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Physiological Adaptation of Holstein Frisian Dairy Cattle in Ethiopia: Review Article

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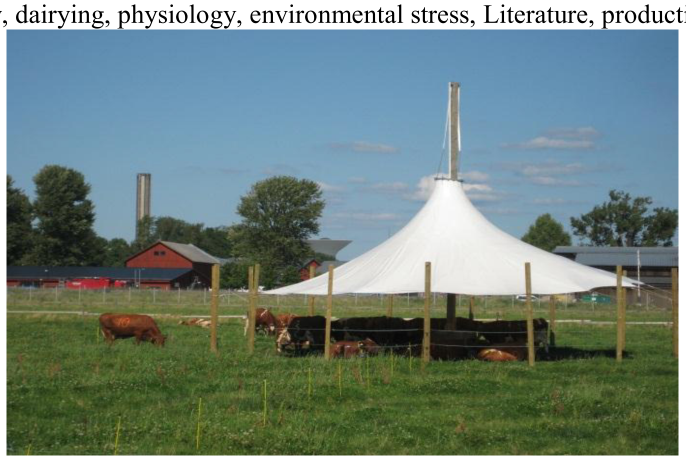
Abstract
This article was planned to summarize available information's on physiological adaptation of Holstein Frisian dairy cattle in Ethiopia. The literature was reviewed for presence of such adaptations. Although a temperate type, Holstein Frisian is the most common and predominate exotic dairy cattle breed in Ethiopia. The reason behind is, its ability to adapt a wide range climatic environments and the world's known high milk production potential. Above 70% livestock production in Ethiopia is on the hand of Smallholders and pastoralists who often lives in harsh environments which may be hot and dry, hot and humid, or cold and can be characterized by scarce feed and water resources and high disease pressure with large seasonal and annual variations. Adaptation to these factors is largely based on genetics, but animals like HF are a special breed that can “learn” to live under such stressful conditions. It seems like Lowering of its metabolic requirement and sweating to keep the internal body environment in "steady state" when external environment is changed, hormonal activities and vasoconstrictions of muscle to cold stress are some of the desirable physiological attributes or adjustments helped them better to fit and survive. Years of research have shown that environmental stress is a huge problem for dairy cattle in tropics. However breeds like Holstein withstand better than other exotic dairy cattle through their unique physiological mechanisms but no such research have so far been done in Ethiopia.
Keywords: Adaptability, dairying, physiology, environmental stress, Literature, productivity



1. Introduction

The most indigenous cattle breeds found in tropical countries belong to the species *Bos indicus*. This is species well adapted to tropical environments. They possess a high degree of heat tolerance, are resistant to tick borne and to other diseases occurring in the tropics, and have a low maintenance requirement. However, its potential for milk production is low. On the other hand, *Bos taurus* (European type) is the predominantly specialized dairy breed of the temperate countries. These breeds have high milk yield potentials but slightly lacking heat tolerance and disease resistance.

The One way of improving tropical cattle regarding milk production is through crossbreeding with *Bos taurus(European type)* dairy breeds. This has been widely used in order to combine the high milk yield potential of exotic breeds with the adaptability of the local ones. For instance, the F_1 crosses can produce up to three times more milk, and have longer lactation and shorter calving intervals than the local breeds (Kiwuwa *et al.,*1983).

Ethiopia is one of the tropical country in which dairy production is mostly dominated by indigenous breeds of low genetic potential for milk production, which accounts for about 81.2 percent of the country’s total annual milk production (CSA, 2009). The main problem of milk production in the country is that of the poor genetic potential of the in digenous cattle, which gives rise to low milk output. Milk production is as low as 0.5 to 2 litres per day over a lactation period of 160 to 200 days. Improving the feeding, water availability and health care of the indigenous cattle would not be enough to increase the quantity of milk per day so as to make the animals to be suitable for commercial market oriented milk production (Zelalem *et al.,* 2011). The average lactation milk production of the indigenous cows ranges from 494 to 850 kg under optimum management (Aynalem *et al*., 2009). Therefore, to meet the ever increasing demand for milk, milk products and thus contribute to economic growth, genetic improvement of the indigenous cattle has been proposed as one of the best options. Genetic improvement strategies of cattle in Ethiopia has been brought through cross breeding, either by introducing germplasm or direct importation of exotic cattle from temperate countries (Habtamu *et al.,*2010). As a result, the ministry of agriculture (MOA) started exercising maintenance and breeding of exotic dairy breeds in the country to ensure constant supply of exotic semen for crossbreeding programme, and imported purebred Holstein Friesian cattle at different times from 1950s till now. Currently the most common exotic dairy breeds in Ethiopia are Holstein Friesian and Jersey, where, the Holstein Friesian breed predominates. The reason behind is, its ability to adapt a wide range climatic environments and the world's known high milk production potential(Mekonnen and Goshu,1987).

Adaptability of an animal can be defined as the ability to survive and reproduce within a defined environment (Prayaga and Henshall, 2005) or the degree to which an organism, population or species can remain/become adapted to a wide range of environments by physiological or genetic means (Barker, 2009). Smallholders, pastoralists and their animals often live in harsh environments which may be hot and dry, hot and humid, or high in altitude and cold. Moreover, these environments can be characterized by scarce feed and water resources and high disease pressure with large seasonal and annual variation.

Adaptation to these factors is largely based on genetics, but animals can "learn" to live under such stressful conditions. In Ethiopia the physical environment greatly differs between locations and production systems based on available resources and economic conditions.

As it is known that Ethiopia is one of the tropical countries which are characterized by such a many type of stressful environments. This extreme environment evokes physiological responses to be unperceivable, repeatable and adjusted to the constraint. Understanding the biochemical mechanisms that enable animals to survive and function under conditions of extreme environments can provide important insights into the nature of physiological adaptation. This article is therefore aimed with the main objectives of:

- Compiling of available information's on physiological attributes of Holstein Frisian dairy cattle helped to adapt in Ethiopia.
- To understand and recommend the appropriate and promising physiological status of Holstein Frisian dairy cattle in order to achieve sustainable dairying system.
- Developing a skill of citing different written sources (literatures) on subject matters.

3. Literature Review

3.1. Historical evolvement and adaptation of Holstein Friesian dairy cattle in Ethiopia.

Domestic animal production has proven to be good sources of food all over the world, and a rapid growth in milk and dairy consumption has been seen in many developing countries over the last years (FAO, 2002). Milk is the one among animal protein, whose demand continues to increase and plays a very important role in feeding the rural and urban population of Ethiopia (Asaminew and Eyasu, 2009). Crossbreeding of cattle has been adopted for blending the adaptability of tropical cattle with the high milking potential of exotic breeds. However, the local environment can sustain only composite genotypes of a moderate level of *Bos taurus* blood. Breeds differ in their physiological response and adaptation to thermal environments (Young, 1985). Friesian crossbreds were noted to be the most suitable for their adaptability in addition to their high milking capacity (Abdella, 2012). As result, ministry of agriculture (MOA) started the introduction of Holstein Frisian dairy cattle to Ethiopia from 1950s towards, aimed to improve milk production of poor performance indigenous dairy cattle breeds.

The origins of this breed are in the area running from the province of Schleswig-Holstein on the Danish-German border to the province of Friesland in the northern part of the Netherlands (Temperate climate). Holsteins are large animals with a characteristic color pattern of black and white or red and white. They are tall, largest of the dairy breeds and predominant in most developed countries. Holsteins has excellent grazing ability and a large feed capacity. Holsteins rank first among the dairy breeds in average milk production per cow.

Most written sources showed that, Holstein Friesian cows remain top On the base of annual milk yield followed by ½ Holstein Friesian of indigenous zebu crosses (3083 kg for total milk and 2678 kg for annual milk yield) which is more higher than mean annual milk yield of pure indigenous zebu (672 kg of total milk and 673kg of annual milk yield) in Ethiopia (Tadesse, 2003). It is desirable to have Holstein give birth (calve for the first time between 24 and 27 or 30) months of age (Training manual on Forage Husbandry and Dairying, 2013). Their wide range adaptability in addition to these characteristic feature made Holstein Friesian type cows the most selected dairy breed in the world, accounts for one-third of all dairy cows in the world.

Characterizing Dairy cattle breeds in terms of adaptive attributes is important for efficient utilization of genetic resources. It in turn is very critical to achieve improved and sustainable production systems of this sector in the country (Zewdu, 2013). Young *et al*. (1989) defined adaptation as a modification in the animal's behavior or metabolic responses resulting from an experience that improves the ability of animal to cope with subsequent challenges. Prayaga and Henshall (2005) also defined it as the ability to survive and reproduce within a defined environment. Barker (2009) defined adaptedness as the state of being adapted, the ability of breeds to produce and reproduce in a given set of environments, or the choice of particular breeds for specific environments. Adaptability is then a measure of potential or actual capacity to adapt in different environments (Hoffmann, 2010).

Adaptation traits are usually characterized by low heritability. In relatively stable environments, such traits have probably reached a selection limit; however, they are expected to respond to selection if the environment shifts, thus resulting in changing fitness profiles and increases in heterozygosity (Hill and Zhang, 2009). Empirical evidence strongly supports the expectation that the genetic basis of population differentiation for fitness traits will be non-additive, with different adaptive gene complexes evolved in each breed. Genetic improvement programs therefore should start with an adapted population, with selection then for production traits (Tucker, 2001). Extensive genetic variation exists between breeds in a species and amongst individuals within breeds.

3.2. Physiological adaptability of Holstein Frisian dairy cattle to high altitudes in Ethiopia

Highlands covers 44% of the country's total land area, 90% of human population and carries an estimated 70% of country's cattle population (CSA, 2010). Cattle are kept and used at altitudes as high as 4000 m and play significant social and economic roles in the subsistence production systems. High altitude environments are characterized by a lower partial pressure of oxygen (pO2) and lower ambient temperatures compared to low-altitude environments at similar latitudes thus, present a number of physiological challenges for endothermic animals. Thus, animals in high-altitude are subject to hypoxia which is defined as the reduced availability of oxygen at high altitude (Schmidt-Nielsen, 1997). The reduced pO_2 at high altitude results in reduced oxygen loading in the lungs such that the blood may not carry a sufficient supply of oxygen to the cells of respiring tissues (Monge *et al*., 1991; Schmidt-Nielsen, 1997). As the result, domestic animals under such circumstances are subjected to many related diseases named as high altitude disease.

Hypoxia at high elevation causes pulmonary vasoconstriction, increased pulmonary artery pressure (PAP), right ventricle stress, congestive right heart failure, and hydrothorax in the chest cavity and brisket disease (Rhodes, 2005). High altitude pulmonary hypertension or brisket disease is an indicative of a classic genetic by environment interaction (Ahola *et al*., 2002). In such a situation the capacity to take in sufficient air by virtue of anatomical features, respiration rate and physiological response is clearly an important aspect of adaptation to life at high altitudes. Introduction of lowland dairy cows to this climate debilitates them, such that even basal metabolism is a challenge to sustain. A characteristic feature of these cattle is a muscular pulmonary vasculature which responds sensitively to alveolar hypoxia by constriction when they are transported to high altitude environment (Holt and Callon, 2007).

However, Holstein Friesian cattle and their crosses appear to be naturally more resistant or not more prone to highland hypoxia than local cattle measured at the same altitudes. Hematological values that are currently in use as references in Ethiopia for all species of animals are those from temperate breeds (Tibbo *et al*., 2005). Thus Holstein Frisian cattle are able to maintain their Arterial hemoglobin oxygen by increasing erythrocytes (red blood cells) and lowering white blood cells of their body in high altitudes (Wuletaw *et al*, 2010). The apparently high altitude adapted animals have thin walled pulmonary arteries and low pulmonary arterial pressure So that they lost hypoxic vasoconstrictor response (Harris *et al*., 1982).

Holstein Frisians are adapted genetically to high altitude by largely eliminating the hypoxic pulmonary vasoconstrictor response in the absence of hypoxemic stimulus to increase red blood cell production and hemoglobin concentration. A rapid development of severe pulmonary hypertension in the lowland cattle when they move to high altitude is associated with the unusually muscular pulmonary arteries normally present in those animals. The thick subcutaneous fat stored under skin is an additional physiological responsive mechanism to adapt cold stress. Climate, temperature and humidity affect physiological function by impairing thermoregulation. Environmental temperature decreases 1.7ºC for each 305 m increase above sea level. For this reason dairy cattle farming is mainly located at highland areas of the tropics and a very small proportion in lowlands (Usman *et al*., 2012).

3.2.1. The role of subcutaneous fat storage in relation to cold stress adaptation

Frisians have more subcutaneous (intramuscular) fat depots which responses to nutritional changes in hot climates. These serve as a source of energy during periods of food shortage adaptation strategy for survival. A seasonal deficiency of feed supply, as observed in Ethiopia (Hwang et al., 2000), prevails in many warm climate regions in which irrigated agriculture is uncommon. Lower maintenance requirements leave more nutrients available for growth and milk production when feed is limited, unless these are channeled into adipose tissue depots. Temperate breeds have thick subcutaneous fat storages than tropical animals. Thus can interfere or impedes normal heat dissipation. But it is very important for heat insulation and conservation against cold stress. Stored fat is used for maintenance, pregnancy & lactation during 'unfavorable' season, an essential strategy for survival. Ability of animals to survive in tropical environments was associated with greater fat deposition in the internal fat depots. Cattle originating and living in cold areas deposit more of their body fat under the skin compared to those adapted to warmer areas (Nigussie *et al.,* 2000).

3.3. The role of hair coat and color in Holstein Frisian to adapt heat or cold stress.

The effect of hair coat characteristics on adaptability to warm climates has been recently examined in depth (Berman, 2004; Olson *et al*., 2006). Hair coat thickness, along with color and weight per unit surface, is an important determinant of non-evaporative heat loss from the body surface. Light colored hair coat such as white, light red, red or combination of these colors can reflects part of visible solar radiation and therefore can protect animals. As well as smooth, light, short and thin hair coats are suitable to enhance heat dissipation through sensible and insensible ways in hot environments.

Biological differences among cows with different colors influence the cow's ability to cope with environmental stress from heat, humidity and solar radiation (Godfrey *et al.*, 1994). Earlier research pointed out that there are physiological differences in adaptation and productivity, depending on the amount of black or white in the skin. The area of distribution of white and black colored patches on the entire body of Holstein Friesian cows have determinant impact to withstand cold or heat stress. The black skin absorbs more environmental and solar radiation while the white reflects more. This predisposes black cows to more heat stress. Climatic stress especially from heat and solar radiation decreases milk production, changes milk composition and lowers reproductive performance. Therefore the skin color is of importance to dairy farming as it may cause significant economic losses.

In the presence of low air temperature and velocity of ventilated air, Holstein Frisian cows maintain proper body temperature thanks to their own body heat which helps them avoid hypothermia. It is also observed that cows develop thicker hair coat. Excessive cooling of cow bodies may lead to thermoregulation or fertility impairments, cold stress, and lower milk production accompanied by increased feed intake (Broucek *et al*., 1991). Study showed that the hair coat is markedly affected by photoperiod, which modulates seasonal changes in hair coat (i.e., the shedding of the long heavy winter coat and its replacement by a thinner and lighter summer coat). Photoperiod, however, is not the only factor affecting hair coat. Warmer ambient conditions enhance the summer-type attributes of hair coat in Holstein cows (Berman and Volcani, 1961). Photoperiod and temperature-induced changes in hair properties affect the ability to maintain thermal balance because hair coat characteristics are well correlated with skin and rectal temperatures, particularly in *B. taurus* (Berman, 2011).

Nutrition also affects characteristics of the hair coat. Limiting nutrition induce the formation of a winter-type hair coat, which impairs heat tolerance. For example, average Holstein cows in Brazil showed markedly thicker and longer coats in summer and winter than well-fed Holsteins (Pinheiro and da Silva, 2000). Interactions between photoperiod, temperature, and nutrition therefore can play an important role in determining hair coat characteristics. The slick hair gene, that endows its carriers with a slick hair coat, was introduced into the Holstein and improved their heat tolerance (Olson et al., 2006; Dikmen *et al*., 2008).

It is noteworthy that Israeli Holsteins have hair coat characteristics close to those of animals possessing the slick gene (Berman, 2004). Marked differences in hair coat thickness and weight/100 cm2 among Holsteins were found between studies carried out in Israel, Egypt, Iraq, United States of America (Olson et al., 2006), Brazil (Pinheiro and Silva, 2000), and Australia which probably reflect differences in nutritional and management states. Therefore, it seems that targeted breeding may offer significant opportunities for improving heat tolerance.

3.4. Physiological adaptability of Holstein Frisian dairy cattle to low altitudes

Animal productivity is an output of metabolic processes for synthesis of milk and meat that all generate heat. Animal productivity may, therefore, be viewed as a heat exchange system, in which animals produce heat through their metabolism and exchange heat with the environment. All terrestrial farm animals are homoeothermic species (they regulate their body temperature within a narrow range). Body temperature is regulated by modulation of metabolic heat production and heat loss from the body. Adaptations to environmental heat stress may involve metabolic heat, evolving in maintenance and production processes, as well as heat loss from the body. Responses to this stress are indispensable to survival as they allow animals to maintain the internal equilibrium necessary for optimal function. The heat generated in the body is used in the maintenance of body temperature, and amounts in excess of that required are dissipated to the environment by evaporative and non-evaporative pathways(Berman, 2011).

The evaporative path is represented by respiratory water loss and by evaporation of water brought to the skin surface by the sweat glands (i.e., sweating rate). Sweating rate depends on the density of sweat glands, their morphology, and water transfer capacity. Non-evaporative heat loss also occurs as heat transfer from the skin to the surrounding air and is largely determined by the skin-to-air temperature gradient, air flow near the body surface, incoming radiant heat, as well as hair coat characteristics. Breed differences in these characteristics may open perspectives for adaptations to warm climates by selection and breeding.

Microclimate (high temperatures and humidity) in tropics has a strong effect on farm animal productivity. These factors have an adverse effect on dairy production, and prevent animals achieving their maximum productivity. It is difficult to manipulate or develop an artificial microclimate, and to obtain optimum productivity it is important to choose an appropriate animal suitable to the particular area. Measures of heat tolerance are indicators of an animal's ability to adapt to a tropical environment. Heat tolerance is the ability to maintain normal metabolism when exposed to high environmental temperatures. Heat tolerance can be determined by measuring rectal temperature, respiration rate and evaporation rate (Lemerle and Goddard,1986). Changes in these parameters are often manifested in changes in productivity, such as milk production. Holstein Frisians are relatively better tolerant and productive than other temperate dairy breeds.

3.5.1. The role of sweat gland and it's characteristics in Holstein Frisian dairy cattle

Sweat glands are most essential component of animal adaptation in hot climates. They produce sweat hormone, enhances heat loss through evaporation during hot temperature. This is useful during very hot temperatures for maximum heat dissipations. Producing more sweat is advantages and is related to sweat gland population density. Physiological heat tolerance in cattle is directly related to sweat gland density & sweating rate. An overview of literature carried out to examine the presumption showed that higher sweating rates prevail in breeds endogenous to warm climates. The characteristics of sweat glands in 5 European breeds (*B. taurus*), namely Ayrshire, Guernsey, Shorthorn, and Friesian, indicated breed differences in sweat gland volume, higher sweating rates about 100 g m−2 h−1, were reported for 25% Senepol:75% Holstein cattle (Dikmen *et al*., 2008).

Sweating rates of about 200 to 260 g m−2 h−1 were measured in hyperthermal Angus and Hereford steers as well as in lactating Holstein cows (Scharf *et al*.,2008). Sweating rates in Holstein and Gyr × Holstein crossbreds were similar, at about 350 g m−2 h−1 (Gebremedhin *et al*., 2010). Although, there may exist a difficulty in a comparison measured in different studies, Sweating rates are related to ambient humidity, and in Holstein cows they varied from 300 to 50 g m−2 h−1 when ambient humidity increased from 30 to 75% (Maia *et al*., 2005). Sweating rates in shaded Sahiwal and Sahiwal × Holstein crossbred heifers were 630 and 380 g m−2 h−1, respectively (Aggarwal and Upadhyay, 1997). Also noteworthy is the presence of large differences in sweating rate between *B. taurus* breeds exposed to heat stress (Scharf *et al*., 2010). As a whole, however, no consistent evidence exists that breeds that evolved in warm climates (Zebu and their crossbreeds) are endowed with higher sweating rates. Humped tropical animals are more adaptable to hot temperature than non-humped temperate breeds. These is because, hump contains more sweat glands compared to other body parts. In this respect, tropical animals like Zebu has 1600 sweat gland population density per cm^2 body surface whereas, the temperate animals like Holstein Frisian has 800 sweat gland population density per cm^2 body surface (i.e. Half of tropical animals).

3.4.2. Ability to reduce feed intake

With higher production, the associated increase in dietary dry matter intake (DMI) in lactating dairy cows enhances heat increment, which when coupled with increases in metabolic heat production to produce milk, aggravates thermal balance during the stressful periods (High Plains Dairy Conference, 2010). Temperature and humidity combine to decrease DMI in Holstein Friesian dairy cows as a physiological means of regulating internal body temperature. This is accomplished by decreasing rumen fermentation and metabolic rates (Moody *et al*., 1971). A reduction in DMI decreases nutrients available for milk synthesis.

With insufficient thermoregulation in warm and humid weather, the cow will be heat stressed (Kadzere *et al*., 2001; West, 2003; Kendall *et al*., 2006). During this time Holstein Frisian starts Shade seeking. This is very important behavioral response to Reduce direct solar radiation heat load. (More frequent in temperate than tropical cattle); they decreases voluntary feed intake: in order to reduce digestive heat.

Shade ameliorates heat load of cattle (Brown-Brandl *et al*., 2005) and reduces mortality in extreme weather events (Entwistle *et al*., 2000); however, production results have been inconsistent. Mitlöhner *et al*. (2002). Reductions in body temperature, respiration rate, and reduced incidence of open-mouthed breathing have been reported when shade is available (Gaughan *et al*., 2004; Brown-Brandl *et al*., 2005). In addition Hormones link info flow between cells and tissues to initiate and maintain physiological responses to heat stress. To cope with heat stress, a complex series of changes that is mediated by many nervous and endocrine systems is initiated. By modifying appetite and food digestive processes, and by alteration in the activity of respiratory enzymes in the respiratory chain and synthesis of proteins, the heat production can be regulated. The autonomic physiological and behavioral thermoregulatory mechanisms of the cow are for example increased respiration rate, reduced activity and reduced feed intake (Schutz *et al.,* 2009; Tucker *et al.,* 2008). Yousef (1985) describes that a high feeding level for a cow decreases both the *lower* and the *upper* level of critical temperatures. Therefore, a heat stressed cow will reduce the feed intake and thus decrease the metabolic heat production. The cow does also actively seek shade and wind (Blackshaw and Blackshaw, 1994). If an animal have more than one alternative of behavioral thermoregulation it can alternates between them.

3.4.3. Ability to reduce metabolic requirement and Metabolism

Exposure of dairy cows to hot environment during summer could stimulate thermoregulatory mechanisms and produces reduction in the rates of metabolism, feed intake and productivity (Berman, 2011). Some tropical animals keep constant body weights on energy intakes less than they would take voluntarily. Indigenous zebu

Crosses of Holstein Frisian will gain this ability and thereby improve its adaptive mechanisms. Temperate breeds produce more than tropical breeds if only supplied with high quality feed. But, they lose weight & fail to survive when fed low quality feed. Reason, their metabolic requirement is too high. When exposed to hot environment, they start experiencing adjustments to this physiological attributes.

Decreased overall performance including decrease in milk yield & its components, Lowered weight gain & growth, So that this helps them to Reduces heat load due to production and important to survive**.** Change in physiological activities like depressed thyroid gland activity in order to reduce overall heat production a very crucial change. Thyroid gland is one of the most sensitive to the ambient heat variation. It has been shown that thyroid hormones are important modulators of developmental process and general metabolism (Ganaie *et al*., 2013). It is a primary stimulus for reduction in both feed intake and milk production. Abnormal increase in rectal temp Rapid increase in reparatory rate (panting); Decrease in rumen Volatile Fatty Acids; Reduced fecal water (water conservation).

3.4.4. Ability to adapt water scarcity

Water is a major problem in tropics, especially, during dry periods. High water content in animal's body during heat stress situation facilitates maintenance of heat balance. Bos taurus breeds like Holstein Friesian, increases water intake: to Compensate water loss due to increased sweating. Water is necessary for maintain osmotic balance (Shearer and K.beede, 1994). The rumen of Holstein Frisian can plays a great role as a water reservoir during dehydration (capacity to tolerate a higher level of weight loss during dehydration).

3.4.5. Milk yield and withstanding thermal stress in Holstein Frisian

Heat tolerance depends upon the upper and lower critical temperatures that define the thermal comfort range. The upper critical temperature for dairy cows, that above which body temperature starts increasing, was reported as in the 25 to 26°C range and as 28.4 (Dikmen and Hansen, 2009), which might reflect milk yield differences. The lower critical temperature, that above which thermoregulatory responses start appearing, is highly dependent upon both milk production-related metabolic rate as well as upon hair coat insulation and season (Berman, 2004, 2005).

A lower metabolic rate may shift the lower critical temperature to higher levels and, thereby, improve heat tolerance. In Holstein heifers, a seasonal decline in metabolic rate was evident of similar relative magnitude in both standard and ad libitum-fed cattle. Diurnal variation in metabolic rate was correlated with rectal temperature changes only in the ad libitum-fed animals. In high-producing Holsteins in a warm climate, a 23% seasonal decrease occurred in metabolic rate between early spring and summer, but no ambient temperature-related diurnal variation was evident. Seasonal differences in heat tolerance require time to develop and fade with the passage of seasons. As a whole, these indicate that maintenance of high milk production in warm climates is dependent more upon heat stress relief than upon breed type.

Recent studies in the US Holstein population indicated that sufficient genetic variation exists for successful selection for heat tolerance (Misztal and Ravagnolo,2002). On the other hand, and in line with the aforementioned, bulls that transmitted high tolerance to heat stress had daughters with lower milk yields and higher pregnancy rates, so that continued selection for milk yield may result in greater susceptibility to heat stress (Bohmanova *et al*., 2005). It seems, therefore, that the dairy industry might benefit from breeding targets modified according to environmental climate and heat stress relief management.

3.5. The effect of crossing on adaptability and performance of Holstein Friesian dairy cattle

Crossbreeding of non-descript type of Bos *indicus* with genetically superior exotic breeds of *Bos taurus* such as Holstein Friesian (HF) is an effective and shortest channel to improve dairy potential of the former (Demeke *et al*., 2000). In many countries of tropical and sub tropical regions, crossbreeding programmes were launched in mid seventies to increase herd productivity by combining the desirable characteristics of the superior dairy potential of *Bos taurus* and better resistance of *Bos indicus* to heat stress and local diseases. The objective was to produce crossbred progeny with early maturity, better milk producing ability and adaptability to the local hot and humid climatic conditions (McDowell,1985).

Crossbreeding in Ethiopia resulted in good improvements in physiological adaptation in addition to production of milk and meat, especially when supplemented with adequate management levels in terms of nutrition and disease control (Alemayehu, 2015). Since indigenous zebu is the most known heat tolerant breeds, Crossing of Holstein Frisian further maximized its physiological adaptability. In Ethiopia, crossbred cattle are mainly cross of zebu with Holstein-Friesian. It appears important to estimate the expected level of heterosis and profitability of crossbreeding for traits of economic interest in dairy cattle. Since the productive and reproductive potentials of Zebu cattle are relatively low, crossbreeding with *B.taurus* ensures high productive and reproductive performance.

Improvement of the genetic potential of indigenous cattle was achieved by cross breeding with high producing cattle of temperate origin to exploit heterosis. Artificial Insemination (AI) services in Ethiopia have been the most widely practiced animal biotechnology all over the country for enhancing crossbreeding.

Crossbreed animals with 50% to 75% Holstein Friesian inheritance gives in better efficiency with respect to reproductive and productive performance, and the Holstein Friesian tended to have rather lower efficiency than crossbred animals (Tadessie, 2003).

A recent study shows that, the total cattle population for the country is estimated to be about 53.99 million. Out of this total cattle population, the female cattle constitute about 55.48% and the remaining 44.52% are male cattle (CSA, 2013). On the other hand, 98.95% of the total cattle in the country are local breeds. The remaining are hybrid and exotic breeds that accounted for about 0.94 and 0.11%, respectively (CSA, 2013). More than 80% of these hybrids or exotics are Holstein Friesian dairy cattle.

3.6. Measurements of physiological responses to heat stress

To be able to keep the body temperature within the interval needed to get the body functions to work properly, the cow exhibit physiological responses to the environmental factors (Schutz *et al.,* 2009; Tucker *et al.,* 2008; West, 2003). There are two types of physiological responses to heat stress. One is controlled by the autonomic nervous system, e.g. sweating and panting. The other is behavioral, e.g. lying in a shaded area. Behavioral processes of thermoregulation involve movement of the whole body, which affects changes in the heat flow to and/or from the body. It can also be changes in posture which influence the effective surface area through which heat can be exchanged with the environment (Bligh, 1985). The first reaction of heat stress is usually behavioral changes as an attempt to cool down, e.g. seeking shade, and extension of the limbs. If that is not enough, the autonomic nervous system will increase or decrease blood flow to the skin (vasodilatation and vasoconstriction respectively) to alter skin temperature (Robertshaw, 1985). To measure if an animal is affected by environmental heat load, e.g. high ambient temperature, humidity or sunshine radiation, knowledge about its physiological responses to heat stress is useful.

Physiological parameters like respiration rate, heart rate, body temperature and skin temperature gives an immediate response to the climatic stress and consequently the level of discomfort/comfort to the animal (Bianca, 1965). These responses have been used as a measure of dairy cow comfort and adaptability to an adverse environment or as a sensitive physiological measure of environmental modification (Roman-Ponce *et al*., 1977). Physiological responses like rectal temperature, pulse rate and respiration rate reflect the degree of stress imposed on animals by climatic parameters (Ganaie *et al*, 2013). The ability of an animal to withstand the rigors of climatic stress under warm conditions has been assessed physiologically by means of changes in body temperature, respiration rate and pulse rate (Leagates *et al*., 1991,Sethi *et al*., 1994).

3.6.1. Core (Rectal) body temperature

Change in rectal temperature has been considered an indicator of heat storage in animal's body and may be used to assess the adversity of thermal environment, which can affect growth, lactation and reproduction of dairy animals (Wet *et al*., 1999, Johnson,1980, Hansen and Arechiga,1999). The rectal temperature is recognized as an important measure of physiological status as well as ideal indicator for assessment of stress in animals (Lefcourt *et al*., 1986). Even a rise of less than 1°C in rectal temperature was enough to reduce performance in most livestock species (McDowell *et al*., 1976). RT is generally considered to be a useful measure of body temperature and changes in RT indicates changes of a similar magnitude in deep body temperature (Herz and Steinhauf,1978, Rosenberg *et al*., 1983). The normal range in RT is very narrow in most domestic animals, not more than about 2.5°C.

The rectal temperature was higher during summer (39.83°C) than autumn (38.30°C) in lactating cows (Padilla *et al*., 2006, Taneja,1960). High relative humidity reduced the effectiveness of the evaporative cooling and the high relative humidity coupled with high environmental temperature apparently overwhelmed the capacity of the cow to maintain normal body temperature. It was shown that rise in air temperature (keeping humidity constant) or in humidity (keeping air temperature constant) was accompanied by rise in the rectal temperature. The high rectal temperature observed in the heat stressed animals was the indicator of disturbance in the homoeothermic status of the animals which was not being effectively countered by the enhanced heat loss by physical and physiological processes of thermolysis (Joshi Tripathy,1991).

3.6.2. Respiration rate

Respiration rate was indicator of heat stress in the hot environment and gave significant correlations with circulating corticoids concentration as given by Kumar(2005). Respiration rate and rectal temperature appeared to be more sensitive indicator of heat stress than pulse rate as shown by Lemerle and Goddard(1986). Normal respiration rate is approximately 10–30 breaths/minute Hafez (1968) and the respiration rate increased when environmental temperature increased (Bond and McDowell, 1972) reported a very high positive correlation between the respiration rate and ambient temperature and it even raises when humidity was constant.

An evaporative heat loss from the respiratory tract is regarded as one of the primary mechanisms for maintenance of heat balance (McDowell *et al*., 1976). This respiratory response arises from direct heat stimulation of peripheral receptors which transmit nervous impulses to the thermal centre in the hypothalamus. The cardio-respiratory centre is then stimulated to send impulses to the diaphragm and intercostal muscles for further respiratory activity (Razdan *et al*., 1968). A high RR in most cases did not necessarily indicate that the animal is successful in keeping its body temperature constant, but rather indicated that it is already overheated and trying to restore normal heat balance (McDowell *et al*., 1976).

Respiration rate is the most consistent of all the physiological responses studied and affected more by solar radiation than by other influences (Gaalas, 1945) observed that increased respiration rate is the first reaction when animals were exposed to environmental temperature above the thermo neutral zone. Therefore, increase in respiratory frequency may be used an index of discomfort in large animals. McLean (1963) found that the significance of increase in respiration rate under heat stress enabled the animal to dissipate the excess body heat by vaporizing more moisture in the expired air, and accounts for about 30 percent of the total heat dissipation. A higher respiration rate of 71.5/minute during summer compared to 38.8/minute in winter was recorded in lactating cows by Taneja (1960, and Bianca and Findlay (1962) found a highly significant increase in the ventilation rate of cattle and buffaloes with increase in the ambient temperature. Chikamune and Shimizu (1983) observed a highly significant correlation between RR and seasonal air temperature in swamp buffalo and Holstein cows when the RH was kept constant, whereas no such significant correlation was observed between RR and RH when the air temperature was kept constant.

3.6.3. Pulse rate

Pulse rate did not exhibited consistent and a definite trend with changing environmental conditions. Regan and Richardson (1938) observed a decrease in pulse rate whereas Gaalas (1945) observed an increase in pulse rate with increase in environmental temperature. An increase in pulse rate with an increase in air temperature in swamp buffaloes was reported. This increasing trend in pulse rate continued even when the ambient temperature declined indicating that the physiological responses of animals returned to its normal levels only after a definite period when animals were brought to comfort zone.

Gangwar *et al*.(1988) reported that environmental temperature has significant relation with the variation in the pulse rate. The result of their studies indicated that average values of pulse rate were higher during summer and lower during winter. Even it was discovered that the heart rate of calves increased during exposure to severe heat. The seemingly contradictory finding that heart rate responds to heat exposure either by a rise or by a fall may be largely explained by the fact that heart rate is positively correlated with metabolic rate.

Overall Summary

During this review literature better was tried to assess about the major & important physiological mechanisms of Holstein Friesian dairy cattle reflecting their fitness and survival in stressful environments of the country and thereby helped them to play great role in improving the milk production of indigenous dairy cows in response to adjust a rapidly growing demands are mentioned. The ability to control high-altitude hypoxia, blood hemoglobin, some disease indecencies, intramuscular fat deposition, reducing feed intake during thermal stress, hormonal and metabolic activities etc, are some of the desirable physiological parameters of Holstein Friesian cattle, helping them to adapt a wide range of climatic condition not only in Ethiopia but also in all over the world. Given its diversified ecology, geographical location, and its large population size, Ethiopia can be considered a centre of diversity for cattle genetic resources. Following strategic breeding schemes and applying appropriate management option like nutrition can farther improve their adaptability and performance in Ethiopia.

Conclusion

Dairying Holstein Friesian cattle is very compatible and productive in most parts of the country especially in highland intensive production system, where most of dairying industry takes place. Lowering of its metabolic requirement, spending more time in shade when the environmental temperature become high, it's hormonal and metabolic activities, vasoconstrictions of muscle to cold stress etc. are some of the responsible physiological attributes or adjustments helped them better to fit and survive those diverse climatic environments. The strategy of Crossbreeding with indigenous zebu dairy cattle farther played a considerable role to improve their behavioral as well as physiological adaptability to stressful climatic conditions and survivability in Ethiopia. Therefore, this is some of the reasons elaborating the adaptability of Holstein Friesian dairy cattle in Ethiopia.

Recommendation

- Understanding the genetic and physiological nature of Holstein Frisian dairy cattle for adaptation will enable us to better manage genetic resources allowing us to make efficient and sustainable decisions for the improvement of these resources.
- Under the prevailing feeding and management conditions, cows with 50 to 75 % Friesian inheritance would be recommended provided that sound breeding programmes are in place to maintain the recommended blood level.
- Limited accessibility of literatures on physiological adaptability of this breeds in case of Ethiopia. Farther research intervention is needed to overcome the problem. Professionals of the sector should think over.

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