



ESTIMATION BREEDING VALUE FOR HEAT TOLERANCE (HT EBV) IN BUNAJI DAIRY CATTLE

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ABSTRACT

The study was conducted at the Abubakar Tafawa Balewa University Dairy Research and Development Center Gubi campus to estimate the breeding value for heat tolerance (HT EBV) in Bunaji dairy cattle. A total of twenty four (24) Bunaji dairy cattle were used for the study out of which fifteen (15) were lactating during the period of the study. The heat stress parameters used in the experiment were; rectal temperatures [Morning Rectal Temperature (MRT), Evening Rectal Temperature (ERT) and Increased Rectal Temperature (IRT)] and Subsequent Day Milk Yield (SDMY). The result from the study revealed a significant ($P < 0.05$) variation within the Bunaji breed in all the parameters studied, except the IRT. The cows with tag numbers B162 and B429 recorded the lowest value of mean MRT of 37.4 °C each while B430 recorded the highest of 38.6 °C. The B158 recorded the lowest value of mean ERT of 38.3°C while B177 recorded the highest of 39.3°C. The B162 recorded the highest value of mean SDMY of 4.0 l/day with mean IRT of 0.1 °C, mean regression coefficient of -0.11 l/°C, a significant negative correlation ($P < 0.05$) of -0.71, an intercept of 4.1 l/day, mean % decline in SDMY per unit increase in IRT of 2.7 %/°C and an estimated breeding value for heat tolerance (HT EBV) of +61.6% /°C. The B193 recorded the lowest value of mean SDMY of 0.7 l/day with mean IRT of 1.2 °C, mean regression coefficient of -0.54 l/°C, a significant negative correlation ($P < 0.05$) of -0.93, an intercept of 1.2 l/day, mean % decline in SDMY per unit increase in IRT of 45 %/°C and HT EBV of -25.0%/°C. The findings from this study showed that, there were significant variations ($P < 0.05$) in HT EBV within the Bunaji dairy cows used, thus selective breeding is recommended in order to improve the population mean of HT EBV of the Bunaji breed in the farm.

Keyword: Milk production, Bunaji, Dairy cattle, Heat stress, Heat tolerance.

INTRODUCTION

The main objective of every dairy farm is to obtain cows that will give higher quantity and quality milk as well as better reproductive statues through their life time. The ability of a cow to possess these qualities relies on many interrelated factors. These factors are broadly grouped into genetic and environmental factors as well as the interactions between the two (Hutu *et al.*, 2020). The work of every breeder is to study, understand and explore the interactions between these factors in every individual or group of individuals in other to develop individuals with higher economic advantage to man. Bunaji or white Fulani is the most numerous and widespread of all Nigerian cattle breeds (Meghen *et al.*, 1999). The Nigerian National Livestock Resources Survey [NNLRS] (1990) estimated that, the white Fulani represents 37% of the national herd. The White Fulani cattle are important for their genetic predisposition of hardiness, heat tolerance and adaptation to local conditions (Alphonsus *et al.*, 2012). They further reported that crosses of White Fulani and Holstein recorded increased milk



production at Animal Production Research Institute (NAPRI), Shika, Zaria. The White Fulani is a triple-purpose animal, with milk production of about 2,300 kg per lactation.

An important environmental factor that interferes with the productivity of an animal is heat stress, which is usually brought about by fluctuations in temperature and/or humidity mostly experienced in tropical regions of the world. However some individuals or breeds are genetically more tolerant to heat stress than others. Heat tolerance in dairy cow can be defined as the rate of decline in milk, fat and protein yields per unit increase of the Temperature-Humidity Index (THI) (Nguyen *et al.*, 2018). Heat stress can be managed in several ways which include, provision of cooling devices such as shades, fans and sprinklers, managing milking time on hot days, changing the dietary pattern and most importantly stocking cows with higher breeding value in terms of tolerant to heat stress. Breeding value refers to the value of animal in a breeding program for a particular trait. Breeding values can be estimated based on the animal's own records and/or the performance of known relatives. Previous research on heat tolerance found that there is genetic variation in performance of dairy cattle under heat stress conditions (Bohmanova *et al.*, 2008) as such, identification and selection for heat tolerant animals is possible, and can offer a promising and long-term remedies to issues related to heat stress in an intensive dairy farm.

Poor productivity in terms of milk yield and quality, conception rate, fast growth rate and longevity has being a major challenge facing dairy farm (Ali *et al.*, 2021). Intense selection for milk yield has increased environmental sensitivity in dairy cows (Bohmanova *et al.*, 2008). Several studies have explored the genetic basis for heat tolerance in dairy cattle and other livestock species [Carabaño *et al.* (2017)]. According to Sigdel *et al.* (2019) and Ansari-Mahyari *et al.* (2019), a possible strategy for reducing the effects of heat stress on dairy cattle is the selection of genetically more thermo-tolerant animals. The study was therefore carried out to determine the level of sensitivity to heat stress of the Bunaji dairy cattle at Abubakar Tafawa Balewa University Dairy Research and Development Centre Bauchi, estimate the breeding value for heat tolerance (HT EBV) of the Bunaji dairy cows and develop the prediction EBV equation for heat tolerance for the Bunaji dairy cattle.

MATERIAL AND METHOD

Description of Study Area

The study was carried out at Abubakar Tafawa Balewa University Dairy Research and Development Centre Gubi Campus, Bauchi State, Nigeria. Bauchi state is located in the northern guinea savannah agro-ecological zone of Nigeria, at approximately 10°17'N, 9°49'E and 690.3m above sea level. Gubi is a village located at about 17 km north-west of Bauchi town. Gubi has a savanna climate with annual high and low temperatures of 35.99°C (96.78°F) and 21.9°C (71.42°F) respectively, average annual precipitation of 89.98mm with about 121.25 days of rainfall (≥ 1.0 mm) per annum and average humidity of 44.73%.

Data Collection

A total of twenty four (24) Bunaji dairy cattles were used for the study out of which fifteen (15) were lactating during the period of the study. Data were collected fortnightly for a period of 16 weeks, starting from 2nd February 2022 to 25th May 2022. The metric data collected from the cows were; Morning Surface Temperatures (MST) and Evening Surface Temperatures (EST). Morning Rectal Temperatures (MRT); obtained in the morning before the cows went out for open grazing, Evening Rectal Temperature (ERT); obtained in the evening when the cows came back from open grazing and had been exposed to heat stress and Increased Rectal Temperatures (IRT). IRTs were obtained mathematically as follow; $IRT = ERT - MRT$.



Subsequent Day Milk Yield (SDMY); daily milk yield recorded on the subsequent days after collecting heat stress data.

Data Analysis

The data collected were subjected to analysis of variance (ANOVA) using SPSS version 26.0, to determine the significant of the variations within the breed and means were separated using Duncan's Multiple Range Test (DMRT). The effect of heat stress on milk yield was estimated for lactating cows using a reaction - norm (RM) model (Nguyen *et al.*, 2016). The slope solutions of SDMYs against IRTs for the lactating cows from this model were used to define the phenotypes of tolerance to heat stress in respect to milk production. The slope was obtained as the drop in daily milk yield as a result of heat stress experienced in preceding days using IRT as the heat stress index. The EBV for heat tolerance for a lactating cow was the % decline in SDMY that was recorded in the cow as a result of being tolerant or susceptible to heat stress. The HT EBV was calculated based on individual performance as follows;

$$HTEBV = P - \bar{P} \dots\dots (i)$$

Where; P, is the mean performance of an individual and \bar{P} , is the population mean. But the relationship between SDMY and IRT was a negative one, thus;

$$HT\ EBV = (-) P - \bar{P} \dots\dots\dots (ii)$$

The prediction equation for HT EBV for Bunaji breed was derived using simple linear regression equation as follow;

$$Y_{ij} = \beta_0 + \beta_1 X_{ij} + e \dots\dots\dots (iii)$$

Where; Y_{ij} was the predicted SDMY of the i^{th} cow with j^{th} IRT, β_0 was the intercept, that is the mean SDMY of the breed when mean IRT is equal to zero, β_1 was the regression coefficient or the slope (b), that is the mean decline in SDMY of the lactating B cows per unit increase in IRT, X_{ij} was the j^{th} IRT of i^{th} cow, e was the error of the estimate, that is how much variation there was in the estimate of the regression coefficient. The regression coefficient was estimated using the formula below;

$$b = \frac{N\sum XY - (\sum X)(\sum Y)}{N\sum X^2 - (\sum X)^2} \dots\dots\dots (iv)$$

Where; b was the regression coefficient or the slope, N was the number of observation, X was the IRT for each observation and Y was the SDYM.

RESULT AND DISCUSSION

The result in Table 1 showed that there were no significant ($P > 0.05$) differences in the surface temperatures of the ban where the cattle were kept as well as the Increased Rectal Temperatures (IRT). However significant ($P < 0.05$) variations were recorded in Morning Rectal Temperatures (MRT) and Evening Rectal Temperatures (ERT). Smith *et al.* (2013) also reported a significant variation in the rectal temperature of Holstein dairy cows. Within the breed the cattle with tag numbers B162 and B429 recorded the lowest mean values of MRT of 37.2 °C each, while B430 recorded the lowest of 38.6 °C. The B158 recorded the lowest mean value of ERT of 38.3 °C while B177, B183 and B449 recorded the highest of 39.3 °C each. Increase in rectal temperature had being used in previous researches to quantify the effect of heat stress on the animals (Srikandakumar *et al.*, 2004).

From Table 2, the result showed that within the Bunaji breed, the cow with tag number B162 recorded the highest mean values of SDMY and HT EBV of 4.0 l/day and +16.6 %



respectively with mean IRT, intercept and regression values of 0.1°C , 4.1 l/day and $-0.11 \text{ l/}^{\circ}\text{C}$ respectively and significant ($P < 0.05$) negative correlation of -0.71 while B193 recorded the lowest mean values of SDMY and HT EBV of 0.7 l/day and -25.7% respectively with mean IRT, intercept and regression values of 1.2°C , 1.2 l/day and $-0.54 \text{ l/}^{\circ}\text{C}$ respectively and a significant ($P < 0.05$) negative correlation between IRT and SDYM of -0.93 . As body temperature rises the cow enters heat stress and is forced to make changes in physiological processes, such as milk production and immune function, to decrease internal heat production (Kadzere *et al.*, 2002). Smith *et al.* (2013) recorded a decline in daily milk yield of Holstein and Jersey cattle at temperature-humidity index > 68 with 0.4 kg/day and 0.7 kg/day respectively. The rectal temperature of animals under heat stress is heritable (Dikmen *et al.*, 2012), so genetic selection for superior individuals based on this trait could reduce the effects of heat stress on production through increased thermo-tolerance (Hayes *et al.*, 2009). Additionally, genetic gain is permanent, persisting through subsequent generations (Nguyen *et al.*, 2016). Data on core body temperature with increasing temperature and humidity as well as altered fatty acid profiles in milk using mid-infrared spectroscopy (MIR) may improve the accuracy of EBVs (Pryce *et al.*, 2018).

During the period of this research, 23 Bunaji cows were available in the farm out of which only 15 were lactating. Thus it was necessary to develop a prediction equation of HT EBV for the rest of the Bunaji cows and incoming ones. A general prediction equation of HT EBV for each breed is of very important because it will serve as a vital tool for future breeding program (Nguyen *et al.*, 2018). The regression analysis of the means SDMYs against the means IRTs of all the lactating Bunaji cows was used to obtain the coefficients that were used to develop the equation. Mean regression coefficient of $-0.66 \text{ l/}^{\circ}\text{C}$, intercept of 1.70 l and error of estimation of 0.1 were recorded as shown in Table 2 and Figure 2. The prediction equation was developed using Best Linear Unbiased Prediction (BLUP) equation as follow; $Y_{ij} = 1.70 - 0.66X_{ij} + 0.1... (v)$. Predicted heat-susceptible and heat-tolerant animals show significant differences in milk yield loss and rectal and intra-vaginal temperatures when exposed to a mild simulated heat wave (Garner *et al.*, 2017).

Table 1: Level of Sensitivity to Heat Stress within the Bunaji Cattle Breed

Tag No	MST (°C)	EST (°C)	MRT (°C)	ERT (°C)	IRT (°C)
B151	36.1	37.7	37.7 ^{ab}	38.5 ^a	0.8
B155	35.6	36.9	37.5 ^a	38.8 ^{ab}	1.2
B156	36.3	37.7	37.4 ^a	38.6 ^{ab}	1.2
B157	35.6	38.0	37.7 ^b	38.4 ^a	0.7
B158	36.2	37.7	37.7 ^{ab}	38.3 ^a	0.7
B162	36.1	37.5	37.2 ^a	38.5 ^a	0.9
B166	35.9	37.4	37.8 ^{ab}	38.4 ^a	1.0
B172	36.1	37.5	37.7 ^{ab}	39.0 ^c	1.0
B175	36.2	37.4	37.9 ^b	38.8 ^{ab}	0.9
B177	36.1	37.6	38.3 ^c	39.3 ^d	1.0
B182	36.2	37.9	37.7 ^{ab}	38.8 ^{ab}	1.1
B183	36.2	37.7	38.2 ^{bc}	39.3 ^d	1.1
B187	36.4	37.7	37.9 ^b	38.6 ^{ab}	0.7
B190	36.3	37.9	37.9 ^b	38.9 ^b	1.0
B193	35.2	37.4	38.1 ^b	38.7 ^b	0.7
B196	36.3	37.4	37.8 ^{ab}	38.9 ^b	1.0
B197	37.0	37.8	38.4 ^c	39.0 ^c	0.6
B429	36.0	37.3	37.2 ^a	38.4 ^a	1.0
B430	36.3	37.6	38.6 ^c	39.1 ^c	0.7
B431	37.1	38.0	37.9 ^{ab}	38.8 ^{ab}	0.9
B446	37.1	37.9	38.1 ^b	38.5 ^a	0.5
B449	36.1	37.9	38.2 ^b	39.3 ^d	1.0
Btonga	36.1	37.5	37.3 ^a	38.4 ^a	0.9
Bull	36.6	37.2	37.4 ^{ab}	38.5 ^a	1.0
G.M	36.2	37.6	37.8	38.7	0.9
S.D	1.9 ^{NS}	1.3 ^{NS}	0.9**	0.5**	0.5 ^{NS}

S.D = standard deviation, ^{NS}=not significant, * = significant at 5% level of probability and ** = significant at 1% level of probability.

Table 2: Estimation of Breeding Value for Heat Tolerance (HT EBV) on Lactating Bunaji Cows.

Tag number	Mean SDMY (l/day)	Mean IRT ($^{\circ}$ C)	Regression coefficient (l/ $^{\circ}$ C)	Correlations	Intercept (l/day)	Estimated % SDYM decline/IRT (%/ $^{\circ}$ C)	HT GEV (%/ $^{\circ}$ C)
B162	4.0 ^a	0.1 ^a	-0.11	-0.71*	4.1	2.7	+16.6
B151	2.8 ^b	0.3 ^a	-0.19	-0.91**	3.0	6.3	+13.0
B155	2.7 ^b	1.2 ^b	-0.63	-0.59 ^{NS}	2.7	23.3	-4.0
B196	3.3 ^b	0.4 ^a	-1.70	-0.95**	5.1	33.3	-14.0
Btonga	1.7 ^c	1.2 ^b	-0.50	-0.87*	2.0	25.0	-5.7
B429	1.0 ^d	1.3 ^c	-0.06	-0.94**	1.0	6.0	+13.3
B182	1.3 ^{cd}	1.2 ^b	-0.17	-0.91**	1.4	12.1	+7.2
B190	1.0 ^d	1.5 ^d	0.04	0.49 ^{NS}	0.9	4.4	+14.9
B183	0.8 ^d	1.5 ^d	-0.39	-0.96**	1.3	40.2	-20.9
B166	2.1 ^c	1.2 ^b	-0.39	-0.97**	2.5	15.6	+3.7
B187	1.0 ^d	1.2 ^b	-0.09	-0.92**	1.0	9.0	+10.3
B177	0.9 ^d	1.2 ^b	-0.28	-0.95**	1.2	23.3	-4.3
B172	1.1 ^d	1.1 ^b	-0.33	-0.86*	1.5	22.0	-2.7
B193	0.7 ^d	1.2 ^b	-0.54	-0.93**	1.2	45.0	-25.7
B156	2.6 ^b	1.2 ^b	-0.69	-0.96**	3.2	21.6	-2.3
G.M	1.8	1.1	-0.41	---	2.1	9.3	
S.D	1.1**	1.2**					

G.M = grand mean, S.D = standard deviation, ^{NS}=not significant, * = significant at 5% level of probability and ** = significant at 1% level of probability.

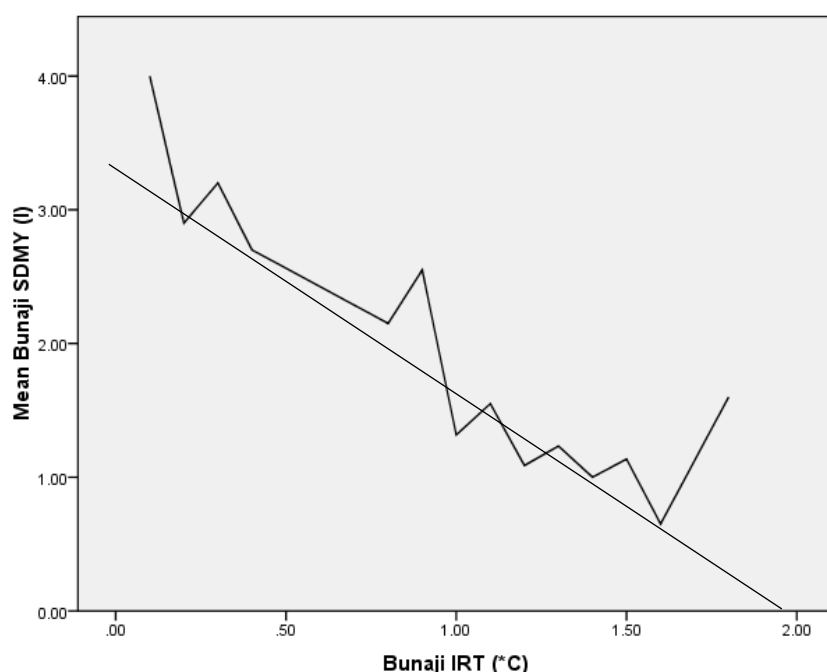


Figure 1: Regression of the SDYMs against the IRTs of Lactating Bunaji Cows

(The slope of the graph indicated a significant negative correlation (-0.835**). Slope = -1.8 l/ $^{\circ}$ C, Intercept = 3.56 l/day and Error of estimate = 0.2



CONCLUSION AND RECOMMENDATION

The findings from the study revealed that there were significant variations in heat tolerance within the Bunaji cattle breed. Some cows recorded better values than the others in maintaining a steady rectal temperature after subjecting to heat stress. Also some cows recorded higher values of mean SDMY than others. Furthermore in the validation of the effect of heat stress on milk yield using the percentage decline in SDMY per unit IRT as parameter, some cows also recorded lower values than others. Thus selective breeding is recommended in Bunaji dairy cattle breed to improve the population mean of HT EBV of the cattle and as such enhance the productivity of the cows.

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