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Impact of Stress on Health and Productivity of Animal: A Review

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Abstract
Stress is any environmental change; including alteration in climate or management that is severe enough to elicit a behavioral or physiological response from the animal. The aims of this paper were to review the likely impact of stress on health and productivity of animal. Animals can be stressed by either psychological stress; restraint, handling or novelty or physical stress: hunger, thirst, fatigue, injury or thermal extremes. Thus, stressor can be any internal or external stimuli or threat that disrupts homeostasis of the body, and elicits a coordinated physiological response within the body in an attempt to reestablish homeostasis. The stress response includes several changes that may have negative effects on the health and performance of animals. These effects include changes in the immune function and increased susceptibility to disease, decreased feed intake and rumination, inhibition of oxytocin release, reduced fertility and effect on meat and by-product quality. Susceptibility to diseases can be increased as a result of situations which are likely to be stressful. For example, several studies have shown an increase in the prevalence of mastitis in dairy cows as a result of chronic fear. The effect of thermal stress on fertility is multifactorial in nature, since hyperthermia directly alters and impairs the cellular functions of various parts/tissues on other body functions like redistribution of blood flow among body organs, reduction in food intake, respiratory alkalosis. More research should be conducted on stress and its impact on animal health and productivity to design and implement possible prevention strategy
Keywords: Animal health, animal productivity, stress

1 INTRODUCTION

Stress is a very broad concept and difficult to define in a concise way to capture all its connotations. Greek philosopher Hippocrates perhaps was the first to attempt to define the word stress in terms of 'balance' which was conceived as an essential state of health and 'disharmony' which manifested as disease when perturbed (Aich *et al*., 2009). In the early 20th century Hans Seyle proposed the general adaptation syndrome which provided the first comprehensive biological theory of stress (Griffin, 1989). In a veterinary context this was identified as an abnormal or extreme adjustment in the physiology of the animal to cope with adverse changes in environment and management (Fraser *et al*., 1975). Stress is generally used in negative connotation and is described as the cumulative detrimental effect of a variety of factors on the health and performance of animals (Kumar *et al*., 2011). Stress can also be defined as any environmental change; that is alteration in climate or management that is severe enough to elicit a behavioural or physiological response from the animal (Etim *et al*., 2013). Stress is the condition where there is undue demand for physical and mental energy due to excessive and aversive environmental factors (stressors) and cause deformations those are identifiable through physiological disequilibrium (Ahmed *et al*., 2015).

From the above it is clear that stress can be defined in many different ways but all these definitions share a common component of adaptive physiological responses following challenges to homeostasis. Stressor can be defined as any internal or external stimuli or threat that disrupts homeostasis of the body, and elicits a coordinated physiological response within the body in an attempt to reestablish homeostasis (Asres and Amha, 2014). Animals can be stressed by either psychological stress; restraint, handling or novelty or physical stress: hunger, thirst, fatigue, injury or thermal extremes (Etim *et al*., 2013).

The different stressors that enhance stress in animal can be chemical stressors: poor water quality low dissolved oxygen, improper pH, Pollution intentional pollution: chemical treatments, accidental pollution: insect spray, Diet composition - type of protein, amino acids, Nitrogenous and other metabolic wastes accumulation of ammonia or nitrite. Biological stressors: population density - crowding, mixing of different species of animal aggression, territoriality, space requirements, Microorganisms - pathogenic and nonpathogenic, Macroorganisms internal and external parasites. Physical stressors: Light, sounds, dissolved gases and temperature. Temperature is one of the most important influences on the immune system of animals and Procedural stressors are handling, shipping and disease treatments (Altan *et al*., 2003; Asres and Amha, 2014).

Problems of stress as described by Moberg (200) include induced changes in the secretion of pituitary hormones, thus leading to altered metabolism, immune competence and behaviour, as well as failure in reproduction. Under prolonged or extreme stressful conditions, the effect of animal health can be very significant resulting in irreversible losses in productivity or even death. Thus , identifying impact of stress and developing and monitoring appropriate measures of animal stress and well- being, developing alternative management practices will reduce stress and improve animal well- being and performance (Etim *et al*., 2013). Therefore the main objective of this paper is to review the impact of stress on health and productivity of animal.

2 IMPACT OF STRESS ON HEALTH AND PRODUCTIVITY OF ANIMAL

The stress response includes several changes that may have negative effects on the performance of farm animals. These effects include changes in the immune function and increased susceptibility to disease, decreased feed intake and rumination, inhibition of oxytocin release, and reduced fertility (Nardone *et al*., 2010). Under heat stress, a number of physiological and behavioral responses vary in intensity and duration in relation to the animal genetic makeup and environmental factors. Climatic, environmental, nutritional, physical, social or physiological stressors are likely to reduce welfare and performance of animals (Kumar *et al*., 2011). Durham (2010) documented that animals feel stress too, and it can compromise their health and ability to thrive. That, in turn, can cost producers money. The detrimental effects caused by stressors encountered by animals during routine handling can pose serious economic problems for the livestock industry due to increased costs ultimately borne by the producer and the consumer (Burdick *et al*., 2011; Etim *et al*., 2013).

Stress reduces the fitness of an animal, which can be expressed through failure to achieve production performance standards, or through disease and death (Durham, 2010). There is some evidence linking stress with pathogen carriage and shedding in farm animals, the mechanisms underlying this effect have not been fully elucidated. Understanding when pathogen loads on the farm are highest or when animals are most susceptible to infection will help identifying times when intervention strategies for pathogen control may be most effective and consequently, increase the safety of food of animal origin (Rostagno, 2009).

As reported by Reid and Bird (1990) animals raised in less than ideal conditions may have reduced weight gain, milk production, birth weights and survival while making stock management more difficult. The behavioural response of livestock to handling can also negatively affect management and production as wilder animal can increase the risk of injury to both the animal and producer (Burdick *et al*., 2011). Low reproductive efficiency in dairy cows inflicts heavy economic losses all over the world. One of the important contributing factors in low fertility is the environmental stress. The effect of thermal stress on fertility is multifactorial in nature, since hyperthermia directly alters and impairs the cellular functions of various parts/tissues on other body functions like redistribution of blood flow among body organs, reduction in food intake, respiratory alkalosis (Abdelatif & Alameen, 2012).

2.1 Impact on Immune Function and Susceptibility of the animal to Disease

It is known that stressors of various types (psychological/physical) can alter the physiological levels of certain hormones, chemokines and cytokines. These alterations send information to the central nervous system to take necessary action which then sends messages to appropriate organs/tissues/cells to respond. These messages can either activate or suppress the immune system as needed and failure to compensate for this by the body can lead to serious health-related problems (Aich *et al*., 2009). Studies have linked a variety of psychological stressors with an increased incidence and severity of respiratory infections in animals (Sheridan *et al*., 1991; Hermann *et al*., 1993). Stress can suppress immune function. However, the ways in which chronic stress suppresses the immune system are highly specific, and only some types of defense against disease are affected. When the stress response involves the release of glucocorticoid or catecholamines, the capacity of cellular immune mechanisms is reduced. In practical terms, this means that some disorders are more likely to be precipitated by chronic stress than others. These include respiratory infectious diseases and Salmonella sp. infection. For example, transport stress has been shown to increase pneumonia caused by bovine herpes virus-1 in calves, in beef cattle and exported animals. Pneumonia caused by Pasteurella sp. and result mortality in calves and sheep, and salmonellosis in sheep and horses (Manteca *et al*. 2013)

Susceptibility to other diseases can also be increased as a result of situations which are likely to be stressful. For example, several studies have shown an increase in the prevalence of mastitis in dairy cows as a result of chronic fear. Although the precise mechanism explaining this effect is not known, it has been suggested that the function of the natural-killer cells could be impaired as a result of stress and this in turn could lead to an increased susceptibility of the mammary gland to infectious agents. The stress of weaning is known to increase the risk of digestive disease in several species (Asres and Amha, 2014).

It has been have confirmed with the infectious BRD model that the stress of weaning and significantly enhances the viral–bacterial synergy leading to fatal bacterial respiratory infection (Hodgson *et al*., 2005) The major stressors young cattle experience include maternal separation or weaning, dietary changes, transportation, social reorganization and other environmental effects.in study by Jericho *et al*.(1982), fifteen suckling calves were removed from their mothers 24 h prior to viral infection (abruptly weaned/stressed, AW). A second group of 15 calves was weaned 2 wks prior to viral infection (pre-conditioned/ control, PC); 2 wks was chosen as an appropriate interval to eliminate psychological and physiological effects associated with breaking the maternal/nutritional bond and to adapt to the dietary change and social re-organization that follows weaning. All calves were transported to Vaccine and Infections Disease Organization VIDO, and aerosol challenged with bovine herpesvirus-1 (BHV-1) followed by *M. haemolytica*; this combined viral–bacterial infection induces fatal pneumonia in 50%–70% of calves.

clinical analyses revealed a significant difference in BRD clinical disease when comparing freshly weaned calves (80% mortality) versus pre-conditioned calves (40% mortality) (Hodgson *et al*., 2005; Aich *et al*., 2007). Increased mortality associated with fresh weaning was characterized by a decrease in both survival time post-infection and, interestingly, decreased lung pathology which suggested a systemic reaction. Contrary to expectations, transportation induced a significant cortisolemia in pre-conditioned but not freshly weaned calves. Cell mediated immunity since stressors have been associated with increased circulatory concentration of glucocorticoid; they also have been linked with decreased functioning of the cells of the immune system. Heat stress reduced serum IgG1 in calves associated with an increased Cortisol concentration and extreme cold stress also reduced colostral immunoglobulin transfer. Thus, environmental extremes can influence disease resistance in dairy calves. (Asres and Amha, 2014). There are reports which suggest that transport can be an important stressor which alters blood leukocyte populations and sets the stage for BRD (Chirase *et al*., 2004).

2.2 Impact of Stress on Hormonal Changes

(Lay, 2010) reported that prenatal stress from restraint (of dams) and stress hormones injection of sows caused offspring to have increased plasma cortisol levels in response to stress and less ability to heal wound when subjected to stress. Cortisol is a glucocorticoid – a class of steroid hormones that suppress the immune system. Cortisol can also raise blood pressure and blood sugar levels. Prenatal stress has been shown to cause an increase in fetal cortisol, which may in turn impair immune function and increase the maximum binding capacity of glucocorticoid receptors in the central nervous system immediately after birth. 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). Phillips and Santurtun, (2013) reported that the simultaneous relationship among thermal stress, plasma aldosterone level and urine electrolyte concentration in bovines. During prolonged heat exposure plasma aldosterone level was reported to decline. Concurrent with this, there were significant fall in serum and urinary K^+. Sparke et. al. (2001) reported an increase in plasma prolactin concentration during thermal stress in dairy cows. Alteration in prolactin secretion may be associated with altered metabolic state of heat stressed animals. One possibility is that prolactin is involved in meeting increased water and electrolyte frequently demands of heat stressed animals.

2.3 Impact on Metabolic Changes

According to Altan *et al*. (2003) heat stress increase lipid peroxidation which was associated with production of large number of free radicals which are capable of initiating peroxidation of polyunsaturated fatty acids. Ralhan *et al*. (2004), also reported that lipid peroxidation is significantly increased during reticulo-ruminal impaction in buffaloes. Heat stress may lead to increased production of transition metal ions (TMI), which can make electron donations to oxygen forming superoxide or H_2O_2 which is further reduced to an extremely reactive OH radical causing oxidative stress (Agarwal and Prabhakaran, 2005).

High ambient temperature can adversely affect the structure and physiology of cells causing impaired transcription, RNA processing, translation, oxidative metabolism, membrane structure and function. Cells generate small amounts of free radicals or reactive oxygen species (ROS) during their normal metabolism. Although low levels of ROS are essential in many biochemical processes, accumulation of ROS may damage biological macromolecules i.e. lipids, proteins, carbohydrates and DNA (Kumar *et al*., 2011).

According to Rampal *et al*. (2002) catalase activity is reduce in oxydementon- methyl induced oxidative stress in buffaloes. Similarly Sharma *et al* (2004) also reported molybdenum induced oxidative stress in crossbred calves. Heat stress in lactating animals results in dramatic reduction in roughage intake, gut motility and rumination which in turn contribute to decreased volatile fatty acid production and may contribute to alteration in acetate: propionate ratio. Rumen pH also declines during thermal stress (Collier *et al*., 1982). Heat stressed animal, particularly a lactating cow, might experience metabolic ketosis as energy input would not satisfy energy need and thus accelerate body fat catabolism accumulating ketone bodies if they are not rapidly excreted. These ketone bodies deplete blood alkali reserves, possibly potentiating respiratory alkalosis (Kumar *et al*., 2011).

2.4 Effect of Stress on Feed Intake and Rumination

The negative effect of stress on feed intake has long been recognized, although the precise pathways involved are still debated. It is likely, however, that the inhibitory effect of stress on appetite results from a complex interplay among leptin, glucocorticoid and the CRF. There is some evidence suggesting that stress may have an inhibitory effect on rumination and this in turn may reduce feed digestibility and therefore performance, and may also increase the risk of ruminal acidosis. The precise mechanism underlying the effect of stress on rumination is not know, but it is interesting to highlight that brain activity during rumination is similar to that during sleep, and stress is known to interfere with sleep (Manteca *et al*., 2013).

2.5 Impact on reproduction

According to Adams (2004) stress reduces the fertility of domestic animals by disrupting the intricate and precisely regulated hormonal cascade that controls the gonadal development and functions. As a consequence, stress retards development of ovarian follicles, reduces ovulation, increase embryo and fetal loss, extends the interval from claving or lambing to conception and increases the services required per conception. Therefore, reproductive performance and reproductive failures can be used as one of several measures of animal welfare (Ahola, 2008).

Under stress, there is a negative feedback effect of progesterone on luteinizing hormone (LH) increasing the first. Are elevated cortisol levels with subsequent depression, there are changes in the release of LH. The level of prostaglandin F2 alpha (PGF2 ∞) and ACTH increase. The levels of epinephrine and norepinephrine also increase. All this adversely affects reproductive function in mammals (Alejandro *et al*., 2014). Fertility in lactating cows varies by season. In the winter, decreases about 50%, 20% in the summer and fall is lower than in the winter. A few years earlier, Brown-Brandl *et al*., (2005) reported that conception rates fell from 52% in winter to 24% in the summer. In summer, 80% of estrus may be undetectable. Brown-Brandl *et al*., (2005) indicated that, the rectal temperature of the animals increased from 38.5˚C to 40˚C in 72 hours after insemination service, pregnancy rates can decrease up to 50%. Heifers and cows studies have indicated that the decline in oocyte quality in the early postpartum period is associated with negative energy balance and low body condition of the animals, which is expressed in developing embryos increased and abnormal having embryos resulting in loss of the hottest months of the year (Mitlöhner *et al*., 2001). Heat stress impairs follicle selection and increases the length of follicular waves; thus reducing the quality of oocytes and modulating follicular steroid genesis (Asres and Amha, 2014). Environmental stress can cause low sperm quality, which is closely related to low fertility in females, probably due to a combination of low fertilization rates and increased embryonic mortality (Alejandro *et al*., 2014).

Moberg (200) reported that stress may result to induced changes in the secretion of pituitary hormones, thus leading to altered metabolism, immune competence and behaviour, as well as failures in reproduction. If the biological cost of stress is greater than the biological reserves needed to satisfy these costs. In other words, resources are shifted from other biological functions to stress response, thereby impairing these other functions. Thus, stressful conditions could diminish reproductive success. Stress is responsible for sub-fertility (Dobson and Smith, 2000). It has been indicated that in cattle, embryonic development is highly sensitive to high temperatures, in the top three to 11 days after service; acquiring more heat tolerance as the gestation period progresses (Bhatia and Tandon, 2005). It is known that the embryos obtained by in vitro fertilization (IVF) are more susceptible to heat stress than those obtained under natural conditions. In this regard, (Freestone *et al*., 2008) indicated that the greatest loss of bovine embryos from IVF, occur before 42 days, when females are under heat stress.

2.6 Impact on meat and by-product quality

According to FAO (2001) effect of stress on meat and by-product quality can be summarized as follows. The energy required for muscle activity in the live animal is obtained from sugars (glycogen) in the muscle. In the healthy and well-rested animal, the glycogen content of the muscle is high. After the animal has been slaughtered, the glycogen in the muscle is converted into lactic acid, and the muscle and carcass becomes firm (rigor mortis). This lactic acid is necessary to produce meat, which is tasteful and tender, of good keeping quality and good color. If the animal is stressed before and during slaughter, the glycogen is used up, and the lactic acid level that develops in the meat after slaughter is reduced. This will have serious adverse effects on meat quality.

Pale Soft Exudative (PSE) meat: PSE in pigs is caused by severe, short-term stress just prior to slaughter, for example during off-loading, handling, holding in pens and stunning. Here the animal is subjected to severe anxiety and fright caused by manhandling, fighting in the pens and bad stunning techniques. All this may result in biochemical processes in the muscle in particular in rapid breakdown of muscle glycogen and the meat becoming very pale with pronounced acidity (pH values of 5.4-5.6 immediately after slaughter) and poor flavor. This type of meat is difficult to use or cannot be used at all by butchers or meat processors and is wasted in extreme cases. Allowing pigs to rest for one hour prior to slaughter and quiet handling will considerably reduce the risk of PSE.

Bruising is the escape of blood from damaged blood vessels into the surrounding muscle tissue. This is caused by a physical blow by a stick or stone, animal horn, metal projection or animal fall and can happen anytime during handling, transport, penning or stunning. Bruises can vary in size from mild (approx. 10-cm diameter) and superficial, to large and severe involving whole limbs, carcass portions or even whole carcasses. Meat that is bruised is wasted as it is not suitable for use as food. Injuries such as torn and haemorrhagic muscles and broken bones, caused during handling, transport and penning, considerably reduce the carcass value because the injured parts or in extreme cases the whole carcass cannot be used for food and are condemned. If secondary bacterial infection occurs in those wounds, this causes abscess formation and septicaemia and the entire carcass may have to be condemned.

Lactic acid in the muscle has the effect of retarding the growth of bacteria that have contaminated the carcass during slaughter and dressing. These bacteria cause spoilage of the meat during storage, particularly in warmer environments, and the meat develops off-smells, colour changes, rancidity and slime. This is spoilage, and these processes decrease the shelf life of meat, thus causing wastage of valuable food. If the contaminating bacteria are those of the food poisoning type, the consumers of the meat become sick, resulting in costly treatment and loss of manpower hours to the national economies. Thus, meat from animals, which have suffered from stress or injuries during handling, transport and slaughter, is likely to have a shorter shelf life due to spoilage. This is perhaps the biggest cause for meat wastage during the production processes

Dark Firm and Dry (DFD) meat can be found in carcasses of cattle or sheep and sometimes pigs and turkeys soon after slaughter. The carcass meat is darker and drier than normal and has a much firmer texture. The muscle glycogen has been used up during the period of handling, transport and pre-slaughter and as a result, after slaughter, there is little lactic acid production, which results in DFD meat. This meat is of inferior quality as the less pronounced taste and the dark colour is less acceptable to the consumer and has a shorter shelf life due to the abnormally high pH- value of the meat (6.4-6.8). DFD meat means that the carcass was from an animal that was stressed, injured or diseased before being slaughtered. It is necessary for animals to be stress and injury free during operations prior to slaughter, so as not to unnecessarily deplete muscle glycogen reserves. It is also important for animals to be well rested during the 24- hour period before slaughter. This is in order to allow for muscle glycogen to be replaced by the body as much as possible (the exception being pigs, which should travel and be slaughtered as stress free as possible but not rested for a prolonged period prior to slaughter). It is important that the glycogen levels in the muscles of the slaughtered carcass are as high as possible, to develop the maximum level of lactic acid in the meat. This acid gives meat an ideal pH level, measured after 24 hours after slaughter, of 6.2 or lower. The 24h (or ultimate) pH higher than 6.2 indicates that the animal was stressed, injured or diseased prior to slaughter.

3 CONCUSSIONS

Stress is a condition in which an animal is unable to maintain a normal physiologic state because of various factors adversely affecting its wellbeing. The stress response includes several changes that may have negative effects on the health and performance of animals. These effects include changes in the immune function and increased susceptibility to disease, decreased feed intake and rumination, inhibition of oxytocin release, reduced fertility and effect on meat and by-product quality. The different stressors that enhance stress in animal can be chemical stressors: poor water quality - low dissolved oxygen, improper pH, Pollution - intentional pollution: chemical treatments, accidental pollution: insect spray, Diet composition - type of protein, amino acids, Nitrogenous and other metabolic wastes accumulation of ammonia or nitrite. Biological stressors: population density - crowding, mixing of different species of animal- aggression, territoriality, space requirements, Microorganisms - pathogenic and nonpathogenic, Macroorganisms - internal and external parasites. Physical stressors: Light, sounds, dissolved gases and temperature

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