

Climate change and the characterization, breeding and conservation of animal genetic resources

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Climate change



Agricultural biodiversity and climate change

- Animal genetic diversity is critical for food security and rural development
 - to select stocks or develop new breeds in response to environmental change, including climate change, disease, changing market conditions
- Most food demand is expected in developing countries where climate change is projected to have the greatest impact

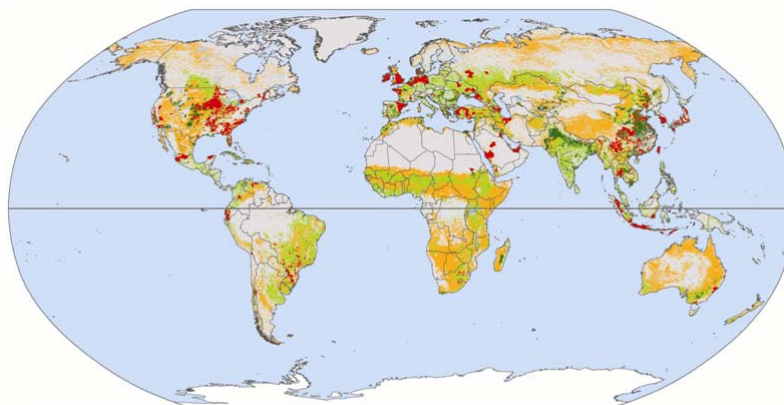
Agricultural biodiversity and climate change

- Climate change is just an additional factor
- Climate change will affect the products and services provided by agricultural biodiversity
- Agricultural biodiversity not yet properly integrated in CC adaptation and mitigation strategies

Livestock biodiversity and climate change

- No climate change models at breed level - detailed data on breeds' adaptation traits and spatial distribution are generally not available
- Breeds' environmental envelopes overlap (5 main species)
- Breed distribution is overlaid by production systems and management
 - Breed-level predictions or bio-geographic models for climate change implications are hardly possible

Estimated distribution of livestock production systems



Livestock production systems

■ Mixed, irrigated	■ Grazing	■ Areas dominated by landless production	National boundaries
■ Mixed, rainfed	■ Other type	■ Boreal and arctic climates	

Farming systems evolution

- smallholder mixed → large-scale industrial
- multifunctional → commodity-specific
- local market → globally integrated markets
- scattered → clustered production
- diverse breeds → narrow genetic base
- dichotomy between large and small farms ↑

Breeding industry trends

- Capital investment – volatility ↑
- Merger and concentration, vertical integration
- Strategic research partnerships with (public) universities, access to public R&D funds

Impacts of climate change on AnGR

	Extensive systems (agro/pastoral, mixed)	Intensive/landless systems
Direct impacts	<ul style="list-style-type: none"> – Catastrophic events – disease epidemics – productivity losses, physiological stress – water availability 	<ul style="list-style-type: none"> – Catastrophic events – disease epidemics – productivity losses, physiological stress – water availability
Indirect impacts	<p>Agro-ecological changes</p> <ul style="list-style-type: none"> – fodder quality and quality – host-pathogen interactions – GHG reduction 	<p>Resource price/availability</p> <ul style="list-style-type: none"> – feed (production; biofuels) – energy – water – GHG reduction

Adaptation differences relevant for CC adaptation



Physiological stress and thermoregulatory

- Yield \uparrow metabolic heat production \uparrow capacity to tolerate elevated temperatures \downarrow
- Ruminants > monogastrics
- Zebu > taurine

Gaps and biases

- Indicators
- Production systems
- Breeds

Nutritional stress

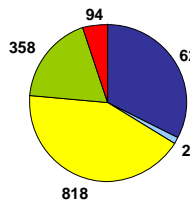
- ability to walk and reach scarce feed resources and to intake water and rehydrate
- ability to respond with increased night-time grazing to high afternoon temperatures
- mobilization of body resources to cope with periodic underfeeding & levels of body weight loss
- relationships between energy reserves, endocrinological parameters and breed reproduction performance (cease of reproduction)
- genetic aspects of diet selection (browsing)

Disease stress

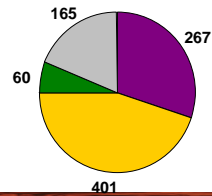
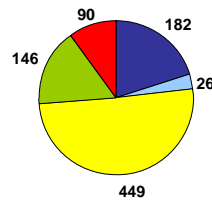
- Climatic effects on host-vector and host-parasite population dynamics
 - geographical expansion of vector-borne infectious diseases to higher elevations and higher latitudes ↑
 - transmission and course of diseases
- Breeds that are reported to be resistant or tolerant to trypanosomiasis, tick burden, tick-borne diseases, internal parasites, dermatophilosis or foot rot (59 cattle breeds, 33 sheep, 6 goat, 5 horse and 4 buffalo breeds)

Local breeds in selected regions

Total



Dryland breeds



- Cattle
- Yak
- Small ruminants
- Equines
- Camelids

- Africa
- Asia
- Latin America
- Near East

CC adaptation of livestock production systems

- Adapting the production environment while maintaining the animal genetic portfolio
- Adapting animals' genetics to the changed environment



Adaptation of husbandry practices

- Shading or sprinkling to reduce excessive heat loads
 - Access to such technologies will determine the ability of producers to adapt their herds to the physiological stress of climate change.
 - Intensive livestock production systems have more potential for adaptation through the adoption of technological changes. This may keep the high-output breeds in such production systems.



Species and breed shifts (direct CC effect)

- Differences in system resilience (rangeland vs. cropland, mixed vs. specialized)
- Introduction of better adapted breeds. The current flow of genetics may reverse.
- Currently underutilized species / breeds may become more attractive, and species substitution will be an option.



Species and breed shifts (indirect C effect)

- Increasing non-food sector demand for feed inputs (biofuel, industrial use), thereby potentially exacerbating the impact of climate change-induced reduction in feed supply
 - Superior FCR will grant monogastrics a comparative advantage to cereal-fed ruminants and commercial breeds will outcompete local breeds
- Predicted shift of C3 to C4 grasslands and increase in shrub cover in grasslands will tend to reduce forage quality
 - Zebuine breeds better deal with low-quality forage than taurine breeds
- Implementation of GHG reduction targets
 - May change the ranking of species and breeds and regional shifts in market. Depending on the scenario, either the local or commercial breeds could gain importance
 - Intensive dairying might become the major focus of cattle production, while commercial meat may be produced by monogastrics

Breeding for CC adaptation and mitigation



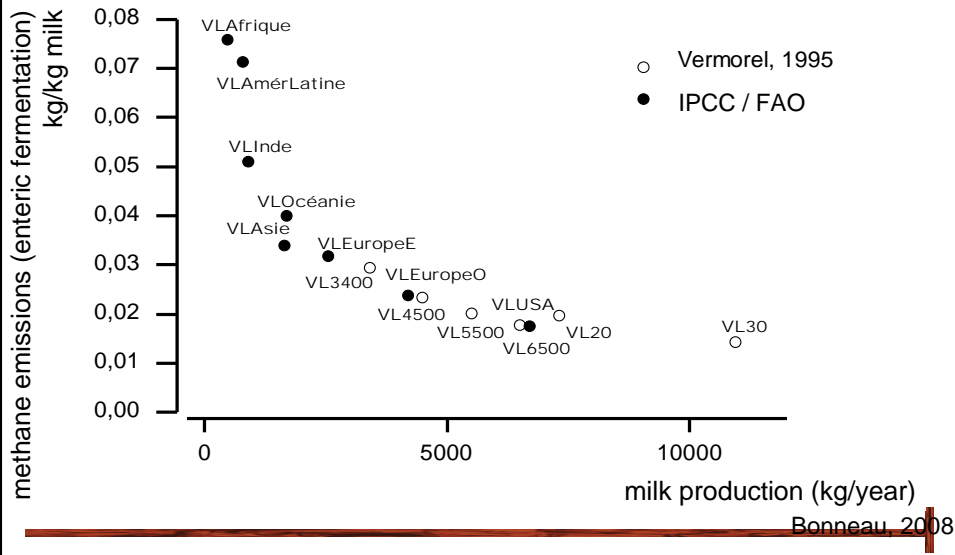
Heat tolerance

- Selection for heat tolerance based on rectal temperature measurements, skin characteristics and inclusion of a temperature-humidity-index in the genetic evaluation models is promising
- Major slick hair gene
- Dairy cattle: difficult to combine heat tolerance with high reproduction and production potential
- Beef cattle: genetic antagonisms seem to be less. Improved characterization of adaptive traits, use of reproductive technologies and molecular markers, and strategic crossbreeding are elements of programmes underway

Productivity and feed efficiency

- Life-Cycle-Analysis model in the UK found that genetic improvement in the annual reduction in GHG emission ranged from 0.8% in pigs (growth rate and fertility) and dairy cattle (milk yield) to 1.2% and 1.3% in broiler (FCR) and layer poultry
- Decrease age of first-calving (esp. zebuine cattle)
- Use genetic variability in feed intake, independent of liveweight and daily gain
- Cereal-based diets: superior FCR will grant monogastrics a comparative advantage to ruminants
 - Ruminants back to forage diets

Effects of productivity increase in dairy production

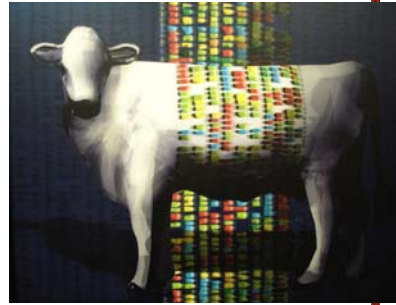


Disease resistance

- Increased and often novel disease pressure will favour genotypes that are resistant or tolerant.
 - Resistant breeds exist; but few scientific studies and underlying mechanisms are not well understood.
 - Potential for genetic improvement of disease resistance. Commercial breeding programmes include disease resistance.
 - Depends very much on the type of disease and the hosts resistance or tolerance mechanisms, the availability and costs of alternative treatment (e.g. vaccines, drugs) and the antimicrobial resistance of pathogens.
 - The importance of molecular markers and marker assisted selection will increase.

Challenges

- Breeding has become a high-tech exercise
- Demanding data quality and quantity, bioinformatics
- G*E assessment
 - Limited breeds, countries, production systems
- Economic constraints for separate breeding programmes
- GS transfer to developing countries?



Challenges

- Most local breeds are not well characterized, few structured breeding programmes
- Only few countries have commercially relevant tropical breeds and trade them
- Continued preclusion of characterization and selection within local breeds from developing countries



Challenges

- LCA of GHG emissions from livestock
 - Breed differences or genetic improvement over time are not well covered
 - Tropical breeds, feeds and systems have been largely ignored
 - Commercial breeds will outcompete local breeds, esp. in monogastrics

Conservation and exchange

- Characterize AnGR and build inventories, including spatial information, of breeds and valuable breeding stocks
- Cryo-conservation of genetic material, or other measures to ensure genetic recovery in the case of a disaster
- Clarify the role of private versus public genebanks; establish genebanks for local breeds and backups for commercial breeds
- Develop operational protocols (e.g. Material transfer agreements)

Conclusions

- CC may exacerbate current sector trends
- More systems research needed
 - breed characterization in the production system
 - biological basis of adaptation
- Developing countries and local breeds need special support to contribute to CC adaptation breeding
- Agricultural biodiversity must be integrated in CC adaptation and mitigation

Global Plan of Action



Arabic/Chinese/English/French/Spanish
German/Norwegian/Polish/Russian
in preparation: Thai, Danish



Thank you



<http://www.fao.org/ag/againfo/programmes/en/A5.html>