Livestock Genetic Gains – limitations and opportunities
Livestock yield gaps are hard to measure - but significant

- Significant gaps exist
- Opportunities to address livestock yield gaps:
  - Technology:
    Health, genetics, feed
  - Non-technical:
    Market access, input delivery
- Need to target
  - By commodity
  - By system
Animals are the products of their genes, their environments and their gene-environment interactions

\[ P = G + E + GE \]

<table>
<thead>
<tr>
<th>Term</th>
<th>Description</th>
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<tbody>
<tr>
<td>P</td>
<td>The animal we see, its production etc.</td>
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<tr>
<td>G</td>
<td>The genetic make up of the animal</td>
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<tr>
<td>E</td>
<td>All factors (ambient conditions, health, nutrition, husbandry) except the genes of the animal</td>
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<tr>
<td>GE</td>
<td>Between the genes and the environment</td>
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Genetic selection, interacting with environment, drives ‘improvement’

In the industrial world genetics has driven dramatic improvements in productivity

- Homogeneous environments (systems, markets, health, regulations, policies....)
- Homogeneous genetics (a handful of well defined breeds)
- Superb data recording driving selection schemes

**Changes in milk yields of US Holstein cows**
Mean phenotype (P), breeding value (A) and environmental effects (E = A - P).
Results relative to 1957 base (mean yield 5859kg).

(Source: http://aipl.arsusda.gov/eval/summary/trend.cfm)
LiveGene
Delivering improved genetics to the world’s small-scale livestock keepers

Targeting
Prioritizing geography, environment, climate and social change, traits, species, breed.

Gene Discovery
Adaptive alleles, characterization, conservation, Genome editing

Delivering Genetic Gains
Digital recording platforms. Phenotyping and farmer feedback.

Integrated data – comms, bio-repository, phenotyping, feedback, bioinformatics.

Partnerships and networks

Capacity Development
Achieving genetic gain in developing countries – the same biological rules but different environments

We must take account of the realities of small-scale livestock producers.

Diversity of:

- Environment
- Climate
- Feeds available
- Endemic diseases
- Local market context
- Infrastructure
- Institutions
Achieving genetic gain in developing countries – the same biological rules but different environments

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No data systems to inform selection.

No infrastructure to manage selection.
Genotype data is cheap and easy to obtain. Phenotype data remains a problem.

Can we skip a generation of technology?

- Fast, light, cheap performance data harvesting.
  - Cheap sensors, mobile platforms, crowd sensing.....
  - Simultaneously providing management information to the farmer and performance data to the breeder.
Time for a new search for variation underlying tropical adaptation and productivity

Identify and make use of the genetics underlying natural variation.

There has been no systematic search for the genomic basis of adaptation. Because until now we have had no validation tools and no delivery tools.

New Genome Editing tools change the landscape.
New tools allow us to look in new places for sources of variation – including wildlife

“traditional” linkage mapping requires crosses – so initial discovery is limited to variants within a species

Cow NDama  KFITRRPSLKLQEQGLIKDQIFSPLHHTLCCERKSTVPFVKQCEAVEK
Cow Boran  KFITRRPSLKLQEQGLIKDQIFSPLHHTLCCERKSTVPFVKQCEAVEK
Human     KFISRRPSLKLQEQGLIKDQIFSPLHHTVCCERHSTVPFVKQCEAVEK
Pig        KFITRRPSLKLQEQGLIKDQIFSPLHHTVCCERENSTVPFVKQCEAVEK
Chicken    KFISRRPSLKLQEQGLIKDQIFSPLHHLVCEGENSTVPQFVRQCIKAVEK
Salmon     KFISRRPSMKLQEQGIKDRVFGCSSLACERGETTVPFKVRQCEAVEK

Comparative gene network and sequence analysis allows to ask new kinds of questions about genomes – eg “what is different about this (group of) species compared to all other mammals”
African Trypanosomiasis

African Trypanosomiasis
- Caused by extracellular protozoan parasites – *Trypanosoma*
- Transmitted between mammals by Tsetse flies (*Glossina* sp.)
- Prevalent in 36 countries of sub-Saharan Africa.

In cattle
- A chronic debilitating and fatal disease.
- A major constraint on livestock and agricultural production in Africa.
- Costs US$ 1 billion annually.

In human (Human Sleeping Sickness)
- Fatal
- 60,000 people die every year
- Both wild and domestic animals are the major reservoir of the parasites for human infection.
Identify and deliver variants associated with adaptation

Targeting → Genotyping → Phenotyping → Genome editing

Data systems

Adapted & productive livestock

Delivery systems
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Capacity Development
LiveGene – examples of outcomes

- A choice of improved genetics for small/medium scale production systems characterized and made available
- NARS equipped to continually and sustainably improve and deliver their genetic resources
- An independent poultry testing and evaluation center for SSA
- A Livestock Genomics Platform for identifying and exploiting allelic variations associated with tropical adaptation which is integrated with breeding programs
- Including a reproductive technology platform developing and applying a range of technologies to improve delivery of appropriate genetics.
- IP ownership and policy models that facilitate access to improved genetics for African small holders
- An open data and sample exchange system acting as a hub for expertise on tropical livestock functional diversity: from targeting, to genome sequence to phenotype to farmer feedback
better lives through livestock

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