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Review Article

A Detailed Review of Transportation Stress in Livestock and its Management Techniques

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Abstract

Transportation of livestock is an inevitable husbandry activity that have been undergoing since a long time. Livestock are transported for many reasons like from drought areas to better feeding area, change of ownership like promotion, slaughtering, re-stocking, etc. Methods used for moving animals are usually on hoof, motor vehicle, train, air and sea. Historically, livestock have been moved on foot but this has been surpassed by increasing urbanization and commercialization. Road transport presents a critical step in animal production and use, and is often seen as one of the key causes of stress, directly affecting production in terms of both economic and animal welfare. Welfare and stress measures during shipment are generally measured in terms of behaviour, biochemical activity, endocrine and pathological variables. Multiple corrective approaches have been tried to reduce the reaction of animals to transport stress such as preconditioning, vitamin administration, vaccination, high-energy diet feeding and electrolyte therapy.

Keywords: Electrolyte Therapy, Livestock, Stress, Transportation, Urbanization, Welfare

Introduction

Transportation of livestock involves grouping and loading of animals at their place of origin, confining them to a moving or stable vehicle, unloading, and eventually lairage or penning at their ultimate destination (Tarrant and Grandin, 2000). Transportation is an unavoidable husbandry activity to which animals are subjected (Gupta *et al*., 2007; Sporer *et al*., 2008; Adenkola and Ayo, 2009a) as a result of marketing and the need to slaughter them for meat in slaughter houses (Chandra and Das, 2001; Minka and Ayo, 2007). As a result of substitution of old stock exhibits, fairs, sports events, seasonal tourism, taming, reproduction and health status, livestock are also transported (Giovagnoli *et al*., 2002). They are often relocated to achieve translocation for growth and fattening shortly before harvest, and often to sources of less costly or more plentiful feed supplies (Tarrant and Grandin, 2000). Live auction markets also sell the bulk of the livestock population, a cycle that increases transport times and multiplies the number of occasions that animals are loaded, unloaded, pushed, introduced into new environments and mixed with new animals. For many reasons animal transport provides cause for concern. Firstly, it can cause extreme stress in animals, which contributes to poor health. Second, stressful transportation will adversely affect the quality of meat. Third, there is a possibility that infectious diseases could spread over long distances. Fourthly, animal welfare can be affected by various conditions of pre-transportation and transportation and can cause injury, reduce efficiency and facilitate the production of animal diseases. The most important risk factors for health problems and losses are found in: (1) unhealthy animals; (2) increased vulnerability to infection by causes of immunosuppression; (3) increased infectiousness; (4) contact with infected animals, (5) pathogen resistance; (6) transport-related stressors, such as inadequate handling, feeding, watering and travel time. Animals must be fit for traveling. Animals that are unhealthy are vulnerable to severe illnesses, accidents and system abnormalities. Infection susceptibility such as pneumonia is increased, with high morbidity and resulting mortality in calves and sheep (bovine herpes virus 1, Shipping fever) and sheep and horses with salmonellosis. Avoid stress factors such as weaning immediately before travel, feed shifts, inadequate ventilation, crowding, lack of maternal antibodies or lack of maternal treatment. Transportation stress can increase the degree and length of pathogen shedding in sub clinically infected animals and thus increase their infectiousness. Such factors can combine to negatively affect the animals in a number of ways. Loading, unloading and driving are related in particular to physical harm and injury.

Mixing new animal classes leads to an increase in the number of social experiences that may result in psychological stress and physical fatigue. These pressures are correlated with changes in metabolism leading to poor health, decreased meat quality and economic losses. Longer journeys often require eliminating food and water for long periods of time, resulting in weight loss and dehydration. Because these transporting animals are subjected to a number of external environmental stimuli, which are called stress factors (Frazer and Brown, 1990), and thus animal transportation is extremely stressful (Sporer *et al*., 2008; Ritter *et al*., 2009; Adenkola and Ayo, 2009b). Where a person fails to fix a problem, stress is said to be imposed on it. Stress is an environmental impact on a person that overtaxes their control systems and decreases their fitness or seems likely to do so (Broom 2000). Road transport of livestock was shown to result in a live-weight loss (Ritter *et al*., 2009; Adenkola and Ayo, 2009a). An individual's welfare is their state with respect to their attempts to cope with their environment (Nielsen *et al*., 2011) and includes both the extent of failure to cope and the ease or difficulty of coping. Welfare and stress measures during transport are generally measured in terms of behaviour, biochemical activity, endocrine and pathological variables. To assess stress, animals can be evaluated for physiological (heart rate, body temperature), biochemical (cortisol, catecholamine, lactate, creatinine kinase), video-observation based behavioural measures, and meat consistency (e.g., pH) analysis during or after transportation. These are used to determine the degree of stress before and after transportation and to achieve proper handling and transportation procedures for various types of animals (Ferlazzo, 2003).

Transportation History

In earlier times the primary form of transportation was only by foot. But several other modes were developed with technology advancement. In 1607, the animals were first transported by English vessel SUSAN CONSTANT. And for the first-time shipment of live cattle happens by rail in Chicago in 1867

Various Shipment Modes

There are many modes by which livestock can be transported-

1. **By Foot / Hoof**: Should be permitted if the distance covered is less and the animals should be given rest for comfort and well-being during movement. Today gujjars and bhakarwals still pursue this tradition during transmigration.

2. **Through Road**: Towards this purpose, trucks are often used. There are basic guidelines on storage capacity, vehicle floor, vehicle layout, etc. that should be followed for animal improvement.

3. **By Rail:** This method should be used for long-distance transport, since this method has several benefits over other techniques. Water and food should be given at regular intervals so that the animals do not shrink.

4. **By Ship:** Animals are transported from one country to another using this process.

5. **By Air:** Very expensive process, mostly used for expensive breeds of dogs and cats transported mainly from one country to another for care

What is Stress?

Stresses are generally perceived as a reflex reaction that naturally happens when animals are exposed to adverse conditions. It has been identified as the cause of many unfavorable outcomes, from severe injuries of pain (Minka and Ayo, 2007; Njidam *et al*., 2005) to death (Vecerek *et al*., 2006; Voslarova *et al*., 2007). Stress is the body's reaction to outside stimuli disrupting the natural physiological equilibrium or homeostasis (Mstl and Palme, 2002).

Physiology of Stress During Transport

Any novel or unusual animal experience can be a source of stress in the animal which causes physiological and psychological changes. Physiological changes involve activation of the hypothalamic-pituitary-adrenal axis, leading to increased concentrations of cortisol, immune suppression, and heart and respiration levels. Stress may be a hypothalamic-adreno-cortical process, which is related to neurogenic stress such as noise and transport, according to Mitchell *et al.* (1988). The combination of many stress events creates the body's reaction to various external factors called stress factors or stressors. The basis of the concept of general adaptation syndrome (GAS) put forward by Seyle (1977) comprises three stages, namely:

a) Mobilization (alarm reaction)
b) Resistance or adaptation and
c) Exhaustion

The first stage includes mobilizing the mechanisms of defence, starting the restructuring of the body control systems. The main first stage signs include adrenal gland secretion, elevated blood viscosity, hypochloraemia and a rise in catabolism of the tissue. When the external trigger activity overwhelms the compensatory potential of the defence mechanisms of the body, then the reaction results in the animal's death. If not, this reaction occurs in the second stage of GAS, called the resistance or adaptation stage, marked by the discharge of adrenal gland secretory granules. Haemodilution and hyperchloremia occur, while anabolism in the tissue dominates with a propensity to recover body weight. If the external stimulation activity is prolonged, the body's compensatory ability may be exhausted, and GAS reaches its final phase-exhaustion. At this stage the alarm reaction symptoms are reappearing, which are now deleterious to the body. The GAS principle describes the process of increasing the body's resistance to the action of an outside stimulus (suprathreshold) (Panin, 1983)

Physiological Metrics and Indicators for Assessing Transport Stress

Stress in cattle can be assessed by comparing baseline metrics when the animal is not exposed to stress-inducing variables with those assessed when the animal is undergoing a stressful event (Michelle, 2014). Physiological parameters such as heart rate, body temperature, respiration rate and hormonal changes can be used to assess stress levels (Aradom, 2012; Michelle, 2014). Physiological measures observed during long transport include: levels of plasma cortisol, heart rate, respiration rate, degree of muscle tremor, mouth shake, changes in rates of adrenaline and noradrenaline, glucocorticoid plasma or saliva, cortical levels of saliva, increases / decreases in body temperature, physical symptoms of nausea or motion sickness, levels of plasma vasopressin, plasma ß-endorphous

levels. Blood osmolality, plasma ß-hydroxybutyrate levels, eating or drinking behaviour, white blood cell counts, red blood cell counts, lymphocyte and immunosuppressant activity and efficacy (Michelle, 2014). Cortical concentrations are used extensively as an indicator of stress, because cortisol is released in response to stressful stimuli during activation of the HPA axis (Swanson*et al*., 2001). In response to long transport an increase in plasma cortisol levels and catecholamine levels has been widely reported in the calf (Odore *et al*., 2004). Transportation stress is known to cause a raise in plasma urea which indicates an increase in muscle breakdown of protein and nucleic acids due to increased cortical concentration and prolonged food deprivation during stressful transport conditions (Guardia *et al*., 2009). Creatinine kinase rises proportionately with the length of the travel and remains elevated several days after transportation (Evangelia *et al*., 2009), because this enzyme is released into the bloodstream when muscle damage occurs and during intense exercise; high levels of this enzyme in the blood plasma suggest physical exhaustion. Furthermore, transport stress activates an increase in activity of thyroid and adrenal function in cattle that is visible after even short journeys and continues to rise after long-distance transport (Fazio *et al*., 2005). Plasma glucose is one of the usually used physiological indicators of stress during transit (Averos *et al*., 2008). Transportation stress has been documented to cause a rise in plasma glucose concentrations due to an attempt to compensate for energy loss during transportation, mobilization of glucose from glycogen in the liver and muscles into the systemic circulation, or reduction of glycogen reserves from the skeletal muscles (Eniolorunda *et al*., 2009). Increased concentration of plasma glucose is mainly due to glycogenolysis associated with the increase in catecholamine and glucocorticoids released during long transportation stress (Tadich *et al*., 2005). The plasma total protein, albumin, and haemoglobin concentration was observed to increase when animals suffered from dehydration as a result of long-hour transport (Parker *et al*., 2003), but the increase was independent of the journey time (Guardia *et al*., 2009). Changes in the metabolism of minerals during cattle transport primarily include calcium, magnesium, sodium, potassium and chloride (Eniolorunda *et al*., 2009). An increase in muscle activity of stressed cattle results from an increase in the concentration of calcium ions in the extracellular tissue fluid.

Factors Responsible for Causing Transportation Stress

The variety of factors includes loading and unloading, improper handling, unsafe driving, bad road conditions, too hot or too cold environment, inadequate ventilation, high stocking densities, unfamiliar group mixing, deck height, lack of water and food, noise, vehicle movement and journey length (Hartung *et al*., 2003). The travel length has a greater effect than the distance and after long transportation; most animals drink and lie down (VonBorell and Schaffer, 2005). Furthermore, control of pre-transport, noise, vibration, novelty, social regrouping, crowding, environment variables (temperature, humidity and gases), restriction, and transit time (Eicher, 2001). Due to factors such as inadequate road vehicles, illegal route schedule and non-compliance with travel time limits, neglect and improper handling of livestock, transport of unfit cattle, insufficient equipment, ventilation, inroad vehicles, are the key critical issues that result in stress during long transport. Overloading, difficulty in ensuring that vehicles have been allowed to carry cattle, and standard interpretation problems (Singh, 2012).Other stress-inducing factors during handling and transportation are: stakeholder attitudes and driving skills; laws and codes of practice; genetic variations between breeds and varying selection pressure; vehicle architecture for transportation; and design of loading equipment; payment of people working with animals; actual physical condition such as temperature, humidity and risk of disease transmission; storage, loading and unloading methods (Broom, 2003).

Effect of Transport Stress on Animals

Loss of Body Weight

The animal loses weight when deprived of food and water (Machado *et al.*, 2016) estimated a loss rate of about 12% of the initial weight of an animal. Live weight loss is arguably the most important economic effect, because weight-based trading of animals (Bravo *et al*., 2018). Most of the losses occur during the first 24 hours of deprivation, with the highest rate taking place during the first 12 hours (Knowles *et al.*, 1999). Deprivation of food and water in transport is the major factor which accounts for lost weight (Marques *et al.*, 2012).

Mortality

During transportation mortality rates vary with the age and species of animals as young sows, sows, and boars are most prone to transport stress, preceded by fattened pigs, dairy cows and calves, while the highest resistance in fattened cattle is observed (Malena *et al*., 2007). In a study conducted by Ibironke *et al*. (2010) a total of 1224

animals, including 1197 cattle (0.10 percent) and 27 camels (0.24 percent), died as a result of transport distress while transport or soon after arrival at the abattoir. Mortality of adult cattle during road transport increases with the duration of the journey: a sixfold increase in fattened cattle mortality and a 15fold increase in fattened cattle for long journeys of more than 300 km relative to short journeys of less than 50 km (Malena *et al*., 2007).Month and season have been associated with increased risk for mortality linked to transport (Simova *et al*., 2017).The duration of the journey has been confirmed as the most important risk factor in the development of transport related diseases and mortality (Padalino *et al*., 2015).

Physiological Responses

Body temperature, heart, and respiration levels usually increase. The pituitary-adrenal axis is triggered, with an associated rise in cortisol, glucose, and free fatty acids circulating. Muscle enzyme levels in the blood are increasing, meaning that muscle exertion is occurring, and the immune system is impaired. The number of white blood cells and neutrophils is increasing, and the number of lymphocytes, eosinophils, and monocytes is declining (Broom, 2003).

Behavioural Alteration

Animals are usually nervous and agitated at the start of a journey, and more often defecate and urinate. Behavioural changes also reflect the first indication of distress (Ayo *et al*., 2002). The numbers of social experiences are initially strong, but slowly declining as the circumstances of the animals slowly shift from entering a new environment to social regrouping, to confining on a lorry, to confining and motion. Adult bovine animals rise more during travel, but lay more during rehabilitation time (Eicher, 2001). Loading in cattle is more difficult than unloading because this was shown by the animal behaviour-mounts and battle bouts were infrequent and during loading balks and drops were slightly more common than unloading (Maria *et al*., 2004).

Immunosuppression

Transport activities are correlated with reductions in peripheral circulating lymphocyte numbers in animals (Earley and O'Riordan, 2006). In a study conducted in Holstein- Friesian bulls lymphocytes were taken after transportation and were cultured, and stimulated with concanavalin A, there was decrease in IFNγ production which suggested that reduction in the immune function (Gupta *et al*., 2007). After transportation, immunosuppressant predisposes calves to acquire bovine respiratory disease (BRD), which usually occurs during the first 45 days of arrival and is associated with 65-80% morbidity and 35-55% mortality.

Carcass Quality and Meat Quality

It has also been shown that stress caused by inhumane transport of food animals decreases the quality of meat produced from those animals, resulting in the supply of low-quality meat to the consumer public (Ibironke *et al*., 2010). Transport primarily affects carcase consistency in terms of the level of bruising. McNally and Warriss (1996) also found more bruising from auction markets among slaughter cattle, and also found that the bruising extent increased with the distance travelled and the time spent in lairage. In a study conducted on lamb by Miranda-de la Lama *et al*. (2011) it was seen that meat from lambs transported on unpaved roads had higher ultimate pH, higher tenderness, and dark-cutting characteristics, with a darker colour, than lambs transported on paved roads.

Various Methods for Mitigating the Transport Stress

Pre-Loading Precautions

Pre-mixing of cattle or pigs leads to more familiarity and these animals travel better than alien animals. Cattle should be mixed 24 hours prior to loading in a pen (BIS, 2007). During this time, victimized or wild animals may be weeded out. Fighting among strangers pigs is common, leading to damage to the skin, wounds and stress. Before loading, smearing pigs with litter or excreta from the same pen mix the pigs from different pens together so they smell similar. Do not mix in vehicles horned and hornless animals as these cause bruise and injury. Feet should not be tied, and every 30 minutes or so animals should be rotated. Pigs should not travel with other animals unless there is a partition separating them. Unless separated by a strong partition, the bulls should not be carried along with other

stocks. Animals that are diseased, wounded, emaciated or heavily pregnant should not be transported, so they should be unhealthy, heavy; animals fed with pen should not move too far as they cannot hold up to the transport rigors. Vehicles should have a portable ramp to allow emergency unloading in the event of prolonged breakdown.

Loading and Unloading

Burdick *et al.* (2010) and Grandin (2001) have convincingly argued that proper design of handling facilities, combined with well-trained handlers who are familiar with low-stress cattle handling techniques, can significantly reduce the stress experiences of cattle when loaded or unloaded, as well as at other times during the overall sequence of sorting, penning, processing and transposition.

Vehicles Used for Transportation

Any vehicle used for livestock transportation should have adequate ventilation, a non-slip floor with adequate drainage and safety from sun and rain, especially for pigs (OIE, 2019). Side surfaces should be smooth, and no protrusions or sharp edges should be present. No vehicle should be fully fenced in. The sides of the vehicles should be high enough to prevent animals from falling out and injuring themselves, especially pigs.Effective heat exchange, which is accomplished by regulating heat loads with suitable ventilation techniques, is needed in optimal on-board thermal environments (Mitchell and Kettlewell, 2008). Broilers and other poultry such as turkeys or ducks are better transported by road. Bird flocks can be subdivided into cages in limited numbers. Plastic crates are recommended which can be stacked on top of each other on a vehicle and which can be quickly washed after use (Weeks, 2012).

Space Allowances for Road and Rail Transport of Livestock as per BIS 2007

a) Transport by road or rail space allowance for cattle

Class	**Weight**	**Mean Cattle Dimensions (m)**	**Space Required (m^2)**	**Space Required (m^2)**
Calves		Width x Length	Unhorned	Horned
	Up to 50 kg	0.27 * 1	0.28	0.28
	50-100	0.46 *1.32	0.56	0.56
Cattle /Buffaloes (Young/Adult)	100-200	0.46 * 1.33	0.62	0.73
	200-300	0.56 * 1.52	0.86	0.96
	300-400	0.64 * 1.65	1.06	1.2
	More than 400	-	>1.27 to 1.73	>1.59 to 2

b) Transport by road or rail space allowance for sheep and goats

Class	**Weight**	**Mean Woollen Sheep/Goat Dimensions (m)**	**Space Required (m^2)**	**Space Required (m^2)**
		Width x Length	**Woolen**	**Shorn**
Lambs	Up to 15 Kg	0.24 * 0.6	0.15	0.15
	16- 20 Kg	0.25 * 0.7	0.17	0.16
Sheep/goats (Adults)	21-25	0.26 * 0.74	0.18	0.16
	26-30	-	0.22	0.2
	31-40	-	0.25	0.24
	41-55	0.35 * 0.91	0.3	0.28
	More than 55	-	> 0.40	> 0.40

In cows and buffaloes the size of the partition should be two square metres, while for horses and mares, it should be 2.25 square metres. For sheep and goats, it has specified size of 0.3 square metres, while for pigs it is 0.6 square metres. For poultry it would be 40 square centimetre (Central Motor Vehicles Rules, 2015).

Driving

Cars should be driven softly, without abrupt stops or jerks. Turns should be taken gently and slowly. In addition, the skill of pre-slaughter logistics depends on the perspectives or future training of drivers (Villarroel *et al*., 2001). Train drivers should stop "jump shunting" of livestock lorries. High ambient temperatures during transport can increase the risk of heat stress and mortality. Transporting animals in vehicles is important during the cooler mornings and evenings, or even at night. This is particularly so for pigs.

Age and Health Status Prior to Transportation

Age, experience, food deficiency level, animal health status and fitness can affect the welfare effects of long journeys (Lewis and Berry, 2006; Averos *et al*., 2008). Nevertheless, livestock transported for slaughter due to illness can be considered to be less suitable for long transportation than healthy herd members, as the transportation can cause, increase or prolong discomfort and other forms of suffering associated with the disease. Of similar purposes, livestock, such as spent hens and multiparous sows and cows, are likely to be less suitable of transport of any duration at the end of their active life than younger livestock brought for slaughter. Schwartzkopf-Genswein *et al*. (2007) found that previous exposure to transport of calves strengthened their ability to withstand transport and handling stresses.

Water and Food Supply at Regular Intervals

Providing access to food and perhaps more importantly water is one of the major concerns when transporting animals for long periods of time. Sheep tend to be more resilient to food and water scarcity than most other livestock (Cockram *et al*., 1997), whereas horses can be vulnerable to excessive hunger and starvation on long journeys, as they are unwilling to drink during travel and from unknown sources (Mars *et al*., 1992). Newly weaned pigs are unlikely to benefit from long trip breaks, because they are not yet accustomed to eating solid food and drinking water (Dybkaer *et al*., 2006). The innovative ways of providing the transport vehicle with accessible food and water are being developed so that breaks can be achieved simply by stopping the vehicle in a sheltered area for a period of time, allowing for the possibility of feeding and drinking, as well as proper rest.

Rest and Fatigue

Cattle need recumbent rest but rarely lie down while on the vehicle (Tarrant and Grandin, 2000), while sheep, pigs and poultry lie down during transportation, although there may be insufficient rest (Cockram *et al*., 1996). On long-duration journeys, ensuring that floor conditions and stocking density allow proper rest to take place is more critical (Petherick and Phillips, 2009). Driving efficiency and various aspects of vehicle design such as shock absorption are factors that affect the comfort of the animals being transported (Cockram *et al*., 1996).

Electrolyte-Mineral Feeding

The significance of balancing dietary ion charges and electrolytes to improve efficiency has been recognized for some years in dairy cattle (Beatty *et al*., 2007). Until transit, electrolyte enrichment of cattle tends to reduce shifts of osmolality on arrival relative to control animals (Schaefer *et al*., 1992). Until transit, electrolyte enrichment of cattle tends to reduce shifts of osmolality on arrival relative to control animals (Schaefer *et al*., 1992). In addition, incorrectly applied, electrolyte treatments may be counter-productive resulting in depletion of potassium and diarrhoea.

High-Energy Feeding

Energy loss or hypoglycemia is one of the typical effects of animal transportation and handling. Subsequently, attempts have been made to alleviate this condition by electrolyte nutritional therapy and high-energy diets before or after transportation. Nutritional supplements in the form of pre-transport energy result in hot carcass weight gains as cattle are shipped to market (Grumpelt *et al*., 2015). This method has been shown to be successful both in the management of animal efficiency in feedlot (Cole *et al*., 1988) and in the regulation of aberration of meat quality and carcass yield (Eldridge and Winfield, 1988). This time scheme would obviously not be consistent with other business realities, such as those at abattoirs and sales yards. Jaggery is a healthy source of energy.

Vehicle and Equipment Sanitation

Agroterrorism is a real concern for the livestock sector today. Trucks, trailers and other vehicles used to move livestock, meat products, goods, feed and offal are at possible risk of disease propagation (Poumian, 1995). The livestock transport sector of agriculture can be particularly vulnerable partly due to increased susceptibility of livestock to disease and lack of farm- and food-related security and surveillance. So, this can be prevented by regular sanitation. The thermo-assisted drying and decontamination (TADD) method was developed by Dee *et al*. (2005) to remove the virus within 20 to 30 minutes after treatment. To eradicate the pathogens, the TADD protocol consists of using hot air to heat the interior of the transport vehicle to a surface temperature of 71°C. This protocol is used successfully in elimination of pathogens in transport vehicles. It has been estimated that more than 90% of pathogens are eliminated by thorough cleaning of the interior and exterior of cattle transport vehicles, while permitted disinfectants will remove an additional 6% to 7% of pathogens (Barrington *et al*., 2002).

Inclusion of Mineral and Vitamin in the Diet

Vitamin C is a natural antioxidant that helps minimize the amount of free radicals in the body and thereby prevents any adverse effects on the body. Vitamin C reduces the gradual levels of radicals that arise as a result of stress during transportation (Chambial *et al*., 2013). Vitamin E also reduces morbidity and stress in transported animals (Carter *et al*., 2000; Choat *et al*., 2000). Supplementation of Chromium reduce morbidity and increase average daily weight gain (Moonsieshageer and Mowat, 1993).

Conclusion

While long-term animal transport is more likely to compromise animal welfare than shorter journeys, it is important to note that it is not the length of the journey but the related negative factors that are the cause of the welfare problems that have been identified and stress on the animals. Factors such as high temperatures and lack of food, water and rest are all compounded by the exposure intensity, and therefore the duration of the journey. In several of our farm animal species, those things are most definitely solvable. Consequently, assuming that conditions are ideal, most safe and fit farm animals may potentially be subjected to long transport times without actually affecting their welfare. Rail route is a more convenient transportation method than other roads. Livestock must undergo pre-travel rest periods. Transportation during the summer season resulted in greater loss of body weight. At any stage during marketing, even on the home farm, mixing groups of unfamiliar animal's results in increased antagonistic behaviour, poorer welfare and poorer meat quality, especially among bulls. Marketing processes should be designed to minimize the extent to which mixing needs to occur.

Conflict of Interests

There is no conflict of interest.

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