, and rate of weight loss during transportation, will serve as the primary foundation for advancing this research. Following this, the subsequent phases of our study will involve utilizing association rule algorithms to detect and comprehend the connections among these factors concerning the stress encountered by cattle during transportation. For a summary of the research process, please consult Fig. 1.

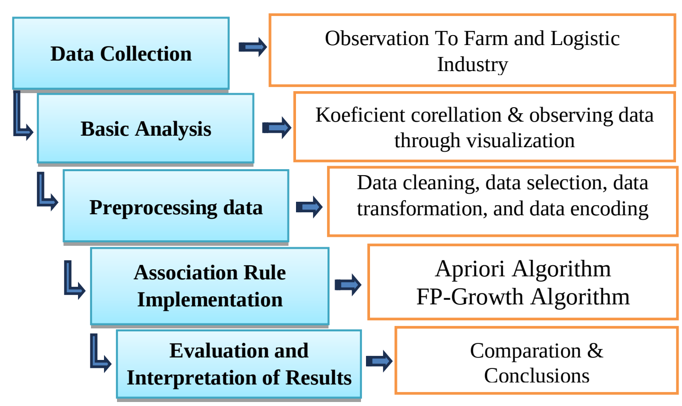

Fig. 1. Methodology.

A. Data Collection

The primary dataset will encompass details concerning the cattle's initial body temperature, starting weight, and rate of weight loss throughout transportation, sourced from pertinent outlets within the cattle sector. Additionally, information regarding cattle behavior during transit will be documented, encompassing stress indicators like agitation, profuse sweating, or any unusual conduct, as supplementary data for potential future use.

B. Basic Analysis

A descriptive analysis will be conducted on the data to initially comprehend the distribution of pertinent variables. Visual aids like charts, histograms, or scatter plots will be employed to scrutinize data patterns. This was done to provide a better understanding of the data, identify the research significance, determine the most appropriate methods, develop hypotheses and theoretical frameworks, improve planning, avoid data redundancy, and enhance the validity and reliability of the research.

C. Data Preprocessing

The collected data will be analyzed to identify and address missing or invalid data. Temperature, weight, and weight loss rate data were converted into appropriate formats for statistical analysis, including data cleaning, removal of duplicate data, data selection, data transformation, and data encoding if necessary.

D. Implementation of Association Rule Algorithm

Association rule mining is a data-mining technique aimed at discovering implicit association rules from a large amount of transactional data. It is also known as association analysis, which establishes connections between various item combinations within a dataset [26]. This association model was applied to the dataset to identify association rules related to stress in cattle during transportation. This involves configuring parameters, such as support, confidence, and lift ratio. There are two association rule models that we will use: Apriori and the FP-Growth algorithm. The Apriori algorithm is an association rule algorithm commonly used to address issues in data analysis involving transactions or lists of items, such as in retail shopping, online shopping carts, product recommendations, or pattern detection in transactional data. The Apriori algorithm is used to discover association rules connecting items or attributes in transactional datasets. Similar to the Apriori algorithm, FP-Growth is a model algorithm for associations resulting from the development of the Apriori algorithm. The primary use cases for both of these algorithms usually involve solving Market Basket Analysis problems, providing the most suitable product recommendations, and analyzing customer purchase patterns. Additionally, FP-Growth has the capability to handle large datasets, analyze transactional data, and provide recommendations in e-commerce. Here are the required notations to generate an association rule.

To measure the initial probabilities of X and Y, we need an equation called Support, which is as follows [27], [28]:

$$S_{supp}(X \rightarrow Y) = \frac{(|X \cup Y|)}{n} \quad (1)$$

S_{supp} = Support value

n = total number of transactions.

After obtaining support, the next step is to find the Confidence value, which is a proportion of transactions containing all items in both X and Y compared to transactions containing only items in X [29], The notation for this is as follows:

$$Confidence(X \rightarrow Y) = \frac{(X \cup Y)}{Support(X)} \quad (2)$$

Lift(X ➝ Y) is a measure used to assess the significance of the association rule X ➝ Y. Support (X ∪ Y) reflects how often itemsets X and Y appear together in transactions, whereas Support (X) and Support (Y) are measures of how often each individual itemset appears in transactions.

E. Evaluation and Interpretation of Results

The results from the use of both algorithms will be evaluated to measure their effectiveness in generating informative association rules. Significant association rules were interpreted to understand the relationship between temperature, initial weight, rate of weight loss, and stress in cattle during transportation. Based on the analysis results, this research will also summarize the findings and conclude that association rules can provide valuable insights into the measurement and management of stress in cattle during transportation in the cattle industry.

IV. RESULT

A. Prepare Dataset

Data collection was carried out through observation. Body temperature data before departure, initial weight, and rate of weight loss during the journey were the primary focus of this study. Fifty data records have been successfully collected from relevant sources in the cattle industry, and for more details, the dataset can be seen in Table I.

TABLE I. DATASET OF PRE-SHIPPING LIVE CATTLE OBSERVATION RESULTS

NO	x1	x2	x3	x4	SUHU AWAL								x13	x14	Shr/kg	%
					x5	x6	x7	x8	x9i	x10	x11	x12				y
1	PO	231	M	4	36	37	36	36	36	36	35	38	36	205	26	11%
2	PO	235	M	4	37	37	37	37	37	37	36	39	37	211	24	10%
3	PO	246	M	5	37	37	37	37	37	37	36	39	37	235	11	4%
4	PO	239	M	5	36	37	36	37	37	37	35	38	36	203	36	15%
5	PO	231	M	4	36	37	37	37	37	37	36	37	37	188	43	19%
….	……	…..	…	….	….	…..	….	….	….	….	….	….	…	…	…	…
….	……	…..	…	….	….	…..	….	….	….	….	….	….	…	…	…	…
49	Bali	151,06	F	4	37	37	40	40	38	39	40	39	39	144	7	5%
50	Bali	143,81	M	4	38	39	40	40	38	39	40	39	39	136	7	5%

The observation results yielded a dataset consisting of 50 data records with 14 independent variables (x) and 1 dependent variable (y). x1 represents the breed of cattle, with two attributes: Peranakan Ongole (PO) and Bali Cattle. x2 represents the initial weight of the cattle, measured either through weighing or estimation based on the chest circumference and body length. x3 indicates the sex of cattle identified through direct observation. Column D represents the age of the cattle. x4–x12 represent temperature measurements taken from various body parts (forehead, orbital, cheek, shoulder, back, thigh, leg, and rectal) using a thermogun for external temperature and a regular thermometer for rectal temperature. x13 represents the average body temperature of the cattle. x14 represents the final weight of the cattle upon reaching their destination. Shr/kg denotes the shrinkage in weight during transportation, measured in kilograms. Column y represents the percentage of weight shrinkage during transportation (Shrink). If observed, we only have 50 data records, a number that indeed appears limited, but obtaining them posed a very challenging task. We utilize this record count as part of algorithm testing, examining how well the algorithm can perform its task with such limited data. Additionally, the limitation in the number of records is turned into a strength in this research.

B. Basic Analysis

Descriptive statistics for the 50 data records indicated that the measurement of live cattle weight before shipment (x2) resulted in a weight range of 125–261 kg, with an average of 195 kg. Age (x3) has a ranged from 3.5 to 4.77 years. The average temperature of the cattle (x13) before shipment range between 35.6°C and 37.4°C. The final weight (x14) has a ranges between 118 kg and 235 kg, with an average of 175.9 kg. The percentage of live cattle weight reduction during transportation (y) ranged from 0% to 27%. We also calculated the correlations for each variable. Table II and Fig. 2 show the results and visualization of the correlation between variables x and y, respectively.

TABLE II. CORRELATION OF EACH VARIABLE WITH THE TARGET VARIABLE

	X2	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13
CC	0,33	-0,22	-0,50	-0,28	-0,35	-0,43	-0,41	-0,29	-0,40	-0,22	-0,49
CP	0,92	0,45	-0,16	-0,17	-0,30	-0,07	0,01	-0,04	-0,22	-0,28	-0,19

a. CC (Coeficient Corelation), CP (Coeficient Pearson)

From the initial analysis, it was found that there were some prunings on the variables that had a less significant impact on variable y. These include x1, x3 to x11, x13, and shr/kg. There are several reasons for this pruning, such as data type mismatches for x1 and x3. Additionally, for temperature measurements, discussions with stakeholders and experts led to an agreement to use only rectal temperature, whereas external body temperature measurements were deemed to have invalid calculations. The results of the initial analysis can be seen in Table III.

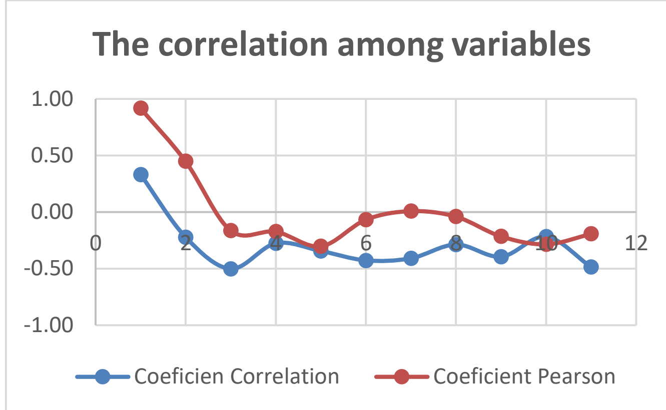

Fig. 2. Illustration of the correlation between each variable x and the label y.

TABLE III. DATASET RESULTING FROM VARIABLE PRUNING THAT IS READY FOR ANALYSIS

No	Weight	Temp	Shrink
1	231	38	11%
2	235	39	10%
3	246	39	4%
4	239	38	15%
5	231	37	19%
….	…..	….	…
….	…..	….	…
49	151	39	5%
50	144	39	5%

Out of several variables that were pruned, only 2 predictor variables and 1 target variable were retained. This simplifies the subsequent analysis process, as there are not too many influential variables to be calculated.

C. Data Preprocessing Process

In this process, we performed data cleaning. We also found that the data needed to be categorized to facilitate calculations, so we transformed the data into Crisp data. Rectal temperature was divided into three attributes: 1) Low Temperature: < 37.5°C (s_low); 2) Normal Temperature: 37.5°C – 39.5°C (s_normal); 3) High Temperature: > 39.5°C (s_high). The initial weight was divided into five attributes: 1) Very Thin Weight: 125 – 150 kg (w_very_thin); 2) Thin Weight: 151 – 175 kg (w_thin); 3) Medium Weight: 176 – 200 kg (w_medium); 4) Fat Weight: 201 – 225 kg (w_fat); 5) Very Fat Weight: 225 – 262 kg (w_very_fat). The percentage of shrinkage was divided into three attributes: 1) Slight Shrinkage Category: ⩽ 9% (p_slight); 2) Moderate Shrinkage: 10% – 18% (p_moderate); 3) High Shrinkage: > 19% (p_high). The dataset resulting from the data transformation is shown in Table IV.

D. Implementation of the Association Rule Algorithm

Descriptive statistics for the 50 data records indicated that the measurement of live cattle weight before shipment (x2) resulted in a weight range of 125–261 kg, with an average of 195 kg. Age (x3) has a ranged from 3.5 to 4.77 years. The average temperature of the cattle (x13) before shipment range between 35.6°C and 37.4°C. The final weight (x14) has a ranges between 118 kg and 235 kg, with an average of 175.9 kg. The percentage of live cattle weight reduction during transportation (y) ranged from 0% to 27%. We also calculated the correlations for each variable. Table I and Fig. 1 show the results and visualization of the correlation between variables x and y, respectively.

TABLE IV. THE RESULTS OF THE TRANSFORMATION BECOME CRISP DATA

NO	WEIGHT	TEMP	SHRINK
0	w_very_thin	s_normal	p_slight
1	w_very_thin	s_normal	p_moderate
2	w_very_thin	s_normal	p_slight
3	w_very_thin	s_normal	p_slight
....	....	....	....
18	w_medium	s_normal	p_slight
19	w_thin	s_normal	p_moderate
....	....	....	....
48	w_fat	s_normal	p_slight
49	w_fat	s_normal	p_slight

- Apriori Algorithm.

From the analysis conducted, relevant rules for the research were obtained. We set a minimum confidence level of 0.01 with a minimum threshold of 1.0. The results from using the Apriori algorithm produced 84 rules. Subsequently, we selected the most relevant rules from these, resulting in five rules that were most relevant to the actual conditions. The five rules that have been generated are listed in Table V.

TABLE V. APRIORI ALGORITHM ASSOCIATION MODEL

Antecedents	Consequents	Sup	Conf	Lift
weight_b_thin Temp_s_normal	Shrink_p_slight	0,17	0,56	1,19
weight_b_thin; Temp_s_High	Shrink_p_ slight	0,07	1,00	2,14
Temp_s_ normal; weight_b_medium	Shrink_p_moderate	0,07	0,50	1,50
Temp_s_low; weight_b_very_fat	Shrink_p_ moderate	0,03	1,00	3,00
Temp_s_ normal; weight_b_veri_thin	Shrink_p_slight	0,13	0,80	1,71

The results obtained provide an overview that out of the five rules, they are supported by Support values ranging from 0.03 to 0.17, Confidence values from 0.50 to 1.00, and Lift Ratios from 1.19 to 3.00. Therefore, the average confidence values obtained served as the basis for the generated rules, indicating a relatively strong correlation.

- FP-Growth Algorithm.

Similarly to what was done previously with Apriori, we set a minimum confidence of 0.01 with a minimum threshold of 1.0 for the FP-Growth algorithm. The results of using the FP-Growth algorithm yielded 21 rules. We then conducted a selection process for these rules, resulting in the identification of the four most relevant rules in line with the actual conditions. These four rules can be observed in Table VI.

TABLE VI. FP-GROWTH ALGORITHM ASSOCIATION MODEL

Antecedents	Consequents	Sup	Conf	Lift
Temp_s_low	Shrink_p_moderate	0,03	1,00	3,00
weight_w_very_thin'; 'Temp_s_low	Shrink_p_slight	0,03	1,00	3,00
Temp_s_high	Shrink_p_ slight	0,07	1,00	2,14
weight_b_thin; 'Temp_s_high	Shrink_p_ slight	0,07	1,00	2,14

The results obtained indicate that out of the four rules, they are supported by Support values ranging from 0.03 to 0.07, Confidence values of 1.00, and Lift Ratio values ranging from 2.14 to 3.00. Therefore, the average Confidence value obtained serves as a strong basis for the generated rules.

The results of this research offer valuable insights into stress measurement and management in the transportation of live cattle within the cattle industry. The rules derived from the FP-Growth algorithm exhibited an exceptional confidence level of 1.00, signifying their robustness within the dataset and a high level of confidence in their applicability. In contrast, the Apriori algorithm yields rules with varying levels of Support and Confidence ranging from 0.50 to 1.00, highlighting the diversity in confidence levels among these rules. However, the overall self-assurance cost remains splendid, indicating a sturdy correlation with a number of popular policies. Furthermore, FP-growth generates rules with better increase Ratios than Apriori, indicating a higher correlation with a number of the rules it generates in the dataset. Tables VII and VIII show the rules given by the heatmap can further clarify the position of each rule.

TABLE VII. RESULT HEATMAP APRIORI MODEL

Weight / Temp	V Thin	Thin	Medium	Fat	Very Fat
Low					
Normal		Slight S = 0,17 C=0,56 L = 1,19	Moderate S = 0,07 C=0,50 L = 1,5	Moderate S = 0,03 C=1,00 L =3,00	Slight S = 0,13 C=0,56 L = 1,71
High		Slight S = 0,07 C=1,00 L = 2,14			

TABLE VIII. RESULT HEATMAP FP-GROWTH MODEL

Weight / Temp	Very Thin	Thin	Medium	Fat	Very Fat
Low	Moderate S = 0,03 C=1 L = 3	Moderate S = 0,03 C=1 L = 3	Moderate S = 0,03 C=1 L = 3	Moderate S = 0,03 C=1 L = 3	Moderate S = 0,03 C=1 L = 3
Normal					
High	Slight S = 0,07 C=1 L = 2,14	Slight S = 0,07 C=1 L = 2,14	Slight S = 0,07 C=1 L = 2,14	Slight S = 0,07 C=1 L = 2,14	Slight S = 0,07 C=1 L = 2,14

TABLE IX. RESULT HEATMAP APRIORI MODEL

Confidence	1	0,8	0,6	0,5	0,2

Four rules obtained from FP-Growth will automatically generate 10 rule. This is because rules 1 and 3 provide flexibility for any weight to be given its effect. Table IX shows the description of the heatmap by focusing on its confidence value.

V. CONCLUSIONS

The goal of this study was to determine the effect of temperature and initial weight on the pressure stages and weight reduction in cattle in the context of farm animal enterprises. The data collected and analyses conducted offer crucial insights into the factors affecting cattle well-being during transportation and their practical implications. Influence of Weight and Temperature on Cattle Stress. The evaluation results indicate that pre-transportation weight and temperature measurements significantly influence cattle pressure stages, that is, glaring within the association policies generated by each algorithm, which exhibit a strong correlation between weight and temperature and a lower frame weight (shrinkage) at the stop of transportation. This indicates that preliminary temperature and weight information can function as guidance for stakeholders to provide the maximum appropriate care of their farm animals, in the long run, lowering farm animal strain in the course of transportation. This information has significant practical implications for the cattle industry, allowing farmers to use temperature and weight data as vital indicators in managing cattle stress during transportation. Preventive measures, such as ensuring proper vehicle ventilation and safeguarding against animal welfare threats can assist in stress reduction and minimize detrimental weight loss in cattle.

This paper has certain limitations. Firstly, qualitative data was used to gather information on cattle behavior during transportation, and further analysis may be necessary to gain a deeper understanding of stress-related behavior. Secondly, the research focused solely on temperature as a contributing factor, disregarding other factors like humidity and population density within the transport vehicle, which might also influence cattle stress during transit. While this research serves as a critical foundation exploration of the factors influencing cattle stress during transportation, it is imperative to conduct subsequent studies with broader variables and larger sample sizes to offer a more comprehensive perspective and enhance stress management practices in the cattle industry.

VI. DISCUSSION

In this chapter, we will delve into the acquired research findings and provide additional context regarding their implications, along with offering recommendations for future research. Although this study has provided valuable insights, there are areas that warrant further investigation. Future research in this field should encompass several facets. Firstly, there is a need to collect more comprehensive behavioral data concerning animal behavior during transportation, as this study predominantly relied on qualitative data. Secondly, it is crucial to consider additional variables such as air humidity and population density within the transport vehicle, as they may also exert an influence on cattle stress during journeys. Lastly, conducting advanced research with larger sample sizes and a broader spectrum of variables can provide a more holistic comprehension of the factors contributing to cattle stress during transportation, ultimately contributing to the enhancement of stress management practices within the cattle industry.

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