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A study was conducted to evaluate the effects of thermalindices and relationship with milk yield in dairy cows using invasive (glucose,total cholesterol, triiodothyronine (T3), thyroxine (T4), aspartateaminotransferase (AST), alanine aminotransferase (ALT) and inorganic phosphate)and non-invasive (Rectal temperature (RT), respiration rate (RR), eartemperature (ET) and skin temperature (ST) markers in the Sahel Savannah ofNigeria. Fifteen (15) clinically healthy dairy cows of three breeds; five eachfrom Holstein Friesian purebred, Simmental and Brown Swiss, aged 5-8 years fromSebore Farms were used for the experiment. The animals were maintained onsimilar feeding programme under hot-dry and cold-dry season. Data collectedincludes thermoregulatory variables: Rectal temperature, respiration rate, eartemperature and skin temperature), blood biochemical variables (glucose,inorganic phosphate, total cholesterol, triiodothyronine (T3), thyroxine (T4),aspartate aminotransferase (AST), and alanine aminotransferase (ALT), daily milkyield and milk component traits (protein and fat percentage). All thethermoregulatory parameter values differed significantly (P<0.05) betweenthe seasons with the exception of ear temperaturewhich was statisticallysimilar (P>0.05). Rectal temperature, respiratory rate and skin temperaturewere significantly (P<0.05) higher during hot- dry season compare tocold-dry season.Glucose, ALT and AST differed significantly (P<0.05) acrossthe breeds of dairy cows while cholesterol, phosphorus, T3 and T4 werestatistically similar (P>0.05). The serum ALT was higher in Simmental(47.74±1.33iu/l) and Brown Swiss (46.59±1.33iu/l) which differed significantly(P<0.05) from Holstein Friesian cows (39.1±1.33iu/l).However, all thebiochemical parameters differed significantly (P<0.05) between the cold-dryand hot-dry seasons with the exception of T3 which was statistically similar(P>0.05).Milk yield was significantly (P<0.05) higher during the cold-dryseason (8.03±0.24kg) than the hot-dry season (6.93±0.21kg) while fat(P<0.05) was significantly higher during the hot than the cold season.Holstein Friesian had the highest average daily milk value (8.16kg) whileSimmental cow had the lowest milk volume (7.08kg). Simmental and Brown Swisscows had the highest percentage of fat (4.07%) which were statisticallydifferent (P<0.05) from Holstein Friesian (3.88%). Protein showed no(P>0.05) significant difference between breeds. Daily milk yield wassignificant, low and negatively correlated with temperature (R=-19, P=0.0005)while moderate, significant and negative correlations was observed with THIandRH (R=-0.24, P=0.0005 and R=0.26, P=0.0061) Fat had significant, low andpositive relationship with temperature (R=0.17, P=0.0019) while low andpositive relationship existed with THIand RH(R=0.19, P=0.76 and R=0.12,P=0.059). Protein had low and negative correlations with all the environmentalfactors with the exception of temperature which was positively associated(R=0.003, P=0.9501).Daily milk yield was significant and highly correlated withphosphorus (R=0.52; p=0.02) and T4 (R=0.94; p=0.05) but significant, high andnegatively correlated with T3 (R=-0.51).Cholesterol was significant, high andnegatively correlated with DMY (R=-0.28).AST was significant, moderately and negatively correlated with DMY (R=-0.26).ALT was negatively correlated with DMY. The regression analysis for predictionof milk yield showed that all the invasive markers combined together bestexplained daily milk yield (R2= 0.52) in Brown Swiss dairy cows compare toSimmental and Holstein Friesian which were weakly predicted (R2= 0.18). Theregression analysis for prediction equation using non-invasive markers, showedthat all the non-invasive markers combined together explains only (R2= 0.05) of milk yield when the breeds were pooled. Itwas concluded that invasive parameters could be a veritable tool in predictingdaily milk yield of different genotypes of dairy cows under the

SahelSavannah condition of Nigeria.

CHAPTER ONE

INTRODUCTION

Heat stress plays a significant role in cattle performanceand likely will be of even greater importance in the future as climate changecontinues. Cattle are produced in a wide range of environments, some of whichpresent thermal challenges to productive performance, even survival in extremecases. High temperatures can have negative consequences for milk production,and for reproduction, welfare and health, in dairy cattle. Especially highyielding dairy cattle would be susceptible because their thermo-neutral zone israther limited as compared to low yielding cows (Kadzere et al., 2002). As aresult of heat stress, losses of 600 to 900 kg milk per cow per lactation hasbeen reported with regard to milk production (West, 2003).Selection of cattleadapted to warm environments represents one strategy to mitigate the effects ofheat stress. There are a number of environmental factors that contribute toheat stress; these include high temperature, high humidity and solar radiation.In tropical regions, animals must be able to balance heat production and heatgain from their environments with dissipation of heat through the skin andrespiratory surfaces; simultaneously, they must avoid excessive thermal energyincoming from the environment (Da-Silva et al.,2003).

The productivity and health of these animals are beingaffected by adverse meteorological conditions prevailing in the tropicalAfrica, predisposing them to hyperthermia (heat stress) and hypothermia (coldstress) (Da-Silva et al.,2003). In the tropical conditions of Nigeria, heatstress is common during dry season, occurring between November and May and witha mean monthly rainfall of less than 51mm (Igono et al., 1982; Walter, 1969).The harmattan season is characterized by marked fluctuations in ambienttemperature (AT) with high AT in the afternoon hours of the day and relativelylow temperature of about 10 OC in the evening and early morning hours of theday. The season is associated with a dry cold and dust-laden wind that blowsfrom Sahara desert and low relative humidity (RH) (Ayo et al., 1998a). Thehot-dry season is also characterized by high ambient temperature, relativehumidity and long duration of sunshine. Of all the stress factors adverselyaffecting dairy production in the tropical environment, ambient temperaturemanifesting in hypothermia and hyperthermia and humidity changes are the mostcrucial. It has been shown that high ambient temperature and high relativehumidity with wide fluctuations in the values result in heat stress which mayalter many physiological parameters in livestock (Ayo et al., 1998b; Sinkalu etal., 2009). These may impair homeostatic mechanisms resulting in pathologicalchanges and alteration in body homeostasis (Teeter et al., 2005).

The general homeostatic responses to thermal stress inmammals include a decrease in fecal and urinary water losses, a reduction infeed intake and production, and an increase in sweating, respiratory and heartrates. Most of the adjustments made by the cow involve dissipating heat to theenvironment and reducing the production of metabolic heat (Kadzereet al.,2002). As milk production increases in dairy cattle, the metabolic heatproduction rises with the metabolizing of large amounts of nutrients, whichmakes the high producing cow more vulnerable to high environmental temperaturesand humidity than animals that are metabolically less active (Kadzere et al.,2002). High producing dairy cows must dissipate large amounts of heat producedduring the metabolism of high dietary energy used for body maintenance and milksynthesis. Several studies reported that heat stress in dairy cattle affectsproduction and reproduction (Garcia-Ispierto et al., 2007; Morton et al., 2007;Bryant et al., 2007). Despite the moderate effects of THI on milk

production,some blood parameters related to energy balance and enzyme activities hadsignificant alterations and cows in the middle of lactation had the highestchanges in these parameters (Dikmen et al., 2008). These authors have indicatedthat the thermoregulatory characteristic of animals associated with thisphenotype is probably due to a lower metabolic rate, increased sensible heat orevaporative heat loss, more efficient transfer of heat to the surface, or acombination of these adaptations. They further reported that dry bulbtemperature is nearly as good a predictor of rectal temperatures of lactatingHolsteins in a subtropical environment as THI. Hormones known to be homeorheticregulators are also implicated in acclimatory responses to thermal stress.These include thyroid hormones, prolactin, somatotropin, glucocorticoids andmineralcorticoids. Triiodothyronine (T3) and thyroxine (T4) are hormonesassociated with metabolic homeostasis and susceptible to climatic changes(Perera et al., 1986). Johnson et al. (1988) also showed decline in thyroidhormones T3 and T4 in response to heat stress which is an attempt to reducemetabolic heat production in the cow. Stress response hormones(glucocorticoids) are elevated during initial heat stress exposure and thenbecome depressed with prolonged periods of thermal stress. Wheelock et al.(2006) demonstrated that heat stress elevates plasma insulin concentrations inlactating dairy cows and this may be important for glucose disposal inperipheral tissues. The blood biochemical profiles are considered important inevaluating the health status of animals. The estimates of biochemicalconstituents are the prerequisites to diagnose several pathophysiological andmetabolic disorders in cattle (McDowell et al., 1992). Numerous authorsreported close relationship between blood levels of calcium, phosphate, totalprotein, aspartate aminotransferase (AST), alanine aminotransferase (ALT) andreproductive traits in dairy cows (Malik et al.,2003).

Justification

There is paucity of information on the use ofthermoregulatory and biochemical parameters as markers of heat stress in dairycows reared in Northern Nigeria especially the Sahel savannah regions.Information on effect of varying environmental/climatic conditions onthermoregulatory and biochemical parameters is particularly important inNorthern Nigeria as dairy milk production is generally low in this areacompared to the temperate regions of the World. A study to investigate whetheror not thermoregulatory and biochemical parameters could be used to estimateadaptability of exotic dairy cows to varying environmental conditions is thennecessary. The vital and biochemical parameters are of significant diagnosticvalues for the spot assessment of health status of dairy cows. These parametershave been demonstrated to be important indices of health, production andadaptability to prevailing environmental conditions in livestock (Oladele etal., 2001; Oladele et al., 2005; Adenkola and Ayo, 2009).

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