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Environmental and Management Stressors: Implications for Reproductive and Productive Performances of Farm Animals in the Tropics

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Abstract. This review examined environmental and management stressors of farm animals and the effects they have on reproductive and productive performances of livestock. Stress is revealed by the inability of an animal to cope with its environment, a phenomenon that is often reflected in a failure to achieve reproductive, productive and genetic potentials. Identification of environmental and management factors/stressors of farm animals is a major step to minimizing and treating stress in livestock. Environmental stress is not limited to climatic factor but extends to nutrition, housing and any stimuli that demand a response from the animal to adapt to new circumstances. Understanding of stressors that impact domestic farm animal productivity and management practices that can relieve stress within the environment will enhance animal comfort and help animal farmers maintain a secure, productive and low-cost food supply. Furthermore, a better understanding of the environmental and management stressors of farm animals and the effects on animal's reproductive and productive performances will enable farmers to establish and maintain suitable environments and employ proper management practices to our farm animals.

Keywords: Environment, management, stressors, implications, farm animals

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1. INTRODUCTION

Physiologists define "stress" as external body forces that tend to displace homeostasis and "strain" as the internal displacement brought about by stress (Stott, 1981). In animal husbandry, stress has actually been conceived as a reflex reaction that occurs ineluctably when animals are exposed to adverse environmental conditions and which is the cause of many unfavourable consequences ranging from discomfort to death (Etim *et al.,* 2013). As reported by Dobson and Smith (2000), stress is revealed by the inability of an animal to cope with its environment, a phenomenon that is often reflected in a failure to achieve genetic potential. Stress in general is looked down as a symptom resulting from exposure of an animal to a hostile environment. To some, it is a non-specific response to all environmental forces; others feel there are specific stress symptoms caused by specific environmental forces. The term stress is sometimes used to describe the hostile environment (Stott, 1981). There are environmental forces that are continuously acting upon animals that disrupt homeostasis, resulting in new adaptations that can be either detrimental or advantageous to man's interest (Stott, 1981). The natural environment is composed of various potentially hostile stressors. It is a basic requirement of life that the cells of an organism must be maintained within closely defined physiological limits. The maintenance of a constant interior milieu results from physiological and behavioural homeostatic adaptations. The physiological regulation of homeostasis is achieved by complex endocrine interactions, principally by the hormones secreted from the adrenal glands (Harvey *et al.,* 1984).

Inability of livestock farmers to identify or recognize environmental factors and management practices that pose stress to farm animals may result in lower performance and reproductive ability of animals leading to shortage of animal and animal products supply. Understanding of stressors that impact domestic farm animal productivity and management practices that can relieve stress within the environment will enhance animal comfort and maintain a secure, productive and low-cost food supply (Curtis, 2012).

This review identified environmental and management stressors of farm animals and their impacts on animals' reproductive and productive performances which will effectively guide farmers in proper management of livestock.

2. ENVIRONMENTAL AND MANAGEMENT STRESSORS

Environmental stress is not limited to climatic factor but extends to nutrition, housing and any stimuli that demand a response from the animal to adapt to new circumstances (Lee, 1993). As reported by Gwasdaukas (1975) of environmental stressors that affect reproductive efficiency, adverse effects of heat stress are most dramatic and the most documented. Other stressors include: animal handling techniques, environment, transportation, disease, management techniques and changes in day length among others.

a. Thermal Stress

Cold or heat stress can affect young or sick animals much more severely than mature, healthy animals (Stull, 1997). Thermal comfort may be quantified as the thermal neutral zone. In the calf, the range is 50 to 85°F in still air (Stull, 1997). This optimal thermal environment promotes maximum performance and provides the least stress for the calf. Within this thermal neutral zone, the calf can maintain body temperature, or homeothermy, by constriction or dilation of blood vessels, changing postures or behaviour, changes in hair, or by sweating and panting. As air temperature falls below 50°F known as the lower critical temperature, the calf must divert food energy from production or growth to produce additional metabolic heat and maintain body temperature. This ultimately leads to a reduced feed efficiency.

i. Cold Stress

Cold stress has been shown to decrease the rate of absorption of colostrums in new born calves. The upper critical temperature, approximately 85°F, is reached when the calf cannot dissipate enough metabolic heat to the environment to maintain homeothermy. Thus, food intake is reduced, thereby lowering heat production generated by digestion and absorption of nutrients. This decreases the growth rate in calves. Other environmental factors such as

humidity, wind chill factors and moisture due to rain or mud affect the upper and lower temperature of the environment (Stull, 1997).

ii. Heat Stress

High ambient temperatures, high direct and indirect solar radiation and humidity are environmental stressing factors that impose strain on animals. Despite having well developed mechanisms of thermoregulation, ruminants do not maintain strict homeothermy under heat stress. There is unequivocal evidence that hyperthermia is deleterious to any form of productivity, regardless of breed and stage of adaptation. The best recognized effect of raised body temperature is an adaptive depression of the metabolic rate associated with reduce appetite. Thus, in domestic ruminants, a rise in body temperature marks the transition from aversive stage to noxious stage. Factors such as water deprivation, nutritional imbalance and nutritional deficiency may exacerbate impact of heat stress.

Stress of hot environment lowers reproductive efficiency in farm animals. Hot weather causes heat stress in animals. Although, effects are more severe in hot climates, dairy cattle in areas with relatively moderate climates are also exposed to periods of heat stress. The resultant decrease in milk production and reproductive efficiency can be offset by implementation of a program consisting of cooling through ventilation, spray and fans. The economic benefit should be determined before the installation of equipment to reduce heat stress.

Gwasdauskas (1975) reported that heat stress will delay puberty in both males and females. Puberty was delayed in Hereford heifers reared at 27°C (80°F) as compared with others reared at 10°C (50°F). Similarly, puberty was delayed in Jersey bulls that were exposed to a 35°C (95°F) for 8 hours a day. Heat stress delays puberty by depressing appetite and slowing growth rate. Hot conditions in most parts of the world are severe enough to lower semen quality resulting in lower conception rate. Spermatozoa in semen collected from bulls during the summer/hot periods show an increase in abnormal morphology and reduce binding to glycosaminoglycans such as heparin.

Skinner and Louw (1966) reported that at a temperature of 40°C, it was found that as little as 12 hours exposure proved critical to optimum

spermatogenesis, and a decline in semen quality occurred after a week at this temperature. Field studies by Venter *et al.* (1973) showed that, at temperatures greater than 18°C, eleven out of twelve short horn bulls were culled either on the basis of poor semen quality or abnormalities of the genitalia, while only one of ten Africander bulls was culled.

Hafez (1967) stated that heifers maintained under temperatures of 10°C reached sexual maturity at 10 months, while those kept under temperatures of 27°C matured at 13 months, possibly as a result of reduced growth at high temperatures. Delayed onset of puberty, particularly, in Bos indicus cattle, constitutes a major limiting factor in the breeding of yearling heifers for beef production. Bonsman *et al.* (1972) found that 2 year old Bos taurus heifers, when imported from a temperate region to subtropical region, suffered an overall drop in calving percentage from 80 to 43 percent. The birth weight of calves born to unadapted European breeds following a summer pregnancy in the tropics is often lower than that of indigenous breeds (Hafez, 1967). This effect was quantified by Bonsma *et al.* (1972) who found that with calves born following a summer gestation in the subtropics, 33 percents were classified as dwarfs.

According to Gwasdauskas (1975), European type cattle in subtropic regions have shorter periods of estrus during the hot seasons than during cooler seasons. More estrus, quiet ovulations and missed detection of oestrus have been reported (Gwasdauskas, 1975). Likewise, sows have a longer period of post-weaning anestrus during the hotter months than in colder months. While true anestrus in cows is not likely prevalent. If cows, ewes and sows are bred during the summer/hot periods, lower fertilization rates and higher embryo mortality will result.

A combination of high humidity and high ambient temperature can have profound adverse effect on milk production. Thus, Johnson *et al.,* (1963) found that the milk yield of forty Holstein cows was seriously depressed by high humidity above an air temperature of 27°C. Under hot room in the United States of America, Richardson (1961) found that the butter fat yields of Holstein cows fell at temperatures above 27°C while Rees (1964), working with various crossbred cows in Tasmania, noted a fall in fat percentage at temperature

around 28°F, high temperature also results in rise in chloride content of milk and a fall in the milk sugar and total nitrogen content. This, and other works on the effect of increased environmental temperature on milk production of cattle, have been reviewed by Findlay (1954), Hancock (1954) and Bianca (1965).

Many experiments have measured the extent of reduction in feed intake as a result of thermal stress. Bianca (1965) found the dry matter intake of Aryshire steers decreased to 5.2kg/day at 40°C having been 7.4kg at 15°C. A long term experiment conducted between 1942 and 1963 sought to quantify the effects of temperature and humidity on weight gain (Mcllvain and Shoop, 1971). They found that high temperatures in conjunction with high humidity levels substantially reduced weight gain of beef steers.

It is accepted that heat stress is among the major cause of lost in production and lost profits in poultry, swine, beef and dairy cattle. The thermal comfort zone for most animals is between 4°C and 25°C. When temperature exceeds 25°C, animals suffer heat stress. In severe cases of heat stress, the deep body temperature rises, animal cells are affected and productive performance is reduced. The effect is increased when the relative humidity is greater than 50%. Animals typically react to heat stress by eating less food, thus, naturally controlling the rise in deep body temperature caused by digestion. Respiratory rate rises and there is a marked increase in insensible heat loss by evaporation of water from the lungs. They also drink at least five (5) times the amount of water they would, under normal temperate conditions, urine output increases and many mineral ions are lost. The body needs continuous supply of electrolyte which balances the body fluids in and around the cells.

3. ANIMAL HANDLING TECHNIQUES

One stressor which is easily eliminated is the improper handling of calves by caretakers which can cause both behavioural and physiological stress (Webster, 1983). This can sometimes adversely affect reproduction. Rearing gilts in confined pens as compared with group pens has delayed puberty. In a research trial by (Gwazdauskas, 1975) it was reported that rearing gilts in confinement reduced the number cycling at 9 months of age by 14 percent units (71 vs 85%).

Beef cows, isolated and confined in a corral either before or after insemination. Transporting animals to a new location has altered estrus cycles and delayed ovulation, as has constraints and mild shock. These examples illustrate that animal handling techniques which are psychologically disturbing to animals will sometimes adversely affect reproductive efficiency (Gwazdauskas, 1975).

According to Hemsworth (2011) a stockperson's attitude and behaviour has a significant effect on animals fear, welfare and productivity. Human behaviour eliciting certain animal responses have been measured as positive or negative. A negative handling behaviour, such as slaps, hits, fast movements, shouting and noise will cause an increase in fear in the animal, resulting in avoidance, stress and handling difficulties. Positive stockperson's behaviours such as pats, strokes, talking, hand resting on the back, slow and deliberate movements will reduce the animal's level of fear of human and result in animal, which are less stressed and are easier to handle. These effects have been demonstrated in many farm animal species. Negative handling significantly increases an animal's cortisol response, that is; stress. Animals exposed to positive handing had a much shorter flight distance, acute cortisol responses were significantly lower compared to animals that had received negative handling. A study by Hemsworth (2011) showed that the growth rate of positively handled pigs was 455g/day, whereas it was only 404g/day in pigs negatively handled. The growth rate of inconsistent pigs was 420g/day. In this situation, the growth rate was reduced due to the animal stress response (cortisol concentrations were elevated in inconsistent and negatively handled pigs) (Hemsworth, 2011).

A similar study was carried out in laying hens, looking at the negative effects of negative handling. The corticosterone stress levels were much higher in hens handled negatively, than in positively handled hens. Subsequently, egg production in the hens was 8% higher in hens that had a positive human-animal relationship. The number of studies across species with strong correlation between stress and negative handling leaves no doubt that negative handling evokes stress, affecting animal welfare and production (Hemsworth, 2011).

In a study by Grandin (1998) it was observed that reducing stress during handling will provide advantages of increased productivity and maintaining meat quality. It was indicated that cattle that become agitated and excited in the squeeze chute have significantly lower weight gains, tougher meat, and more borderline dark cutters (Voisnet *et al.,* 1997). Agitation and excitement in the squeeze chute are influenced by both genetic factors and the animal's previous handling experiences. Reports from commercial feedlots indicated that quiet handling methods help improve productivity. Short term stressors that occur during handling and transport have been shown to interfere with the biological mechanisms of both reproduction and immune functions. Electric prods, restraint and other handling stressors will lower female reproductive functions (Stott *et al.,* 1975; Hixon *et al.,* 1981; Stoebel and Moberg, 1982;). In both pigs and cattle, transport or restraint stress lowers immune functions (Kelly *et al.,* 1981; Mertshing and Kelly, 1983). In cattle, the stress imposed by transit has a greater detrimental effect on animals physiology than the stress of feed and water deprivation for the same length of time (Kelly *et al.,* 1981; Blecha *et al.,* 1984;). Transport stress can also lower rumen function compared to controls subjected to feed withdrawal (Fordyce, 1987). In sheep, chasing by dogs, handlings, and sorting, two or three weeks after mating caused early embryonic losses (Belyaev and Borodin, 1982).

Numerous studies showed that fearful pigs that have been treated aversively by humans have few piglets born, lower weight gains and chronic stress response (Hemsworth, 1993; Hemsworth *et al.,* 1989; Hemsworth and Barnett, 1991). It was found that pigs that had been slapped or shocked by their regular caretakers had lower weight gains (Hemsworth *et al.,* 1989). They also found that cows milked by a confident and quiet introvert had higher milk yields (Seabrook, 1972). Quiet handling of market weight pigs at the slaughter plant will help maintain pork quality. Rough handling, pile-ups and excessive use of electric prods prior to stunning will increase pale, soft, exudative pork (PSE) (Barton, 1984). Plant management reported than an additional 10 percent of their daily pork production was suitable for export to Japan because the incidence of PSE was reduced (Grandin, 1998b).

a. Effect of Novelty

Novelty is anything new or sudden change in an animals environment. Thus, novelty is a very strong stressor of farm animals (Dantzer and Mormede, 1983). A sudden novel event, such as a person stamping his foot in a pen of commercial pigs, is one of the best tests for determining genetic difference in the reactivity of pigs reared under identical conditions (Lawrence *et al.,* 1991). This test was superior to other tests such as willingness to leave a pen or movement eases through a hallway. Other example of sudden novel stimulus would be a stamping of foot, a train passing a pen where newly arrived calves are received, or an auction ring. The paradox of novelty is that it will cause an intense behaviour and physiological reaction when suddenly introduced to an animal with a flighty excitable temperament but the same flighty animal may be the most attracted to a novel object when allowed to approach it voluntarily. The most reactive and excitable pigs with the greatest startle reactions were also the most likely to voluntarily approach a novel bucket placed in their pen (Lawrence *et al.,* 1991). In cattle, breeds with the largest flight zone had the greatest tendency to approach novel objects or a person laying on the ground (Murphey *et al.,* 1980; Murphey *et al.,* 1981).

b. Improving Handling Practices

i. Move small bunches: Finishing pigs should be moved in small bunches of three to six during loading. On ranches, and feedlots, move small bunches of cattle that can be easily handled. The staggering alley leading to the truck loading ramp or processing area should only be filled half full.

ii. Do not overload the crowd pen: The crowd pen for pigs or cattle should be filled only ½ to ¾ full. Half full is best. It is important to avoid using the crowd gate if possible. On a round crowd pen, the crowd gate should be closed and set on the first notch and left there. It should not be used to push animals. Cattle and pigs need room to turn and should be handled in small discrete bunches, with spaces in between the bunches. For sheep, the crowd pen may be filled completely, as long as the sheep are not too tightly packed. Sheep should be moved in one continuous stream, never breaking flow, to maintain following behaviour.

iii. **Eliminate electric prods:** Use other driving aids such as plastic paddles or sticks with plastic streamers or flags tied on them. Use these devices to work the animal's flight zone and to turn the animals. These devices work better than plain sorting sticks, because the animals can see them easily.

iv. **Reduce noise:** Avoid yelling at animals, whistling or whip cracking. Cattle are more sensitive to high pitched noise than are people (Heffner and Heffner, 1983). They are more sensitive at 8000Hz (Ames, 1974; Heffner and Heffner, 1983), and more sensitive to sound than human ears at 7000 to 8000Hz. Clanging noises on steel should be silenced, and hydraulic systems should be quiet and designed to avoid the sound frequencies for which cattle have maximum sensitivity. On sequence chute, the clatter of side bars should be quieted with rubber pads. Reducing a high pitched whine in a hydraulic system resulted in calmer cattle (Grandin, 1993; Grandin, 1998c). In a pork slaughter engineering conveyor, equipment for reduced noise combined with quiet handling resulted in reduced squealing and pig pile-ups.

v. **Slow is faster:** Move pigs and cattle at a slow walk. Fearful animals are more likely to balk and are more difficult to handle. Handlers should move more slowly and deliberately. Sudden jerky motions frighten animals. In the wild, sudden movements are associated with predators.

vi. **Avoid isolating individual animals:** A lone animal left by itself will become stressed (Kilgore and Langren, 1970; Whitlestone *et al.,* 1970) and can also be dangerous to people. Grandin (1998b) observed that many handling accidents are caused by a panicked lone animal attempting to rejoin its herd mates.

4. ENVIRONMENT

Stull (1997) reported that other potential sources of stress include the environment; the physical components of the calf's environment include space available and the surfaces with which the animal comes in contact with. Flooring materials and space allocation in confinement systems have been studied in calf's system. Slippery surfaces should be avoided to prevent injury, both in individual stalls and group pens. Calved placed in group pens should be provided

with enough feeder space to allow all calves access. Water availability should also provide easy access, especially to the small, young calf. Another environmental stressor of the calf's environment which may have a greater impact on health and well-being is the waste management system. Toxic gases, especially elevated ammonia levels, can cause damage to the lung epithelium and precipitate respiratory disease. The calf may be continually exposed to these gases with the accumulation of manure and urine.

5. DISEASE

As reported by Stull (1997), stressor is that which results in the onset and spread of disease. The susceptibility of the calf depends on many factors including its immunity levels, pathogen challenge and preventive health program. The new born animal dependent on colostrums; the new born receive the colostrums within 24 hours and preferably within 6 hours to maximize the transfer of passive immunity. Colostrums, not only contains immunoglobulin, but also contains higher concentration of protein, fat, vitamins, and minerals compared to milk of later lactation. Thus, colostrums assist the new born both in immunity and enhanced nutrition. Cleanliness and stocking density can affect the pathogen challenge to the new born animals. Dry, sanitized and clean housing is important in minimizing disease. The umbilical cord should be dipped in 7% tincture of iodine solution to help prevent access to pathogenic bacteria. Vaccination and parasite programs are important components in effectively managing disease and parasite infections. Herd history and ages of animals will assist in planning an effective preventive health program.

6. OTHER STRESSORS

Other examples of common stressors in the management of dairy calves as identified by Stull (1997), and other animals include; management techniques such as ear tagging, dehorning or transportation. The stress caused by transportation have been reported to adversely affect animal welfare and cause economic losses related to mortality, carcass damage and reduced meat quality (Warrus *et al.,* 1994; Akinwumi *et al.,* 2013). Furthermore, transportation has

been shown to negatively affect the meat quality in terms of tenderness and overall acceptability (Villarroel *et al.,* 2013). It also results in increased plasma concentrations of cortisol, adrenaline, non-adrenaline and dopamine, shrinkage loss and deterioration in meat quality (Kadim *et al.,* 2006). It also alters serum concentration of animals (Lv *et al.,* 2010). The cardiovascular system is influenced by vibration, resulting in increased heart rate and blood pressure and peripheral vasoconstriction (Randall *et al.,* 1995). According to Von Borell *et al.* (2007), transportation is considered as a major stressor of farm animals and might have deleterious effects on the health, well-being, performance and ultimately on product quality. These management techniques should be planned to minimize the total additive effect of all stressors on the calf. Social stress can occur when young animals are isolated from herd mates or through interaction of an individual herd mates. Calves recently introduced to a herd and sick or injured calves may experience social stress.

Pigs in social groups are known to form hierarchies. Sows at the bottom of the hierarchy may produce litters of prenatally stressed piglets (Durham, 2010). The effects associated with prenatal stress in swine, however, are not caused by cortisol alone (Lay*,* 2010). They are continuing research to identify the other factors involved.

7. EFFECTS OF ENVIRONMENTAL AND MANAGEMENT STRESSORS ON ANIMALS

Environmental and management stressors erode efficiency and cost livestock production enterprises billions of dollars annually in lost potential profitability (WAAESD, 2012). For example in the absence of heat abatement measures, total losses across all animal classes averaged $2.4 billion annually as of 2003. Of the total, reduction in milk production potential represented a major portion of losses to the dairy industry, which averaged $897 million and $1.5 billion. Chronic stress on farm animals can have deleterious effects on their health, productivity and welfare. Acute stress at milking is most obviously apparent in a reduced milk yield resulting from inhibition of oxytocin secretion leading to increased residual milk (NMC, 2004). Adverse weather conditions

including the effects of hot and cold climatic conditions are particularly difficult for confinement beef cattle feeding enterprises (WAAESD, 2012) as well as other livestock enterprises. Dobson and Smith (2000) reported that field data from dairy cows show that stressors such as milk fever or lameness increase the calving to conception interval by 13-14 days, and extra 0.5 inseminations are required per conception. A variety of endocrine regulatory points exist whereby stress limits the efficiency of reproduction. High financial losses are incurred by the livestock industry as a result of carcass bruising (Grandin, 1981). Contrary to popular belief, livestock can be bruised moments before slaughter and stunned animal can be bruised until they are bled. Fear is a very strong stressor (Gradin, 1998). Bruising is an impact injury that can occur at any stage in the transport chain and may be attributed to poor design of handling facilities, ignorant and abusive stockmanship and poor road driving techniques during transportation (Grandin, 1981). Transport produces an immediate constant increase in Arginine Vasopression (AVP) and Corticotrophin-releasing hormone (CRH) secretion. Transport reduces the number of CL after superovulation and can interfere with pregnancy rates after estrous synchronization. According to Dobson and Smith (1995) reported that transport of post-partum cows or sheep before an oestradist-induced LH surge delayed gonadotrophin secretion possibly by affecting hypothalamic activity. Dobson and Smith (1995) further stated that in addition, reduced LH responses to GnRH were observed in cattle during transport. In sheep, adrenocorticotrophic hormone (ACTH) also diminished the LH response to GnRH, but only when GnRH was administered 3h after ACTH, not after 0.5h. It was suggested that very early suppression of LH secretion by stressors is not mediated by ACTH action at the pituitary but that immediate activation of the sympathetic nervous system maybe involved (Smith and Dobson, 2002). Stressors affect reproductive function through actions at the hypothalamus as well as impairing pituitary LH release induced by GnRH. Human-animal interactions influence stress responses in animals – the behaviour of stockman and embryo transfer personnel could affect success (Dobson *et al.,* 2001). Fear and pain are very strong causes of stress in livestock and stress affects the quality and value of meat from affected animals. Stress induced meat quality

problems such as dark cutters cause large monetary losses to the livestock industry. Antemortem glycogen breakdown is triggered by increased adrenaline release in stressful situations, or by strenuous muscle activity. To reduce stress, prevent fighting and preserve meat quality, strange animals should not be mixed shortly before slaughter (NMC, 2004). Efficient, experienced and quiet handling of livestock, using recommended techniques and facilities, as well as taking measures to eliminate pain and accidental injury, will reduce stress in animals and prevent quality deficiencies in meat and by-products (Chambers and Grandin, 2001).

8. CONCLUSION

Stress is any change in environment; that is alteration in climate or management that is severe enough to elicit a behavioural and physiological response from the animal. Inability of an animal to cope with its environment depicts stress and results in failure to produce and reproduce optimally. Environmental and management stressors erode efficiency and cost livestock production enterprises billions of dollars annually in lost potential profitability. Therefore identifying and understanding stressors of farm animals will effectively guide farmers in raising animals in suitable environments (comfort zones) and in employing proper management practices to improve the reproductive and productive efficiencies of livestock so as to prevent lost to livestock production enterprises. Putting aside financial aspects, exposure of animals to avoidable stress compromises welfare, whether biotechnology is involved or not. The fact that stressors can be deleterious to such an important function as reproduction emphasizes that stress is important and should be minimized whenever possible.

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