Assessment of phenotypes based on deviations in milk yield as indicators of general resilience of dairy cattle in Kenya

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Introduction

- Environmental disturbances contribute to observed low dairy production in SSA
- Breeding for resilience to environmental stressors in dairy cattle might increase dairy productivity
- But resilience must be quantified first for it to be improved genetically
- Some indicators to measure resilience of animals have been defined based on the deviations from expected performance level (Berghof *et al* 2019).
- Resilient animal deviate with a smaller range from the expectation or recover faster from the disturbance

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Which indicators

Variance of deviations:

- the severity and duration of environmental perturbations
- Lower variance for more resilient animals

Lag 1 autocorrelation of deviations:

- captures the duration (rate of recovery) of environmental perturbations
- Resilient animals have autocorrelation around 0 or toward -1

Skewness of deviations:

- severity of environmental perturbations
- A higher skew indicates better resilience

❑ Heritability estimates of these indicators range from 0.02 to 0.26 and have expected correlation with fitness related traits (Poppe *et al*., 2020, 2021 and Berghof *et al* 2019)

Problem

❑The potential of using such indicators in sub-Saharan Africa is yet to be tested

❑Use of actual deviation can mislead e.g., animals of different genotypes, performing in different environments etc

❑For instance, a change of 3 values from an expectation of 5, is equivalent to 60% change and from an expectation of 15, it is only 20%

❑This would conclude that animals with overall low production are resilient which might not be the case

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Objectives

1. To test the applicability of indicators based on deviations in milk yield in quantifying general environmental resilience of dairy cattle performing in SSA
2. To derive these indicators using proportion of (standardized) deviations and test for any improvement
3. To determine genetic relationship of these indicators with longevity and average milk production

Methods: Data

- Animals performing in three large-scale farms in Kenya representing 3 different agroecological zones
- A final dataset of 307,155 first-parity milk records from 2670 animals was used to define the indicators
- Data of female animals that exited through death from a disease or sale for slaughter (n=1389) was used to define two longevity traits:
  - Productive life span: difference in days between the first calving date and date of exit
  - Herd life: the age of an animal in days before it exited the herd

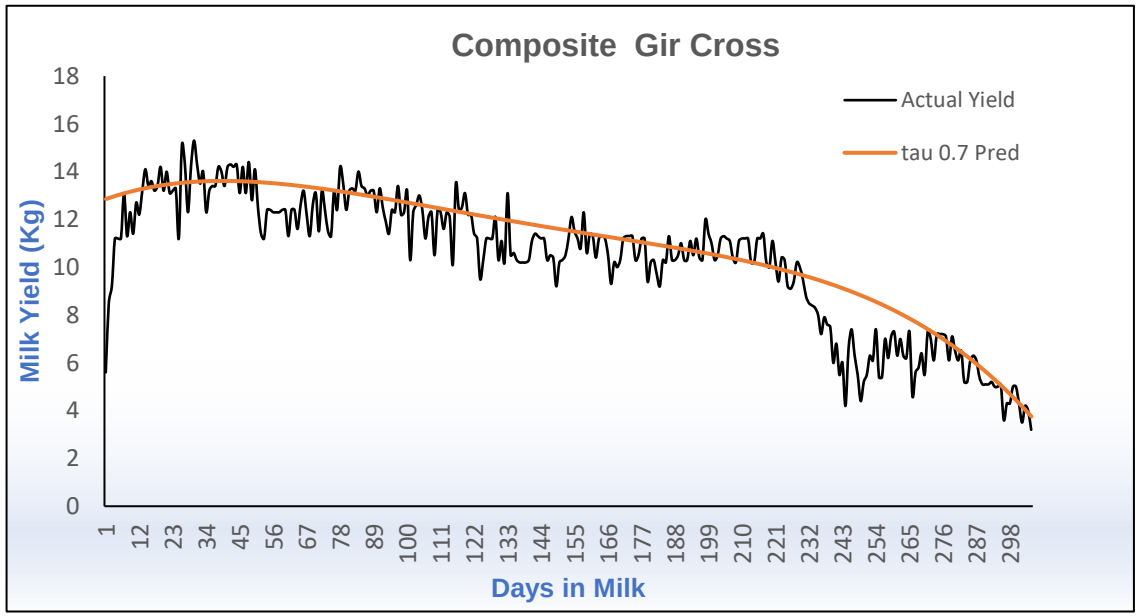
Methods: Statistical analyses

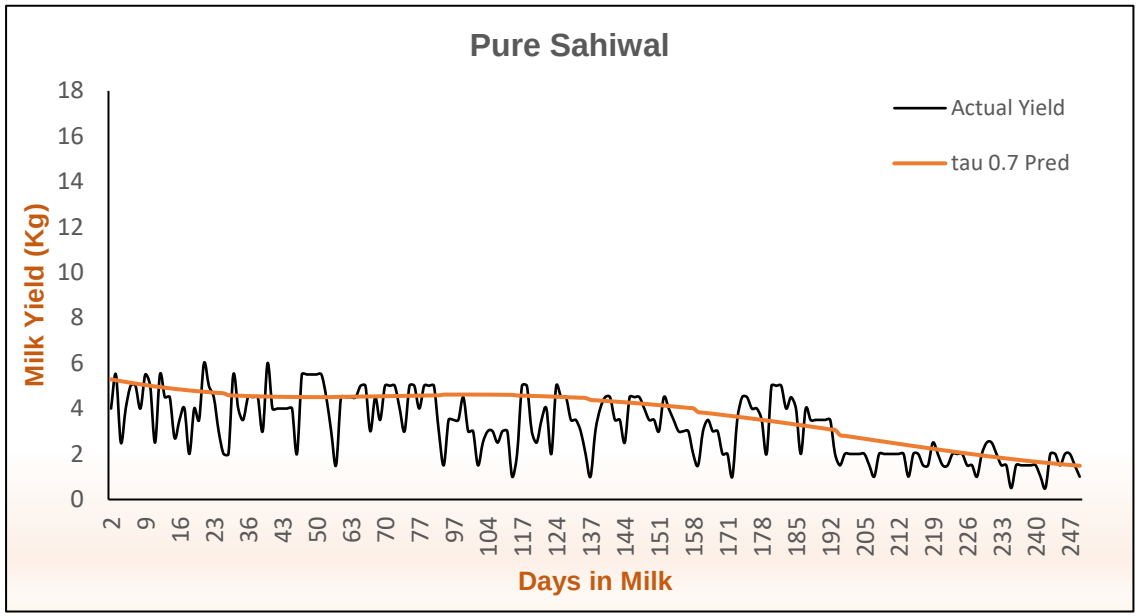
- Lactation curves modelled using 4th order polynomial quantile regression using 0.7th quantile
- From these curves, deviation in milk yield was calculated as: $Deviation_i = Expected\ Yield_i - Actual\ Yield_i$
- And standardized deviation as: $\frac{Deviation_i}{Expected\ Yield_i}$
- Univariate and bivariate animal models were used to estimate genetic parameters of all the resilience indicators, average milk yield and longevity traits adjusting for encountered fixed effects
- Fixed effects model terms for resilience indicators and longevity traits included

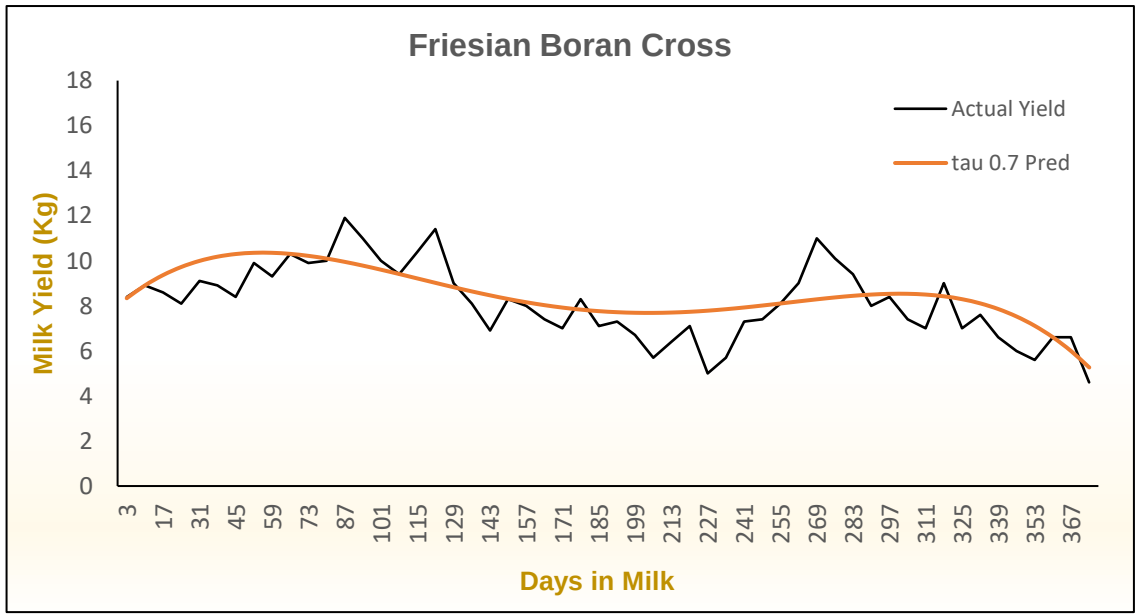
$$Resilience\ Indicator = U + farm + ysc + breed + obs + age + dim1 + dim2$$
$$productive\ life\ span = U + farm + ysb + breed + age + AMY + lacts + exitcode + yse$$
$$herdlife = U + farm + ysb + breed + AMY + lacts + exitcode + yse$$

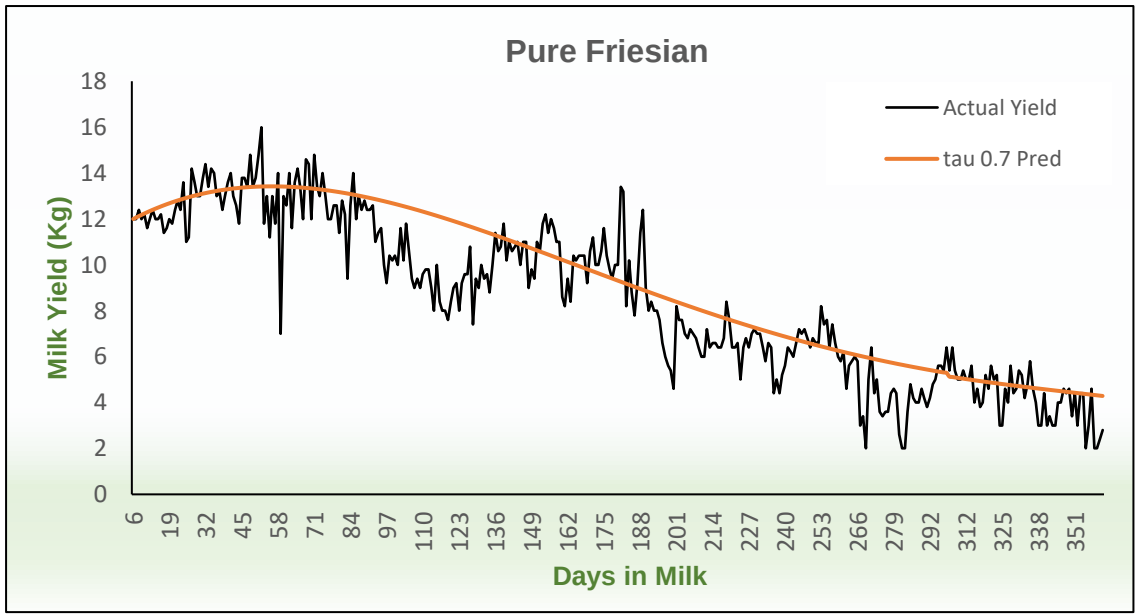
where ysb, ysc, and yse are year season of birth, calving and exit respectively; obs represent the number of test-day observations, dim1 and dim2 are days in milk class of first and last milk record for an individual animal, respectively; lacts is the total number of calving before exit, and exitcode is the exit reason for the animal, either death from a disease or sale for slaughter

Trend of actual and predicted milk production based on 0.7th quantile of selected few animals









Results and Discussions

Genetic parameters of indicators

- All the indicators based on two methods had almost similar heritability estimates
- All traits had low but significant heritability estimates (P<0.05) which are comparable to those previously reported (Poppe et al., 2020, 2021)
- Variance of deviations had the highest heritability estimates
  - Might be the most suitable for assessing resilience
  - Similar results reported by (Elgersma *et al.*, 2018, Poppe *et al.*, 2020, 2021)

Trait	Additive Variance	Phenotypic Variance	Heritability
Variance of actual deviations	0.057(0.013)	0.299(0.009)	0.19(0.04)
Skewness of actual deviations	0.001(0.001)	0.031(0.001)	0.05(0.03)
Autocorrelation of actual deviations	0.014(0.018)	0.725(0.021)	0.02(0.03)
Variance of standardized deviations	0.047(0.011)	0.272(0.008)	0.17(0.04)
Skewness of standardized deviations	0.002(0.001)	0.031(0.001)	0.07(0.03)
Autocorrelation of standardized deviations	0.045(0.03)	0.949(0.028)	0.05(0.03)

Productive life span and is the difference in days between the first calving date and date of death from a disease or sale for slaughter. Herd life and is the age of an animal in days before it died from a disease or was sold for slaughter

Results and Discussions

Relationship with average milk yield

- Only variance of deviations indicators had significant correlations with average milk yield
- Variance of actual deviations had a positive correlation with milk yield: High resilience translates to low milk
  - ➢ Variance of actual deviations is based on actual deviations: animals with low milk production profile have low deviations and low variance hence considered resilient
- Variance of standardized deviations had negative correlation with milk yield: High resilience translates to high milk
  - ➢ Variance of standardized deviations is based on proportion hence does not favor low producing animals
  - ➢ However, this observation is environment specific and does not necessarily mean that all high producers are resilient

Resilience indicator	Average Milk Yield
Variance of actual deviations	0.72(0.08)*
Variance of standardized deviations	-0.66(0.08)*
Autocorrelation of actual deviations	-0.14(0.21)
Autocorrelation of standardized deviations	-0.2(0.17)
Skewness of actual deviations	-0.31(0.24)
Skewness of standardized deviations	-0.39(0.23)

Genetic correlations of resilience indicators with average daily milk yield. Asterisk indicates significance at P<0.05

Results and Discussions

Relationship with longevity traits

- Only variance of actual and standardized deviations had significant negative correlation with longevity traits
  - ➢ This shows that resilient animals and low producing animals had greater longevity
  - ➢ Similar results reported (Elgerisma et al 2018, Poppe et al 2020, 2021)

Resilience indicator	Productive Lifespan	Herd life
Variance of actual deviations	-0.47(0.26)*	-0.43(0.28)*
Variance of standardized deviations	-0.49(0.26)*	-0.47(0.28)*
Autocorrelation of actual deviations	-0.07(0.48)	0.12(0.5)
Autocorrelation of standardized deviations	-0.15(0.42)	-0.02(0.44)
Skewness of actual deviations	0.19(0.68)	0.05(0.72)
Skewness of standardized deviations	0.59(0.51)	0.67(0.55)

Genetic correlations of resilience indicators with productive life span and herd life. Asterisk indicates significance at P<0.05

Conclusion

- There is a possibility for harnessing these indicators to measure resilience of dairy animals
- Variance of standardized deviations could be a better indicator of resilience of dairy animals in sub-Saharan Africa
  - ➢ It does not inaccurately group low producing cows as being resilient
- Resilient animals:
  - ➢ Have better longevity
  - ➢ Produce milk yield that is much closer to their optimal production

Thank You!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