Better lives through livestock

Heat stress research and adaptation in Africa

C.C. Ekine-Dzivenu, R. Mrode, G.Gebreyohanes, J.M. Ojango, A.M. Okeyo

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One CGIAR: a global research partnership for a food secure future.

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ILRI is co-hosted by both the governments of Ethiopia and Kenya, with offices in 8 other countries in Africa (Burkina Faso, Burundi, Mali, Nigeria, Senegal, Tanzania, Uganda and Zimbabwe); 4 countries in Asia (China, India, Nepal and Vietnam).

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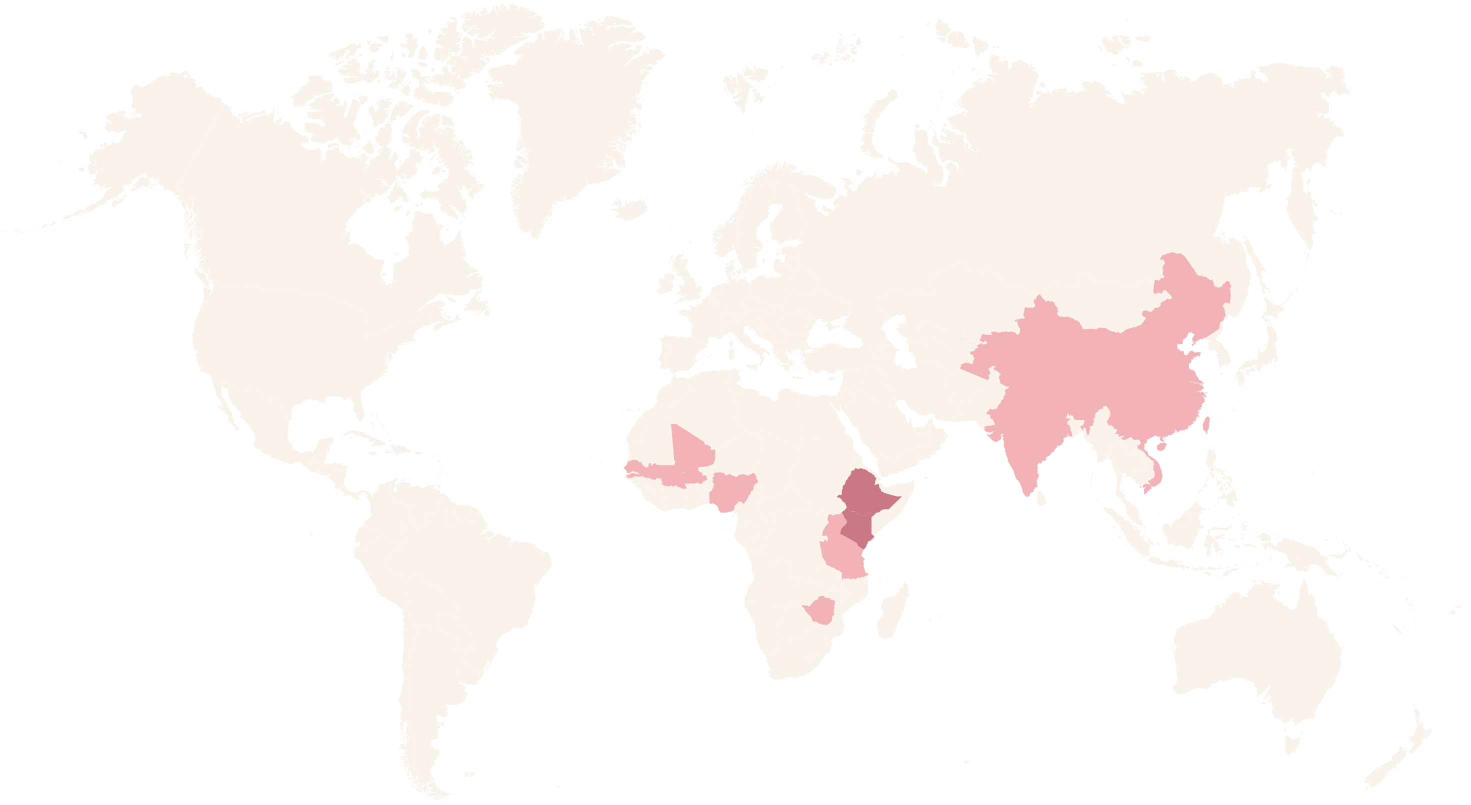

ILRI's **mission** is to improve food and nutritional security and to reduce poverty in developing countries through research for efficient, safe and sustainable use of livestock — *ensuring better lives through livestock*

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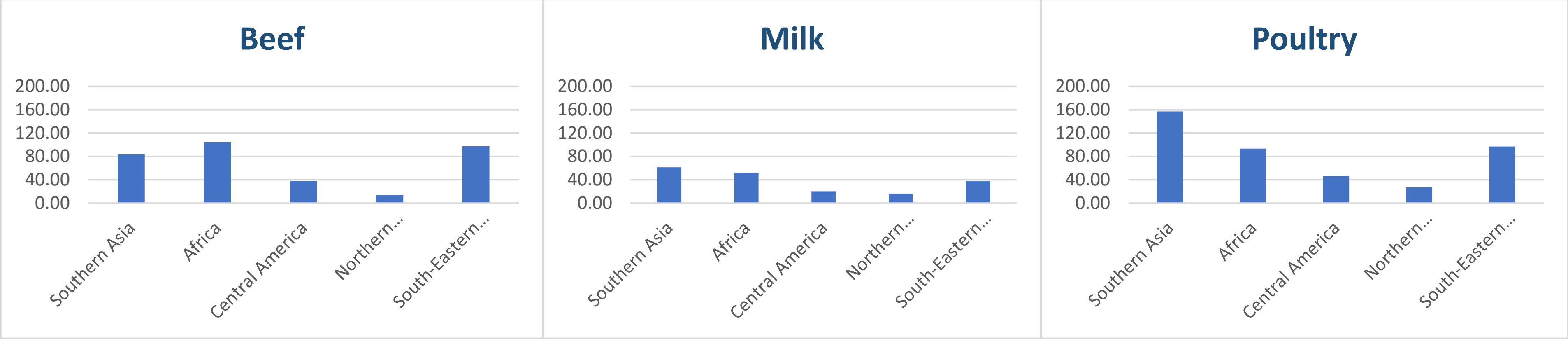
Demand for food will keep growing

Especially in LMICs

Demand for milk, meat, eggs is increasing fastest in LMICs driven by population, rising incomes and urbanization

Not based on significant over-consumption in LMICs



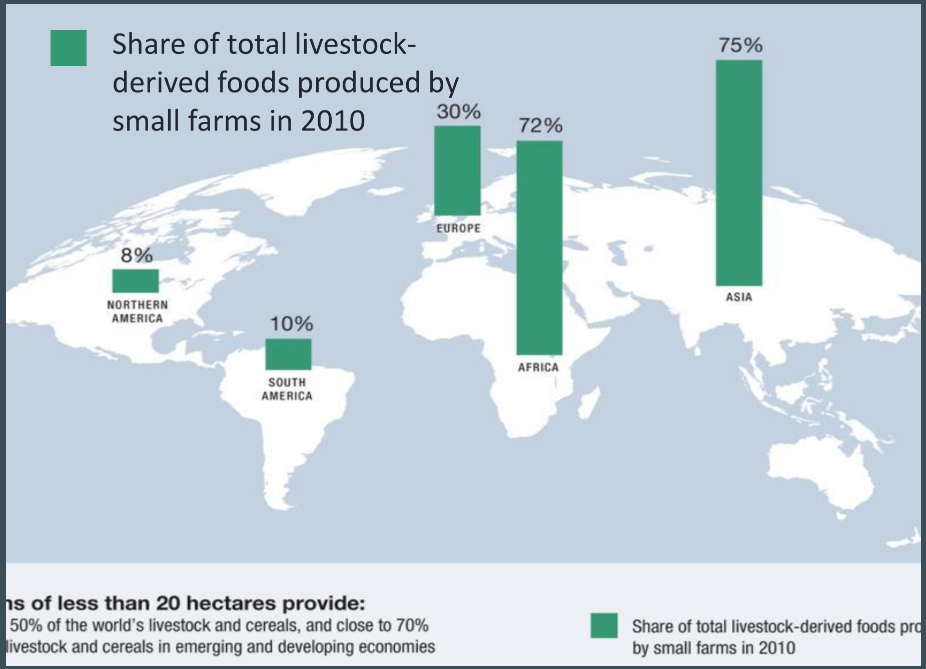
Projections based on IMPACT model, Dolapo Enahoro (ILRI), **Percentage changes in demand 2010 to 2030**

- **1.7 billion people** derive some livelihood from livestock; over **half a billion** depend on livestock
- **Livestock are fundamental** to many economies; provide income, jobs, and supporting risk mitigation
- Livestock are the basis for **farm sustainability**, make food crop farming even possible for many in the Global South – circular bioeconomy, integrated livestock-food farms

Smallholder farmers currently provide most of the meat, milk and eggs AND staple cereals in LMICs

Farms of less than 20 hectares provide:

Nearly 50% of the world's livestock and cereals, and close to 70% of the livestock and cereals in emerging and developing economies



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Climate change is expected to have major impacts on livestock productivity

Climate change is expected to have major impacts on livestock, including increased heat stress in animals in many parts of the world.

Smallholder systems of lower- and middle-income economies are more vulnerable to the impacts of a changing global climate than other dairy systems

Even though dairy cattle in sub-Saharan Africa is subject to high ambient temperature and relative humidity, research on the effect of heat stress on livestock productivity and milk production under this climatic conditions is very limited or largely non-existent.

Heat stress is important for dairy production because of its negative effects on productivity and ultimate profitability of the farmers

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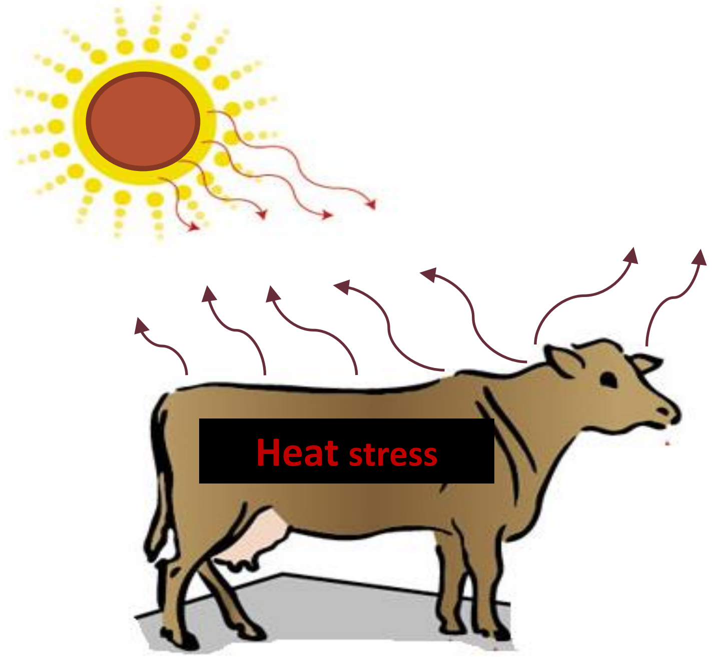

- Dairy cattle develops numerous physiological mechanisms for coping with heat stress including reducing feed intake which results in reduced milk yield.

In cows
- Changes in milk composition
- Increased occurrence of mastitis
- Lengthened oestrus cycle and shortened oestrus periods
- Reduced conception rate
- Placental malfunction
- Decreased foetal growth rate
- Increased embryo mortality

In bulls
- Lowered libido
- Reduced sperm cell concentration
- Reduced sperm cell mobility
- Increased % of abnormal sperm cell

In calves
- Low birth weight
- Reduced growth rate
- Reduced ability to survive

Few published articles quantifying the effect of heatstress on livestock productivity in SSA

Contents lists available at ScienceDirect

Livestock Science

journal homepage: www.elsevier.com/locate/livsci

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Evaluating the impact of heat stress as measured by temperature-humidity index (THI) on test-day milk yield of small holder dairy cattle in a sub-Sahara African climate

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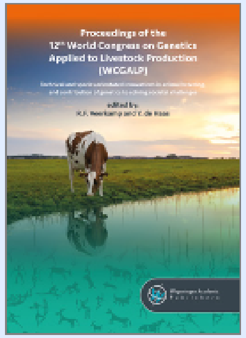

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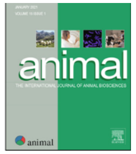

Modeling heat stress effects on dairy cattle milk production in a tropical environment using test-day records and random regression models

J.M. Mbuthia, M. Mayer, N. Reinsch *

The objective of this study was to detect heat stress thresholds, milk yield loss and individual animal variations using random regression models for dairy cattle from test-day milk records.in Kenya

Considering a one day lag, the estimated heat stress thresholds were about 22 ° C and 69 index units for TA and THI, respectively.

410. Genomic analysis of milk yield and heat tolerance in small holder dairy system of sub-Saharan Africa

C.C. Ekine-Dzivenu, R. Mrode1, R.D. Oloo, D. Komwihangilo, E. Lyatuu, G. Msuta, J.M. Ojango, A.M. Okeyo

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Commercial farms, 4 **main dairy breeds**: Friesian, Ayrshire, Jersey and Guernsey

The general pattern is a seasonal fluctuation of milk yield following weather variation, particularly temperature. The lowest milk yield was in March which also had the highest average daily temperatures of 20ºC

Heat stress thresholds were about 22 ºC and 69 index units for TA and THI, after which a declining trend was observed

As expected, milk loss increased with increasing heat load. The comfort zone for TA was below 22 ºC after which a declining trend was observed. Average milk yield loss was −0.27, −0.19 and −0.35 kg/ºC per day for the first, second and third lactation, respectively.

The THI comfort zone was below about 69, above which there was a declining trend in milk yield. The average milk yield loss was −0.29, −0.19 and −0.37 kg/THI unit per day for the first, second and third lactation, respectively.

There is different degrees of variation btw cows with almost no change in variance along the THI trajectory for cows in the 1st and 3rd lactation but tended to increase across the THI trajectory in the 2nd lactation.

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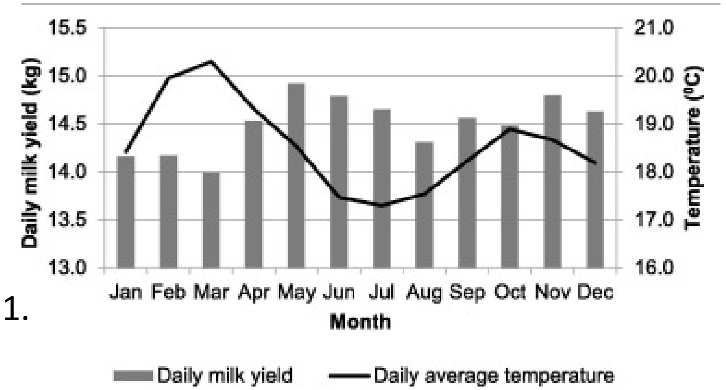

Fig 1.

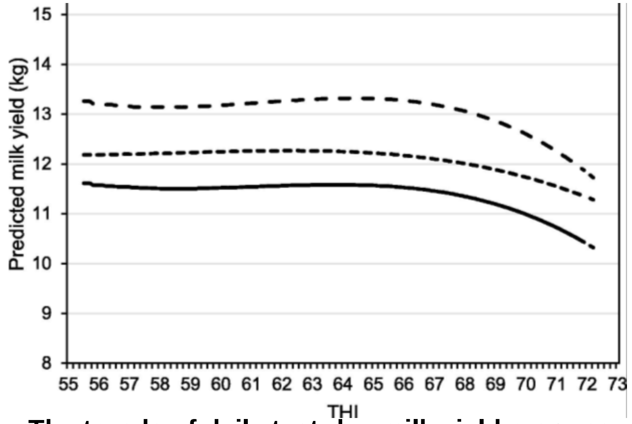

Fig 2. **The trends of daily test-day milk yield response to THI for the first three lactations**

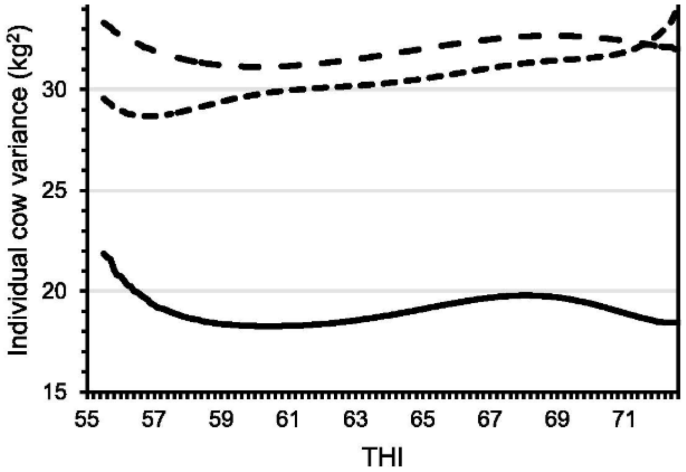

Fig 3.

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Evaluating the impact of heat stress as measured by temperature-humidity index (THI) on test-day milk yield of small holder dairy cattle in a sub-Sahara African climate

C.C. Ekine-Dzivenu[a,*], R. Mrode[a,b], E. Oyieng[a], D. Komwihangilo[c], E. Lyatuu[c], G. Msuta[c], J.M. K. Ojango[a], A.M. Okeyo[a]

This study evaluates the effect of heat stress on milk production and describes the pattern of response of milk yield to increasing heat load, using temperature-humidity index (THI) on test-day milk records of **crossbred dairy cows** in **small holder dairy cattle herds** in the sub-Saharan African climate of Tanzania.

Part of a wider project called AADGG (African Asian Dairy Genetic Gains project) which is developing and testing a multi-country genetic gains platform using smallholder dairy cattle performance data and genomic information

Daily milk yield followed the pattern of a lactation curve and peaked at 8.5l in 60 days
Seasonal fluctuation of milk yield following weather variation

Results indicate that cows experienced heat stress between THI values of 67 and 76 and daily milk production, reduced by 4.16% to 14.42% across THI groups (heat stress levels).

Milk yield showed a W-shaped pattern of response across the THI scale at the population level, indicating a non-linear relationship between milk yield and THI

THI and its squared term were significantly negatively and positively (-0.61, 0.004) associated with milk production indicating that there is no unique slope and change in milk yield is different across the THI interval.

Fig. 1.

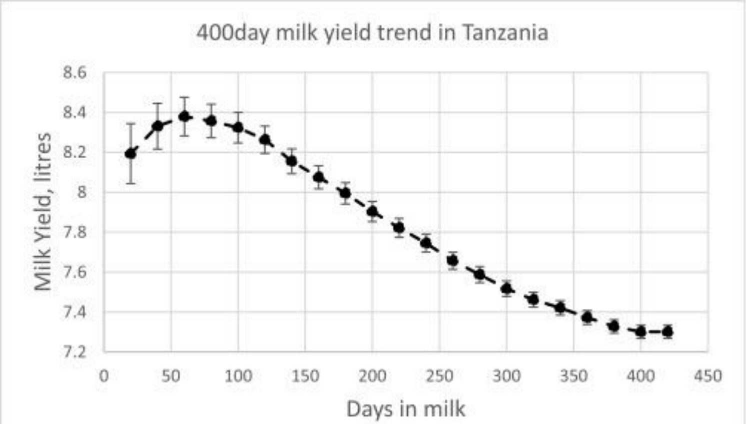


Fig.2.

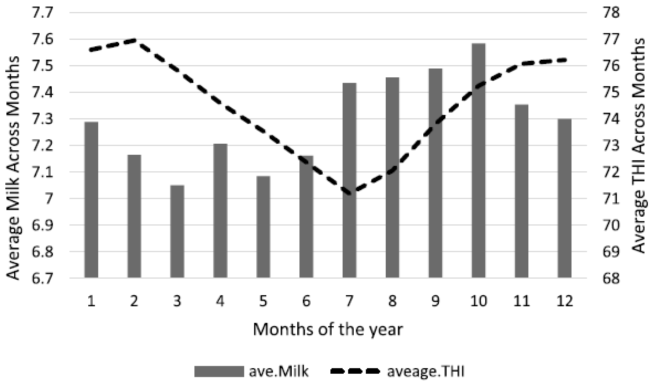
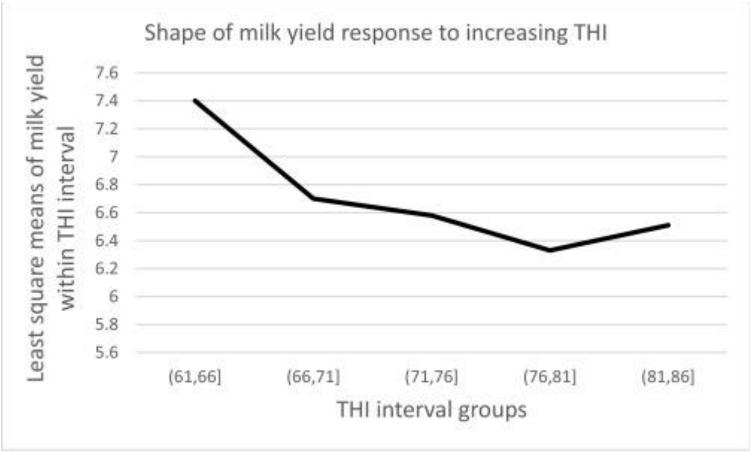


Fig. 3. Trend in milk yield and Temperature Humidity Index (THI) across months.

Fig. 3.



Objective

The goal of this study, was to **evaluate changes in genetic parameters for milk yield and heat tolerance** in small holder dairy cattle population of Tanzania under different heat stress (THI) thresholds as **a first step toward including this trait in selection indices for dairy cattle in the region.**

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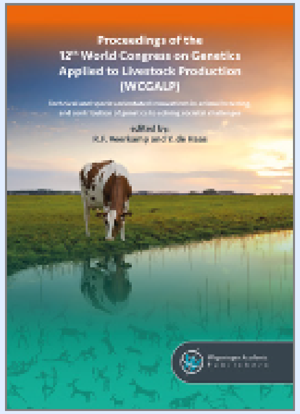

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Results

Table 1. Basic description of milk yield and weather data.

	Mean	Std	Range
Milk, liters	7.90	4.21	1 - 38
Temp, ºC	21.05	5.50	11.6 - 30.64
RH, %	80.48	3.73	68.06 - 89.61.
THI	76.3	3.78	69 - 82

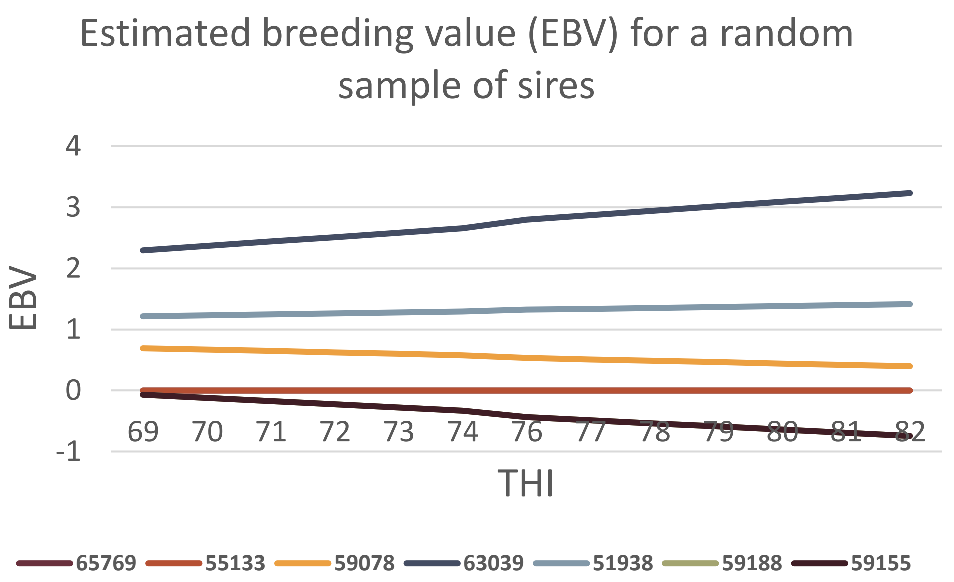


Table 2. Estimates for genetic parameters and heritability for milk production at different THI thresholds (heat stress levels).

	THI thresholds		
Variance Components	69	71	78
σ^2_a	9.83(1.21)	9.16 (1.32)	7.52(1.39)
σ^2_{aht}	0.10(0.61)	1.96(1.20)	2.15(0.95)
$\sigma_{a\ (a,\ aht)}$	-1.00(0.59)	-2.10(0.93)	-0.24(0.72)
$r_{g(a,\ aht)}$	-0.99(NE)	-0.50(0.15)	-0.06(0.19)
$r_{pe\ (pe,peht)}$	-0.92(NE)	0.64(NE)	0.90(NE)
σ^2_{wys}	8.85(0.38)	6.65(0.37)	5.47(0.43)
σ^2_e	5.47(0.12)	4.79(0.12)	4.15(0.18)
h^2	0.38	0.44	0.50

Use of the data for Genomic analysis of milk yield and heat tolerance for small holder dairy system of sub-Saharan Africa

Objective: Evaluate changes in genetic parameters for milk yield and estimate breeding values for milk production under heat stress conditions.

Data –phenotype, genotype, weather

Phenotype

Monthly milk collected, between Nov 2016 and May 2020

Genotype

Cows and bulls genotyped on the 50K chip and imputed to the Illumina HD chip

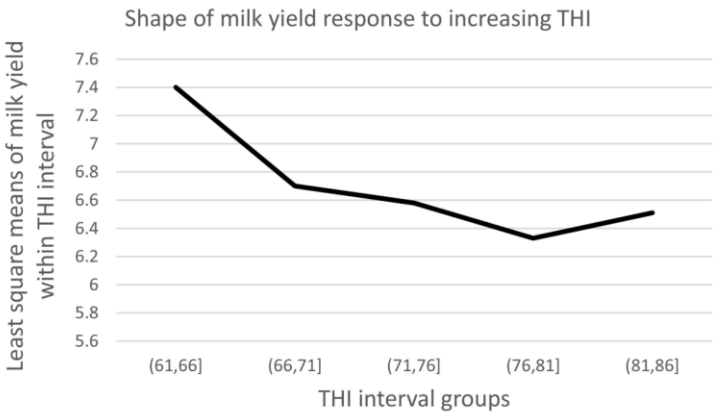
Climate Data

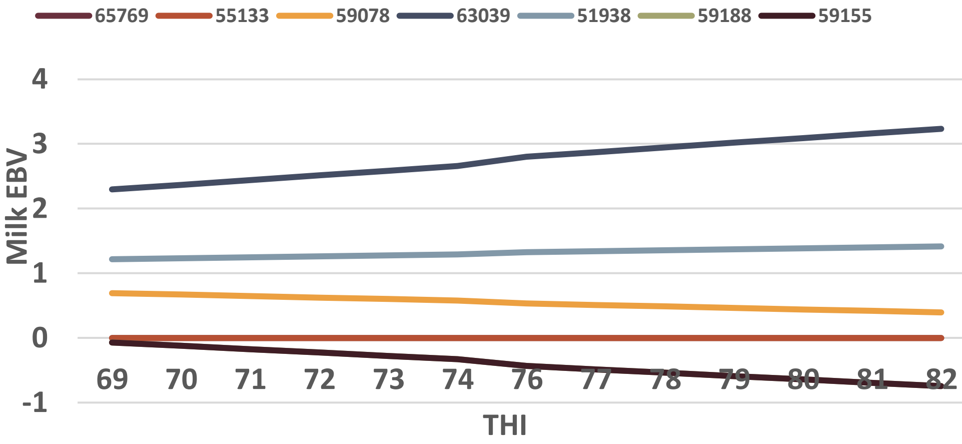
Obtained using GPS coordinates of the farms, data includes daily maximum and minimum relative humidity.

Variance Components	THI Thresholds		
	69	71	78
σ^2_a	9.83	9.16	7.52
σ^2_{aht}	0.10	1.96	2.15
$\sigma_{a\ (a,\ aht)}$	-1.00	-2.10	-0.24
$r_{g(a,\ aht)}$	-0.99	-0.50	-0.06

Results Antagonistic relationships between milk yield and thermal tolerance. Milk production reduced by 4.16% to 14.42% across THI groups (heat stress levels).

Reaction norm shows genetic variations exist between sires, indicating the possibility to select animals that perform optimally in different environments.





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ADGG African Dairy Genetic Gains More productive and profitable dairy cows
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World Congress on Genetics Applied to Livestock Production Rotterdam | The Netherlands 3 - 8 July 2022

Take home message

- Our study detected antagonistic relationships between milk yield and thermal tolerance for heat stress.
- This result suggests that selection for increased milk yield disregarding heat tolerance will result in deteriorating heat tolerance in this population.
- It is important to note that not observing animals across the THI gradient due to low retention of cows in the small holder farms may contribute to the low permanent environmental variances observed.
- Moderate heritability estimates for milk yield over different heat stress levels show potential to genetically improve milk yield for climate conditions with high THI values howbeit with care to avoid unfavourable correlated response of thermal stress on milk production.
- The reaction norms for the sire EBVs along the trajectory of THI indicates that genetic variations exist which can be used to select animals that perform optimally in different environments.

Take home message cont'd

In the longer term

- Identifying sires and dams that carry genes to improve thermotolerance and using them for breeding

In the short term

Precautionary measures need to be taken for mitigation

- Herd management and animal husbandry measures to protect the animal from too much heat.
  - Direct protection from sunlight using shades in form of trees
  - Corrugated sheet metal painted white on the top
- Provision of adequate feed and water at all times
- Increasing the use of concentrate when the weather is hot

African Asian Genetic Gain Program

Addressing the challenges facing small holder livestock (dairy) systems through innovative application of ICT and genomic technology

Little or no systematic way for data collection to drive sustainable breeding programs. Continuous Phenotyping across a wide range of very dispersed smallholder farms

Acknowledging our numerous partners

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