



Better lives through livestock

Genetics and genomic approaches for sustainable dairy cattle improvement

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Sustainable Dairy Improvement Program

- Characteristics of a sustainable development (FAO)
 - Environmentally non-degrading
 - **Economically viable**
 - **Conserves genetic resources**
 - Technically appropriate
 - **Socially acceptable**



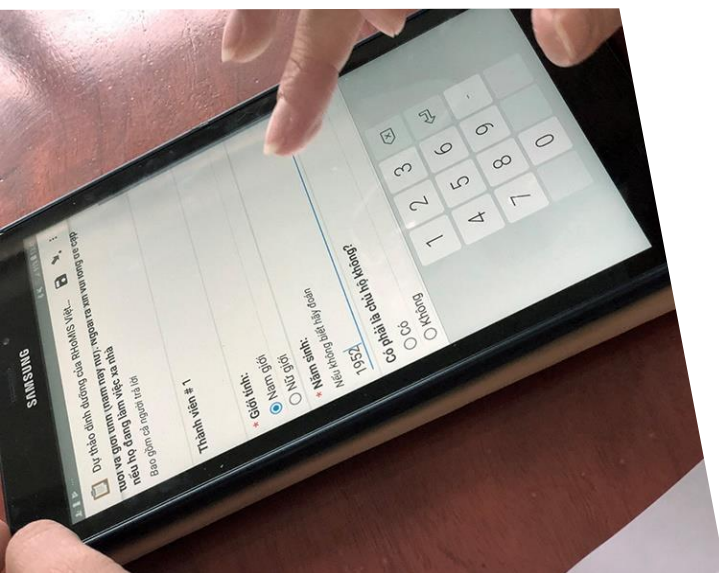
Sustainable Dairy Genetic Improvement Program

- Components of a sustainable dairy genetic improvement programme therefore should include
 - Improvements in productivity with no adverse effect fitness
 - Improve fitness - reproductivity ability, disease resistance robustness
 - Improving welfare traits (body condition, sound feet etc)
 - Little or no negative impact on the environment

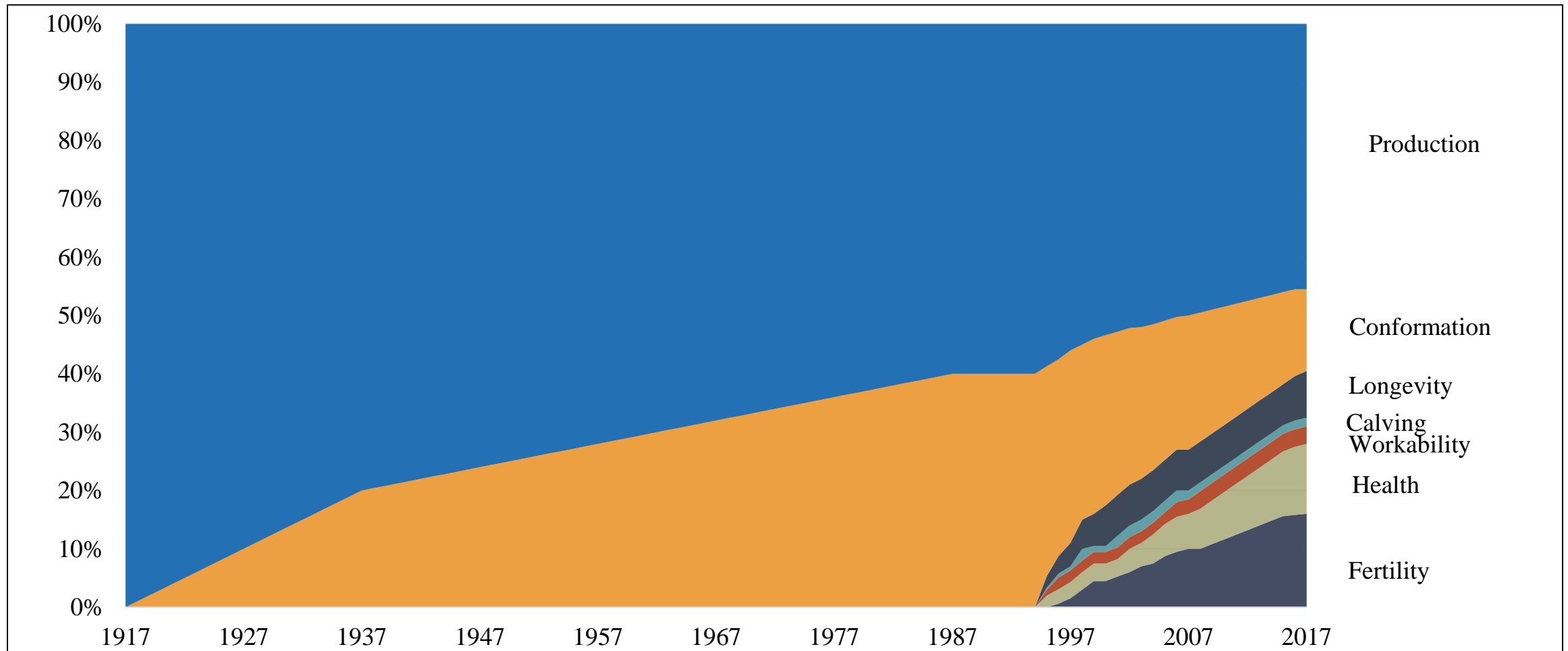


Some of the genetic approaches to achieve sustainable dairy genetic programs

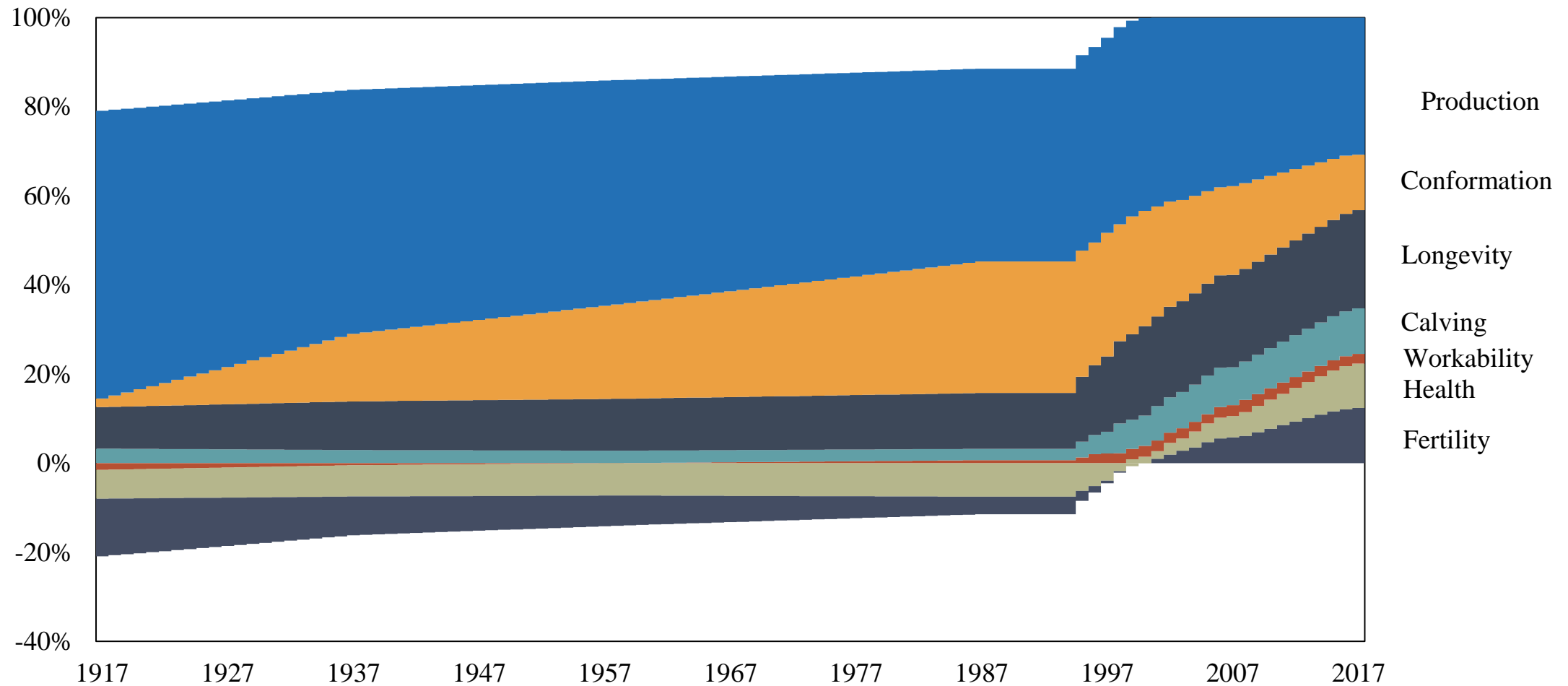
- Internationally efforts - broadening breeding goals
- **Harmonization of trait definitions**
- Establishing data collection protocol for the difficult to measure traits
- International dairy genetic evaluations –broader set of top bulls available ➡ maintain genetic diversity
- Introgression of desirable alleles



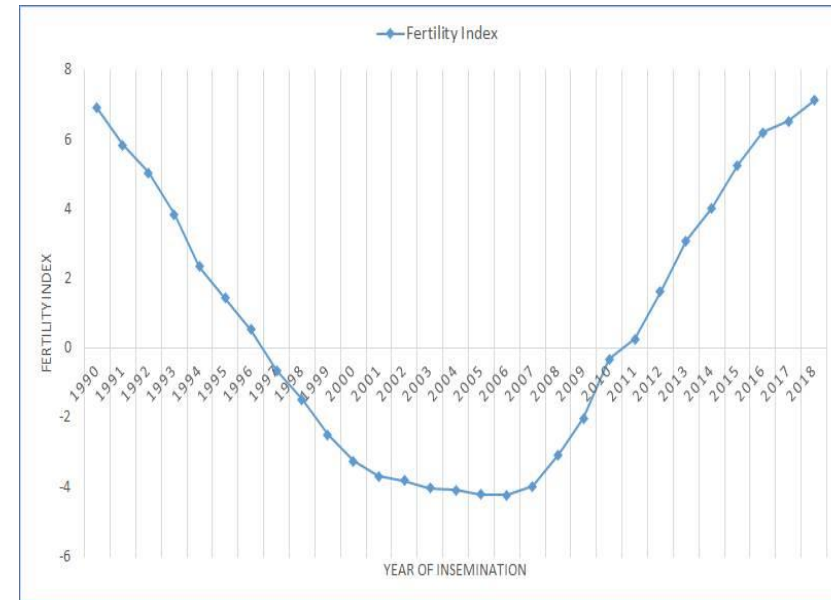
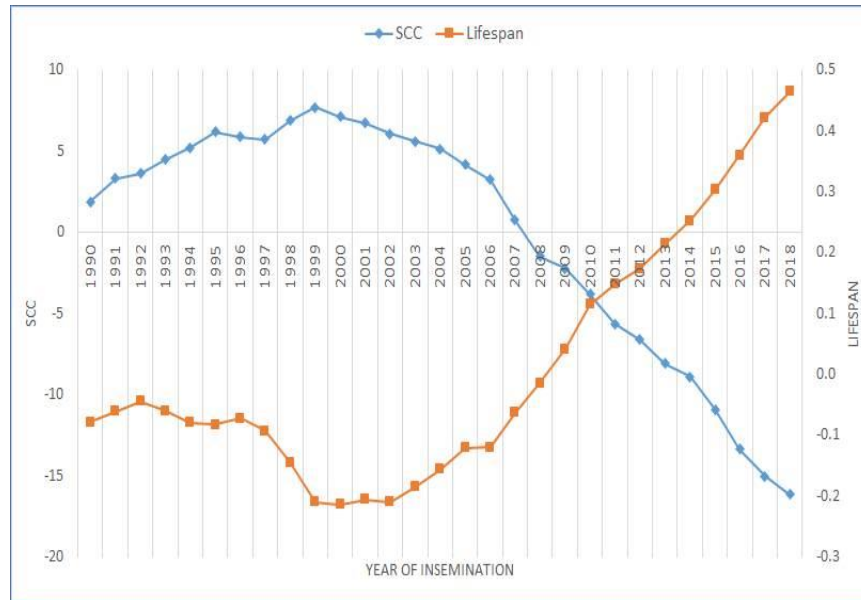
Worldwide summary of the relative weights on various major traits in national economic indexes for dairy cows from 1917 to 2017 (Miglior et al., 2017).



Proportionate estimates of response world-wide for major traits in the national economic indexes for dairy cow from 1917 to 2017 (Miglior et al., 2017).



Impact of Broader indices in the UK



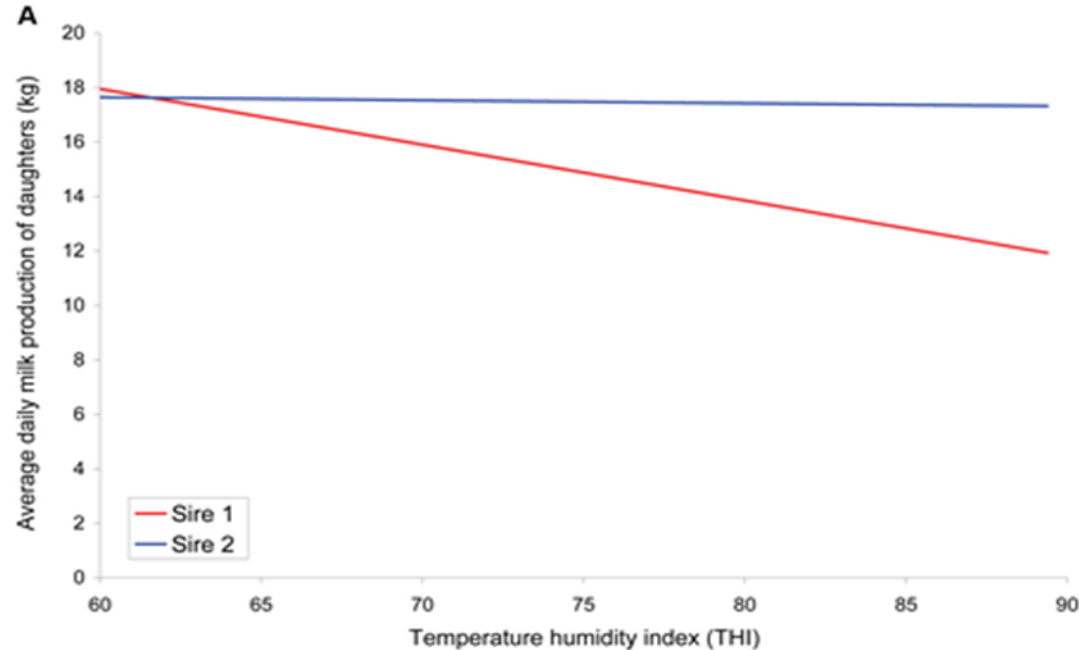
- UK Genetic trends for the for somatic cell count (SCC—indirect measure of mastitis), lifespan and fertility
- Notice initial decline but improvements commenced after putting traits in the index

Some approaches for sustainability dairy cattle breeding given climate change

- Some major sustainability issues in dairy cattle breeding given climate change
- **Heat tolerance**
- Feed resources and methane emission
- Conserving and utilization adaptive traits in indigenous breeds



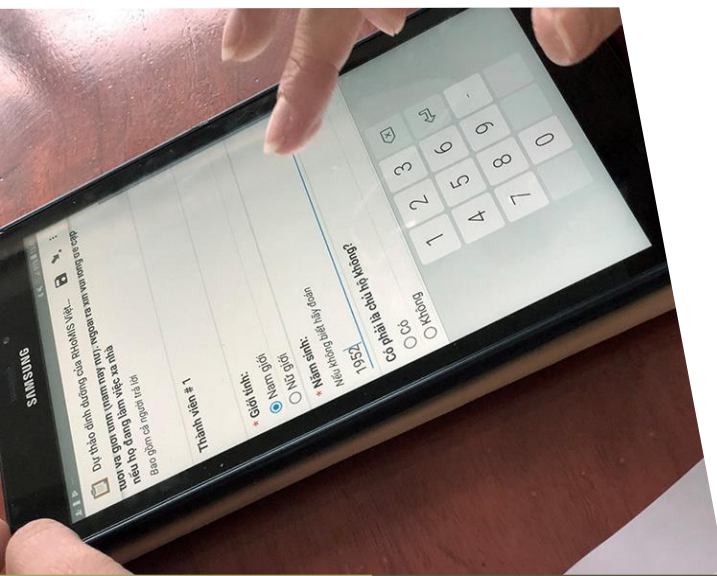
Breeding to Adaptation to Heat stress



Nguyen et al 2016
 J.Dairy science: 99:2849–
 2862

- Trait = rate of decline in milk yield with increasing THI; $h^2 \approx 0.20$
- “how well does an animal cope?” ~ resilience
- Dairy sires being selected in Australia based on animal resilience to heat stress measured on the basis of productivity using THI

Evaluating the impact of heat stress on milk yield using THI for small holder dairy system (Ekine-Dzivenu et al 2020)

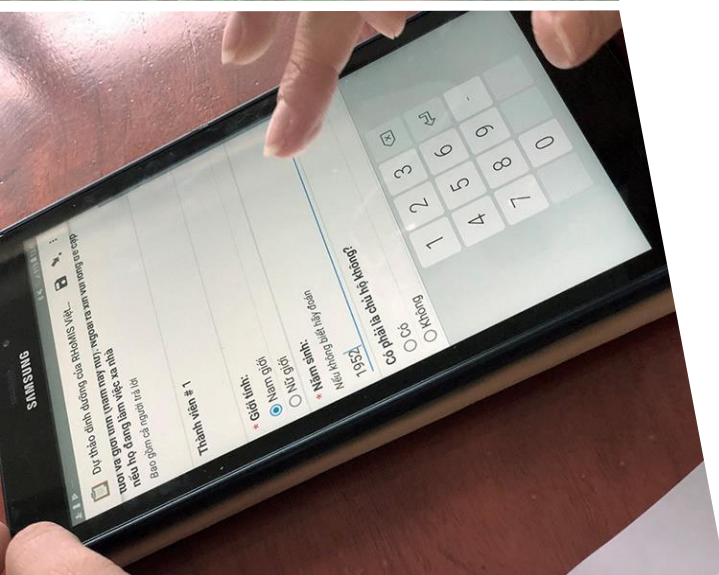


- Effect of heat stress on milk yield assessed using THI grouped 5 classes (61-66, 67-71, 72-78, 79-81, 82-86)
 - Heat stress reduced milk yield by 4.16% to 14.42% across THI groups
 - THI was non-linearly related with milk yield with significant negatively and positively coefficients (-0.61, 0.004).
- Next step is to study the trait at the genetics level

Breeding for heat tolerance through introgression of the slick gene

- The slick hair gene located on chromosome BTA20 in Senepol cattle is responsible for
 - a smooth and short hair coat
 - confers thermotolerance
 - associated with an improved capacity for heat dissipation.
- Introgression of the gene into some Holstein cattle has been shown
 - to produce animals with lower body temperatures
 - smaller declines in production under hot conditions (Dikmen et al., 2014; Ortiz-Colón et al., 2018)
- Some breeding companies are currently marketing positive slick bulls to farmers



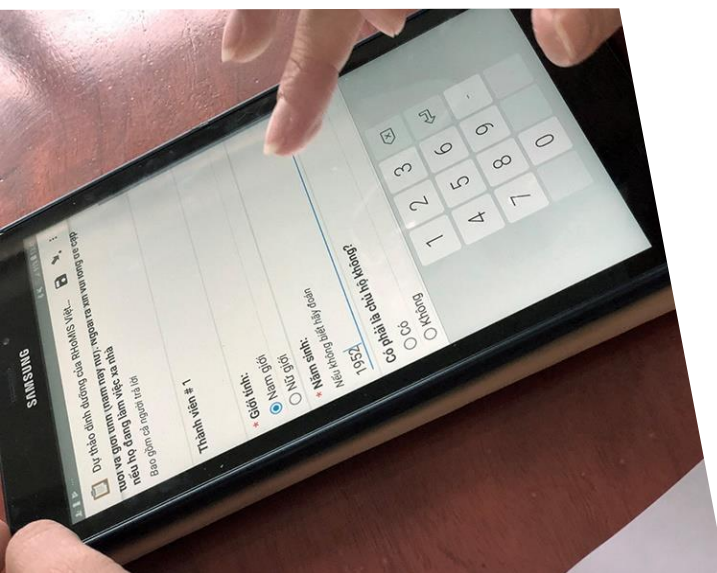


- Important as livestock is deemed a major contributor
 - Heritability estimates vary from 0.12 to 0.45
 - Difficult to measure routinely in large number of animals & lots of interest on indirect predictors
 - 20% reduction over 10 years feasible in Spanish Holstein with a weight of about 33% on methane in the total merit index and a reduction in gain for production traits by 18% (González-Recio, et al, 2020)
- In Danish Holstein - accuracy of genomic selection for methane was about 0.42 but including ECM and BW in both reference and validation populations increased accuracy by 92% (Manzanilla-Pech et al 2020)
- Selection for feed efficiency is good proxy ➡ 26% reduction in methane over a 10-year period (de Haas et al. ,2011)

Breeding for feed efficiency

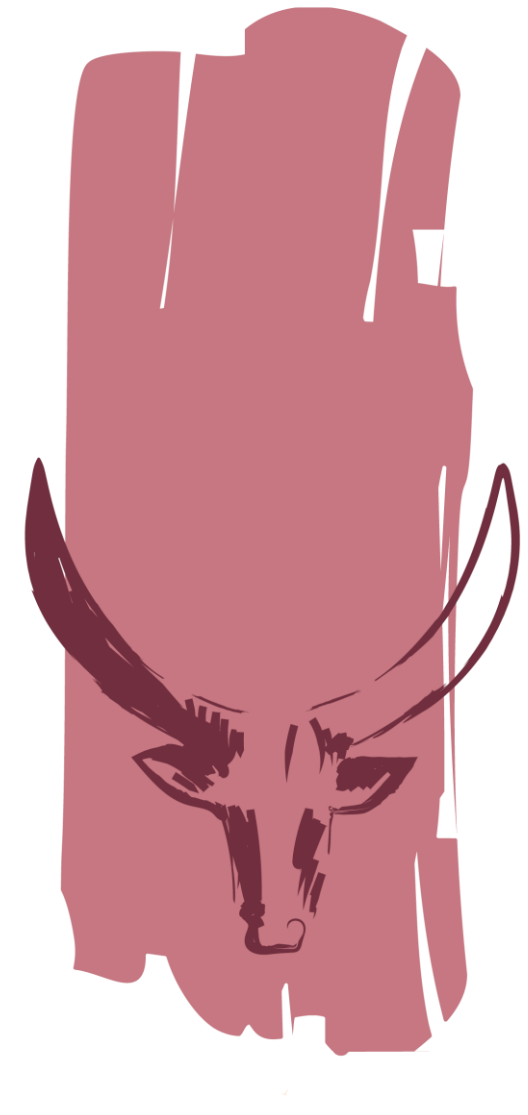


- Feeds account for about 70% of production cost
 - Difficult and expensive to measure
- Genomics has allowed DMI data to be pooled from 9 countries and enabled international evaluations (Berry et al, 2014)



Breeding for Feed efficiency

- Saved Feed = $v_1 \times \text{GEBV}_{\text{Maintenance}} + v_2 \times \text{GEBV}_{\text{Metabolic}}$
- About one third of feed consumed is used for body maintenance and this is directly related to the body size.
- Number of countries have implemented index : Saved Feed cost (SFC) for maintenance using genomic models
- Nordic countries : Indirect predictors- body weight and type traits
- Netherlands : DMI or Indirect predictors :milk, fat and protein and body weight.
- SFC accounts for 5% of the Dutch Total Merit index called NVI



Improving efficiency in Tanzania Cows using milk yield and body weight Genetic parameters, forward validation and index

Milk yield, $h^2 = 0.12$, body weight, $h^2 = 0.22$ and $r_g = 0.34$

Trait	Method	Correlation	Regression
Milk yield	FRM-GBLUP	0.57	1.1
	FRM-ssGBLUP	0.59	1.0
	RRM-GBLUP	0.55	1.0
	RRM-ssGBLUP	0.53	0.92
Body weight	FRM-GBLUP	0.83	1.0
	FRM-ssGBLUP	0.77	1.1

- Restricted index: improves the rate of milk production but with restrictions on body weight
- More efficient cows milk without increasing the amount of feed consumed.



Sustainable cattle breeding in developing countries: Incorporating the genetic basis of adaptation

- Indigenous breeds represent a unique set of genotypes adapted to surviving under harsh conditions and are disease/parasite resistant.
- **Genomics provide the means for understanding the genetic basis of this adaptation**
- **Kwondo et al 2020 - Several loci in African cattle related to immunity, heat-tolerance, trypanotolerance and reproduction-related genes.**



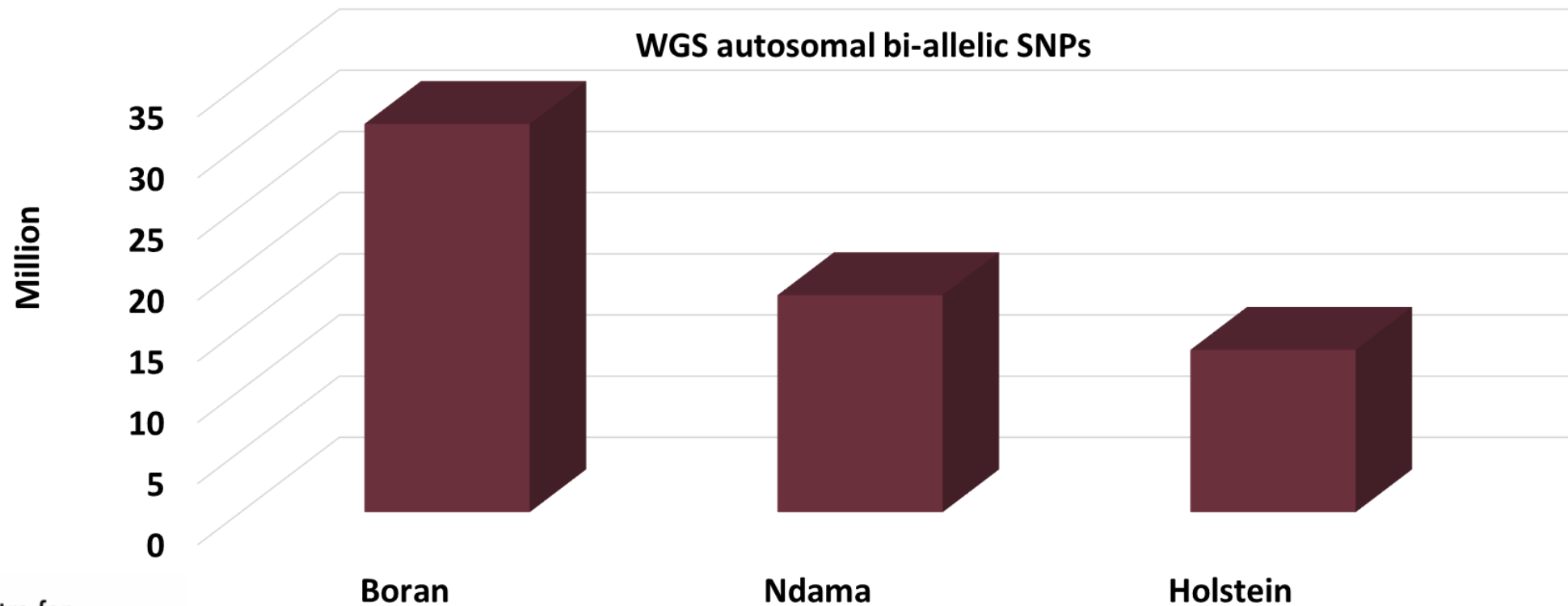
Sustainable cattle breeding in developing countries: Incorporating the genetic basis of adaptation

- Small ruminants -- adaptation to arid environments and resistance to endoparasites in sheep from Tunisia (Ahbara et al, 2021)
- Paths for utilization
 - Incorporation of functional regions/genes in genomic prediction --- BayesR or BayesRC
 - Approach increased accuracy of prediction for heat tolerance for production traits by up 10% (Cheruiyot et al, under review)
 - Gene editing & surrogate sires

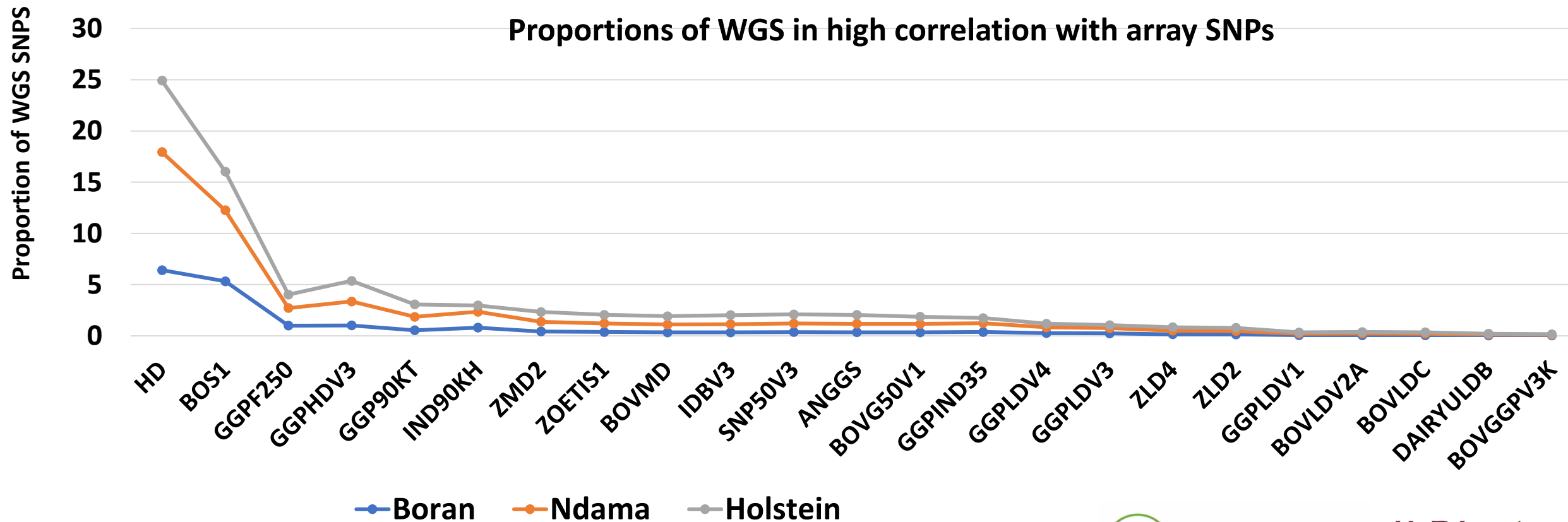


Challenge of adequacy commercial SNP array: Examined in three African cattle

- Uniqueness genotypes of indigenous breeds leads to another challenge; adequacy of commercial SNPs panels



Assessment of the 23 commercial Bovine SNP arrays in 3 cattle breeds



Genomics as a platform for collecting difficult to measure or expensive traits

- Genomics gives us the ability to undertake
 - Detailed phenotyping of difficult to measure traits in small cohort of animals
 - Enables prediction of gEBVs for a wider population connected to cohort with records
- Successfully used in Genomic Information Nucleus (Ginfo) project in Australia to capture fitness traits in few herds but connected to the national population. (Pryce et al, 2017)
 - Increased accuracy of prediction 5 to 7 % for fertility traits in the Holstein
- In developing countries, where data capture is a challenge, genomics may provide an opportunity to capture difficult or expensive traits



Conclusions

- Expanding national indices to include fitness and welfare traits has been fundamental in breeding for sustainability in dairy cattle
- Genomics have offered us the opportunity both to capture and incorporate difficult to measure or expensive traits
- Genomics provide the basis for understanding and utilizing adaptive traits in indigenous breeds to ensure sustainability



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