Food and Agriculture Organization of the United Nations

How animal genetic diversity contributes to resilience and robustness

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FAO and resilience

- FAO has a unique role to play in **preventing and addressing acute hunger and supporting countries experiencing food crises to return to a path of growth and prosperity**, given the Organization's mandate to end hunger, long-standing permanent country presence, and substantial expertise and experience in both humanitarian and development contexts.
- FAO provides the KORE – Knowledge Resilience – platform, a **knowledge sharing platform to support building resilience to food insecurity and malnutrition in the face of shocks and stresses**.

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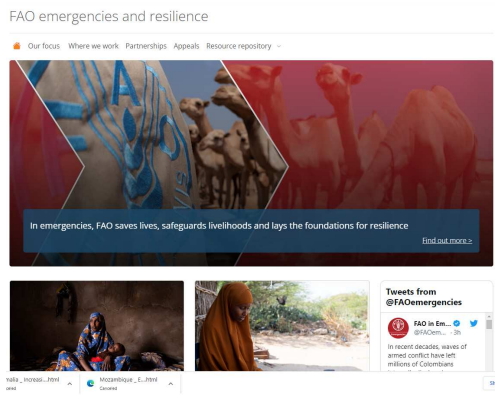
Definitions

FAO defines resilience as

- the **ability of people, communities or systems** to withstand damage and **recover rapidly** when confronted by disasters or crises.



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Definitions

In the context of animal genetic resources (AnGR)

- **Adaptation:** characteristics of animals which promote welfare and favor survival in specific environment (Nlyas et al 2015)
- **Adaptedness:** degree to which an organism is able to live and reproduce in a given set of environmental conditions (Endler 1986)
- **Adaptability**: the quality of being able to adjust to new conditions (Oxford languages) / relative ability of an individual to survive and reproduce next generation to ensure continued survival of the population and is the result of natural selection over many generations (Naskar et al. 2012)
- **Robustness**: capacity to maintain productivity in a wide range of environments without compromising reproduction, health and wellbeing
- **GxE interaction**: variation in phenotypic response of specific genotypes to specific environments (Lynch & Walsh, 1998)
- **Resilience: capacity of e.g. an animal to be minimally affected by disturbances or to rapidly return to the state pertained before exposure to a disturbance (Berghof et al. 2019)**

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Animal genetic resources (AnGR) and resilience

- Different scale to be considered
  - individual
  - population/breed
  - species
- Production system

73rd Annual Meeting of EAAP, Porto, 3-9th September 2022

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The genetic base of resilience

- A wide range of traits (heat stress tolerance, disease resilience-resistance or tolerance, feeding patterns, behaviour…) to be considered on different scales and with different **inheritance patterns** (from monogenic to complex inheritance)


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DAD-IS/ Zeynel Gocmez


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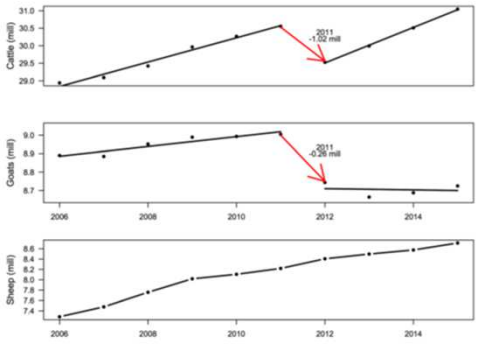
How do extreme events impact our use of livestock species?

- Livestock species are expected to have different adaptive capacities, with for instance different Temperature-Humidity Index (THI) threshold for heat stress
- Impacts of extreme events are expected to differ in terms of productivity, morbidity and mortality
  - Huho et al. (2011) showed smaller impact of drought on camel mortality in several African countries and thus an increase in camel population compared to e.g. cattle
  - 2011 drought in Mexico led to a decrease in cattle and goat population (but not sheep which were raised in unaffected regions)- Differences in production systems need to be considered!



Cattle, goat and sheep population trend in Mexico
(Murray-Tortarolo and Jaramillo 2019)

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How do extreme events impact our use of livestock species?

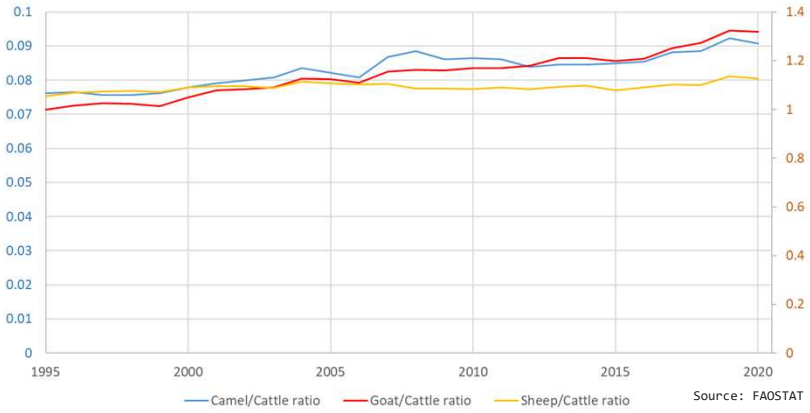

Photo: DAD-IS; NAGRCD; Prof Dr Schwartz; ESGPIP; Gley Khaldi

The trend in camel (+19%), goat (+30%), and sheep (+5%) vs cattle ratio in Africa seems to indicate an increasing preference for small ruminants and camel

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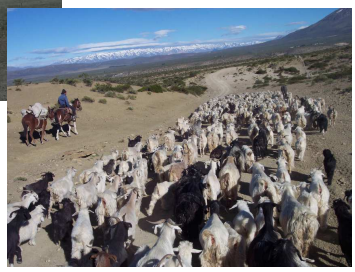
How do extreme events impact our use of livestock breeds?

The example of the Neuquen Creole Goates in Patagonia, Argentina (Lanari et al.2021)

- A vulcanic eruption in 2011 affected more than 1500 farms in Rio Negro´s southern line
- On average 65% of livestock (sheep and goat) were lost
- 70% of farmers were left with no meat for self-consumption
- Emergency programme used Neuquen Creole Goats (NCG) for restocking
- Evaluation 3 years later



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How do extreme events impact our use of livestock breeds?

The example of the Neuquen Creole Goats in Patagonia, Argentina (Lanari et al. 2021)

- Positive effects of species diversity (sheep & goat) on diversification of products
- Meat from NCG for self consumption, and mohair and wool from Angora goats and Merino sheep for marketing
- Young people remain in the region thanks to perspectives offered by keeping NCG

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How do extreme events impact our use of livestock breeds?

Adaptedness viewed as an important factor of preference for local breeds

Multiple studies underline the importance of traits related to resilience for the choice of specific breed

Photos: DAD-IS / Irene Hoffmann

	Preferred breed		
Main reason for preference (%)	N´Dama (n=57)	Crossbred (n=48)	Fulani Zebu (n=55)
Market price	0	35	49
Disease resistance	30	18	0
Body size	0	15	16
Low raising cost	27	0	0
Milk yield	0	6	18
Tolerance to feed shortage	18	2	0
Other	25	24	17

Reported main reason for preferring a cattle breed group in Mali (Traore et al. 2017)

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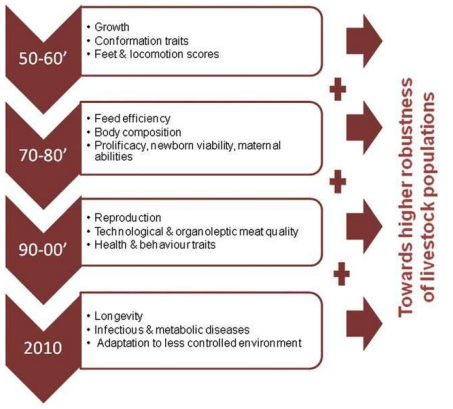
Traits of interest

Functional and fitness traits

- Traits that consider the general fitness or functionality of animals within a usual set of environmental conditions
- E.g.: functional longevity, fertility, feet and legs and (indirect) health traits
- Indicators for adaptation and to a certain extent for robustness
- Considered in several breeding programmes (economic weight)
- BUT: Do not really consider coping with strong and or unusual perturbations/ extreme events (resilience)
- More robust animals are more resilient?



Evolution of breeding goals in livestock selection programmes for meat production (Phocas et al. 2016)

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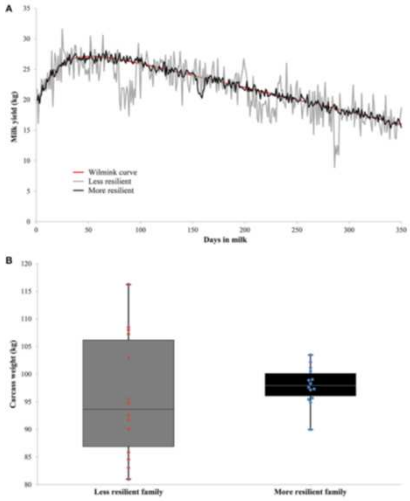
Traits of interest

General resilience indicators

- Fluctuations of selected traits within a usual set of environmental conditions
- E.g.: variance, autocorrelation or skewness of milk production or carcass weight at individual or family level (Berghof et al. 2019)
- Consider different aspects of resilience (healthy and easy-to-manage animals that need little/less attention)
- Economic value of resilience on farms, where labour time is restricted (large farms)



Production traits suitable for investigating resilience (Berghof et al. 2019)

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Examples for breeding programmes considering resilience/robustness

Integration of traits related to adaptedness/robustness

- In dairy and beef cattle, integration of traits related to health and functionality in the selection indexes
- Genetic resistance to some climate related diseases and parasites studied but rarely implemented in practice (e.g. worm egg count in sheep, Karlson and Greef 2006)
- Selection for heat tolerance (as deviation of traits affected by heat stress) feasible in dairy cattle (Nguyeb et al. 2016) or chicken (Radwan 2020), but not implemented

DAD-IS/ Dr A.K. Fazlul Haque Bhuiyan

Dikmen et al. 2014

Use of specific phenotype related to adaptation

- Naked neck and naked phenotypes in poultry
- "Slick" Holstein bulls offered by some breeding organizations

➢ *Currently, only anecdotal integration*

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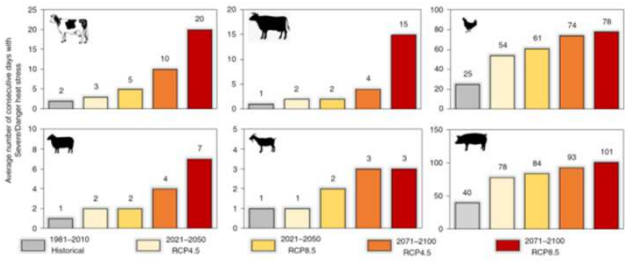
Why do we need more resilience?

	2000	2090 SSP1-2.6	2090 SSP5-8.5
Cattle	8.0	17.2	61.2
Goat	9.1	23.1	68.7
Sheep	10.7	19.9	63.2
Pigs	9.1	25.8	69.4
Poultry	12.0	29.3	75.0

Proportion (%) of global animal populations with at least 1 day of extreme heat stress in 2000, and 2090 under SSP1-2.6 and SSP5-8.5 (Thornton et al. 2021)



Predicted number of consecutive days with Severe/Danger heat stress in East Africa (Rahimi et al. 2021)

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Strategies to cope with climate change and extreme events

Change in the breeding stock

Shift of species (e.g. cattle to goat or camel)

Crossbreeding schemes (locally adapted X exotic)

Shift of breeds (locally adapted)

Diversification of production systems

More integrated crop x livestock systems (e.g. agroforestry)

Use of various species and breeds within farms

Diversification of products

Increase resilence of production systems by using **adapted AnGR** and by **diversification.**

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Strategies to cope with climate change and extreme events

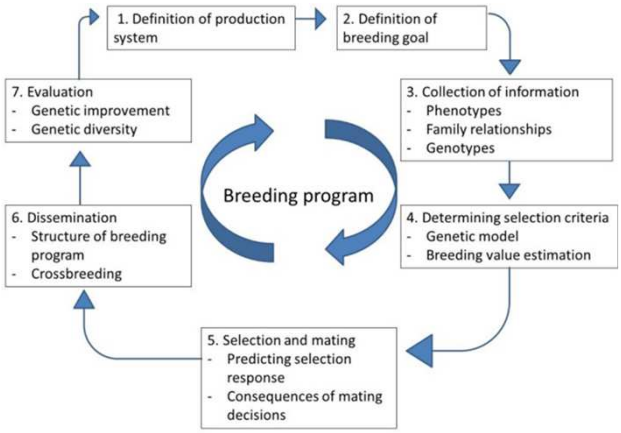
Breeding programmes

Emphasize breeding objectives related to robustness and adaptation

Include resilience to micro-environmental disturbance

Consider GxE interactions

Exploit combination of dense genotyping x fine phenotyping approaches (micro- and macro environmental data)



Source: Kor Oldenbroek and Liesbeth van der Waaij, 2015

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Conclusion

Limited impacts of climate change on the use of AnGR up to now

- Some shifts in species and breed preference in the most affected regions
- Potential traits of importance rarely considered in breeding programmes
- Potential for diversification of systems not fully exploited – to be further documented to create evidence for good practices

Large impacts in future

- Need to consider GxE and phenotype approaches to identify traits of interest
- New technologies offer potential tools for data collection (including in developing regions)
- Breeding strategies need always to be considered in a larger framework (economic weights - short term gains versus value of long-term robustness/resilience)

There is no one fits it all solution….

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Thank you!

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