



ESTIMATION OF GENOMIC BREEDING VALUE FOR HEAT TOLERANCE (HTGEBV) IN WADARA DAIRY CATTLE

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ABSTRACT

The research was conducted to estimate the genomic breeding value for heat tolerance (HT GEBV) in wadara dairy cattle breed at Abubakar Tafawa Balewa University Dairy Research and Development Center Gubi campus, Bauchi state, Nigeria. A total of thirty five (35) Wadara dairy cattle were used for the study. The basic parameters measured 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). Variations were recorded within wadara breed in the basic parameters at $P < 0.05$. The cow with tag number W383 recorded the highest mean IRT of 1.2°C , while W368 recorded the lowest mean IRT of 0.3°C . W362 and W358 recorded highest mean SDMY of 2.4 l, while W354 recorded the lowest mean SDMY of 0.5 l. W360 recorded the highest mean estimated percentage decline in SDMY per unit increase in IRT of $61.3\%/^{\circ}\text{C}$, while W359 record the lowest ($22.0\%/^{\circ}\text{C}$). W359 had the highest HT GEBV of $+16.7\%/^{\circ}\text{C}$ while W360 had the lowest of $-22.6\%/^{\circ}\text{C}$. The coefficients obtained from correlation analysis between the IRTs and SDMYs of all the lactating wadara cows were used to develop the prediction equation of HT GEBV for all the wadara cattle breed in the farm. Mean regression coefficient of $-0.66\text{ l}/^{\circ}\text{C}$, intercept of 1.70 l and error of estimation of 0.1 were obtained through the analysis. The prediction equation was developed using genomics best linear unbiased prediction (GBLUP) equation as follow; $Y_{ij} = 1.75 - 0.64X_{ij} + 0.1$. The findings from this study showed that there were significant ($P < 0.05$) genomic variations in HT GEBV within the wadara dairy cattle at Abubakar Tafawa Balewa University Dairy Research and Development Center. Thus selective breeding is recommended in order to improve the population mean of HT GEBV of wadara cattle breed in the farm.

Keyword: Milk production, Wadara dairy cattle, Heat stress, Heat tolerance, Genomic breeding value.

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 status 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. The work of every breeder is to study, understand and explore the interactions between these factors in every individual or group of individuals in order to develop individuals with higher economic advantage to man (FAO, 2023). Wadara is a Nigerian breed of cattle, they are medium-sized, lightly built cattle, and are usually dark-red, black, pied or brown. Ogundipe and Adeoye (2013) reported 880 kg average milk yield per lactation from wadara cows and 1644 kg from Wadara-Friesian crosses. 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 (NADIS, 2016). Breeding value refers to the genetic potential of an animal for a particular trait in a breeding program (Hutu *et al.*, 2020). 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 (Hayes *et al.*, 2003, 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 (Hare *et al.*, 2006). As at the time of this study no significant genetic improvement had been done in regarding to reduction of the adverse effect of heart stress on the cows in Abubakar Tafawa Balewa university dairy research and development centre. Several studies have explored the genetic basis for heat tolerance in dairy cattle and other livestock species [reviewed by 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 objectives of this study were to determine the level of sensitivity to heat stress of the wadara dairy cattle at Abubakar Tafawa Balewa University dairy Research and Development Centre, estimate the genomic breeding value for heat tolerance (HT GEBV) of the wadara dairy cattle and also develop the prediction GEBV equation for heat tolerance for the wadara dairy cattle breed.

MATERIALS AND METHOD

Description of the 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 ($\geq 1.0\text{mm}$) per annum and average humidity of 44.73%. (NiMet 2022).

Data Collection

A total of thirty five (35) Wadara dairy cattle were used for the experiment. Data were collected fortnightly for a period of 16weeks, 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 cattle went out for open grazing, Evening Rectal Temperature (ERT) obtained in the evening when the animals 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. The 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. GEBV for heat tolerance for a lactating cow was the percentage decline in SDMY that was recorded in the cow as a result of being tolerant or susceptible to heart stress. HT GEBV was calculated based on individual performance as follows;

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

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;

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

The genomic prediction equation for wadara breed was derived using simple linear regression equation as follow;

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

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 wadara 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;

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

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 subsequent day milk yield.

RESULT AND DISCUSSION

From Table 1 below, the result 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 morning rectal temperatures. However significant ($P < 0.05$) variations were recorded in ERT and IRT. Within the Wadara breed the cattle with tag numbers W374 and W381 had the highest mean ERT of 39.2 °C, while W361 had the lowest of 38.4 °C. W383 had the highest mean IRT of 1.2 °C while W368 had the lowest of 0.3 °C. 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 below, within the wadara breed, W359 recorded the best level of heat tolerance which was indicated on its estimated percentage decline in SDMY per unit IRT of 22.0 %/°C, with an intercept of 1.5 l, and HT GEBV of +16.7 %/°C while W360 recorded the poorest level of heat tolerance with the highest estimated percentage loss in SDMY per unit IRT of 61.3%/°C with an intercept of 1.9 l and HT GEBV of -22.6 %/°C. As body temperature



risers 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). Genomically 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). 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). However, because heat tolerance is a genomic trait that has been identified only recently, the GEBVs are less reliable than those of already established phenotype-based production traits (Pryce *et al.*, 2018). The accuracy of GEBVs for heat tolerance is further limited using variations in test-day milk production to measure heat stress, as variations between days are not wholly dependent on ambient conditions (Nguyen *et al.*, 2016; Bohmanova *et al.*, 2008). 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 GEBVs (Pryce *et al.*, 2018).

During the period of this research, 34 wadara cows were available in the farm out of which only 12 were lactating. Thus it was necessary to develop a prediction equation of HT GEBV for the rest of the wadara cows and incoming ones. A general prediction equation of HT GEBV for each breed is of very important because it will serve as a vital tool for future breeding program (Nguyen *et al.*, 2018). The correlation analysis between the mean IRTs and mean SDMYs of all the lactating wadara 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 below. The prediction equation was developed using genomics best linear unbiased prediction (GBLUP) equation as follow;
$$Y_{ij} = 1.70 - 0.66X_{ij} + 0.1$$

Table 1: Level of Heat Stress Tolerance within the Wadara Breed

Wadara Tag	MST ($^{\circ}\text{C}$)	EST ($^{\circ}\text{C}$)	MRT ($^{\circ}\text{C}$)	ERT ($^{\circ}\text{C}$)	IRT($^{\circ}\text{C}$)
W352	35.9	37.3	38.0	38.6 ^a	0.6 ^{ab}
W354	36.0	37.5	37.9	38.7 ^{ab}	0.7 ^{ab}
W355	36.5	37.5.1	38.6	38.6 ^a	0.7 ^{ab}
W356	36.5	38.2	38.6	39.0 ^b	0.6 ^{ab}
W357	36.5	37.2	38.0	38.8 ^{ab}	0.9 ^b
W358	36.4	38.7	38.1	38.8 ^{ab}	0.5 ^a
W359	35.9	37.5	37.9	38.8 ^{ab}	1.0 ^c
W360	35.2	38.4	38.2	38.8 ^{ab}	0.7 ^{ab}
W361	36.2	37.7	37.7	38.4 ^a	0.9 ^b
W362	36.0	37.4	37.9	38.7 ^{ab}	0.9 ^b
W364	36.3	37.3	37.7	38.5 ^a	0.8 ^{ab}
W365	36.6	37.5	38.1	38.9 ^b	0.9 ^b
W366	35.4	37.1	37.7	38.6 ^{ab}	0.9 ^b
W367	36.8	38.2	38.2	39.1 ^c	0.9 ^b
W368	36.8	37.2	38.3	38.5 ^a	0.3 ^a
W369	37.8	38.7	38.7	39.1 ^c	0.4 ^a
W370	36.4	37.5	38.3	38.6 ^{ab}	0.6 ^{ab}
W371	37.2	38.4	38.4	39.0 ^d	0.6 ^{ab}
W373	36.5	37.7	38.2	38.9 ^{ab}	0.7 ^{ab}
W374	35.6	37.4	37.0	39.2 ^d	1.1 ^d
W375	36.2	37.5	38.2	39.0 ^b	1.1 ^d
W376	36.2	37.3	38.3	39.0 ^b	0.8 ^{ab}
W380	37.3	37.8	38.5	39.1 ^d	0.8 ^{ab}
W381	36.5	37.2	38.3	39.2 ^d	1.0 ^c
W382	36.8	37.1	38.0	38.8 ^{ab}	0.8 ^{ab}
W383	36.3	37.0	37.4	38.8 ^{ab}	1.2 ^d
W384	36.5	37.4	35.9	38.6 ^a	0.5 ^a
W385	36.2	37.5	38.2	39.2 ^d	1.1 ^d
W386	36.2	37.3	38.2	38.8 ^{ab}	0.5 ^a
W387	36.6	38.0	38.2	39.1 ^d	1.0 ^c
W388	36.4	37.6	38.2	38.6 ^a	0.6 ^{ab}
W389	37.7	37.2	38.2	38.9 ^b	0.7 ^{ab}
W390	35.9	37.4	38.3	38.8 ^{ab}	0.7 ^{ab}
W392	36.9	37.3	38.3	39.4 ^e	0.7 ^{ab}
W394	36.5	37.5	37.8	38.9 ^b	1.1 ^d
G.M	36.3	37.4	38.0	38.9	0.8
S.D	1.4 ^{NS}	1.3 ^{NS}	1.0 ^{NS}	0.5*	0.5**

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

Table 2: Assessment of Genomic Breeding Value for Heat Tolerance (HT GEBV) on Lactating Wadara Cows.

Tag number	Mean SDMY (°C)	Mean IRT (°C)	Slope (l/°C)	Correlations	Intercept (l)	Estimated % SDYM decline/IRT (%/°C)	HT GEBV (%/°C)
W380	0.8 ^d	0.8	-0.46	-0.83*	1.1	41.8	-3.1
W362	2.4 ^a	0.9	-1.12	-0.99**	3.4	32.9	+5.8
W359	1.3 ^b	0.9	-0.33	-0.91**	1.5	22.0	+16.7
W361	1.4 ^b	0.8	-1.05	-0.94**	2.2	47.7	-9.0
W355	1.1 ^c	0.7	-0.83	-0.95**	1.6	51.9	-13.2
W383	0.6 ^d	1.3	-0.37	-0.85*	1.1	33.6	+5.1
W354	0.5 ^d	0.7	-0.18	-0.82*	0.7	25.7	+13
W360	1.2 ^c	0.7	-0.88	-0.98**	1.9	61.3	-22.6
W358	2.4 ^a	0.5	-0.78	-0.93**	2.8	27.9	+10.8
W357	1.1 ^c	0.9	-0.30	-0.77*	1.3	23.1	+15.6
W356	1.3 ^b	0.6	-1.14	-0.89**	2.0	57.0	-18.3
W365	0.9 ^d	0.9	-0.52	-0.99**	1.3	40.0	-1.3
G.M	1.3	0.8	-0.66	-0.44**	1.7	38.7	
S.D	0.6**	0.4 ^{NS}					

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

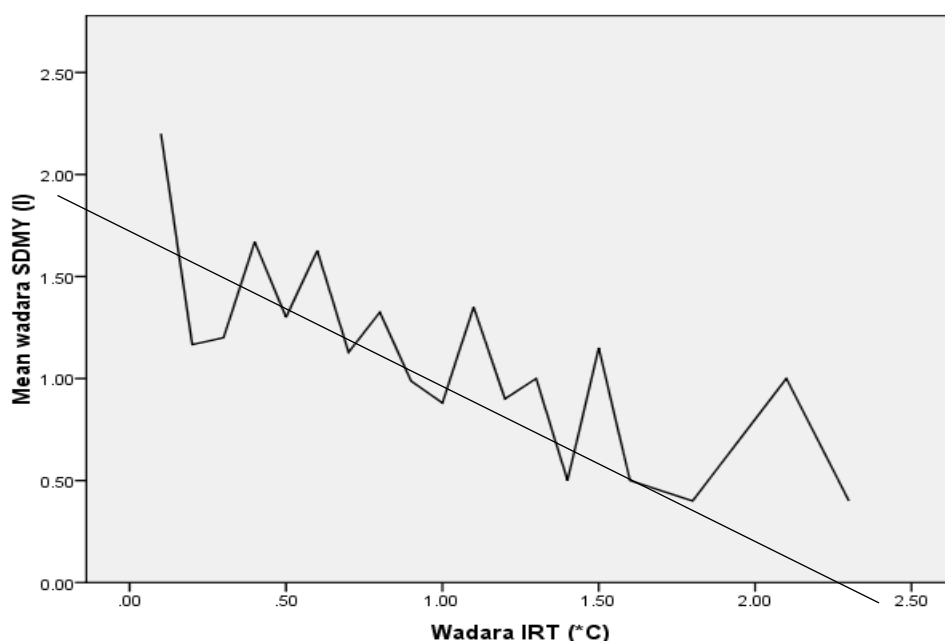


Figure 1: Correlation Graph of mean IRTs against mean SDYMs of Lactating Wadara Cows (The slope of the graph indicated a significant negative correlation (-0.44**) between IRT and SDY). Slope =0.66 l/°C, Intercept =1.70 l and Error of estimate = 0.1



CONCLUSION AND RECOMMENDATION

The findings from this study revealed a significant genomic variation in HT GEBV within Wadara cattle breed. Some cows are better than the others in maintaining a steady rectal temperature after subjecting to heat stress. 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 proved to be better than others. Some cows have higher value of mean SDMY than others. Thus selective breeding is recommended in Wadara dairy cattle breed to improve the population mean of HT GEBV of the cattle and as such enhance the productivity of the cows

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