Improving Livestock Productivity and Resilience in Africa: Application of Genetic Technologies and Challenges

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Animal Genetic Research for Africa (Biosciences for Farming in Africa), Nairobi, 10-11 September 2015

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Issues in Livestock production in Developing Countries

Meet increasing demands for food of animal origin on an increasingly competitive market

Must utilize the potential of the AnGR and increase the productivity per animal!

- **Improve the livelihoods** of communities keeping livestock
- **Without environmental degradation**: land and water
- Cope with **diseases & stress**
- Considering the needs for **future genetic diversity**

Need for resilient animals

The huge genetic diversity is an opportunity

The challenge: *How can we identify and utilize the best animals for & in different environments?*

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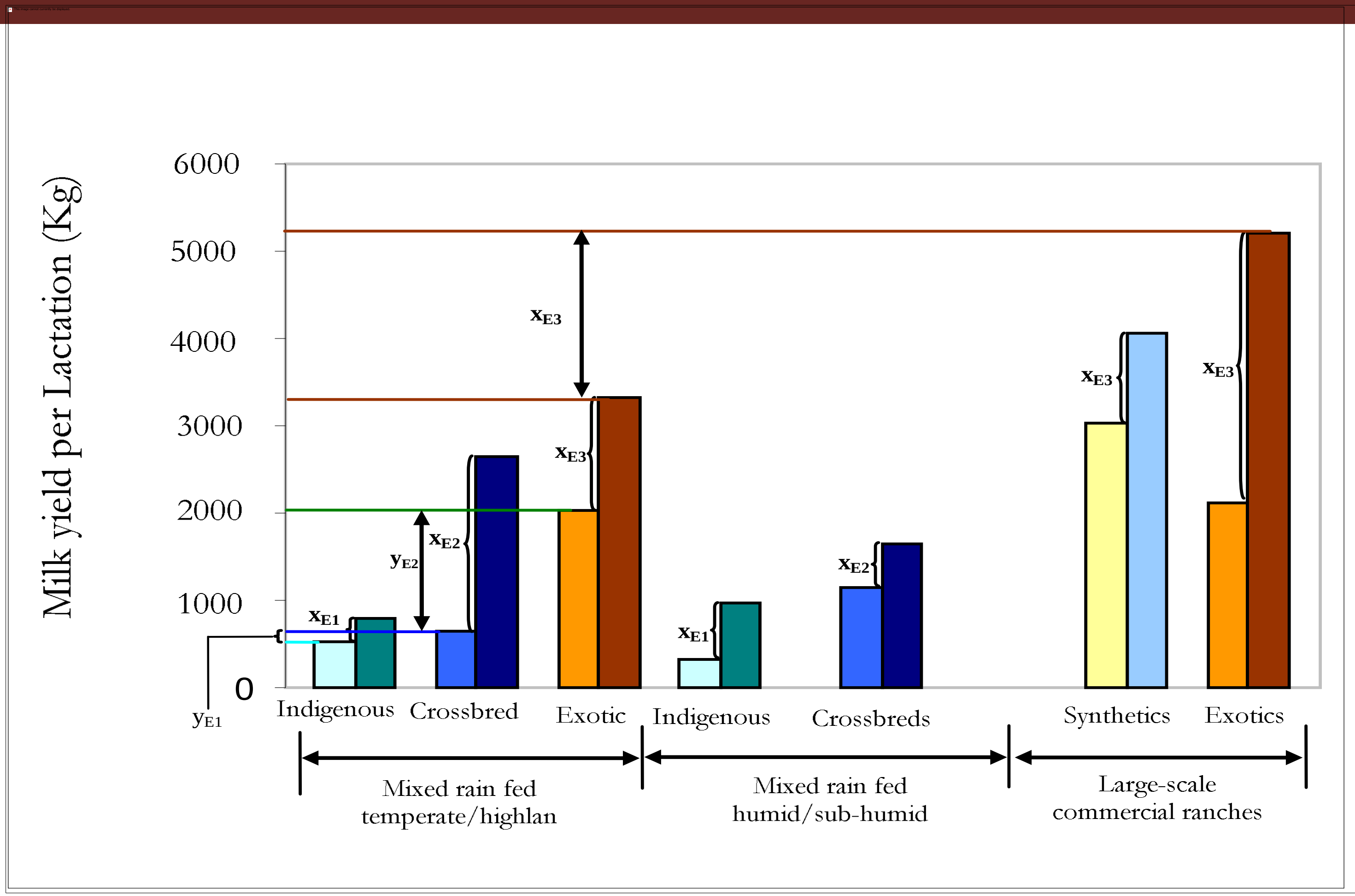
Needs and Technologies:

- Use Mathematical modeling to predict future scenarios & gene swoops
- Data to understand animals & environment
- Genomic & ICT tools to identify, improve and deliver the desired animals
- Match genotype with current environments
- Multiply and deliver desire[illegible] reproductive technology

Fitting livestock genotypes to different environments- the dairy example



Light coloured bars = Minimum production
Dark coloured bars = Maximum production
xi = Differences in production due to “animal husbandry practices”
yi = Differences in production due to “genotype”

Why is change a challenge ?

- Production systems are mainly small scale or pastoral, transaction costs are high
- Climate change!
- Limited resources, poverty, available feeds
- Endemic diseases
- Local Markets, skewed prices
- Poor Infrastructure
- Lack of feedback systems to inform management decisions
- Weak institutions

Unfortunately, We want to move

This Animal

This Environment

To this

Environment

Animal

To change an animal…

application of “technologies” is needed

Developed countries: What changed?

1960
5000 kg
milk/cow

2005
10 000kg
milk/cow

2050
?? kg milk/cow

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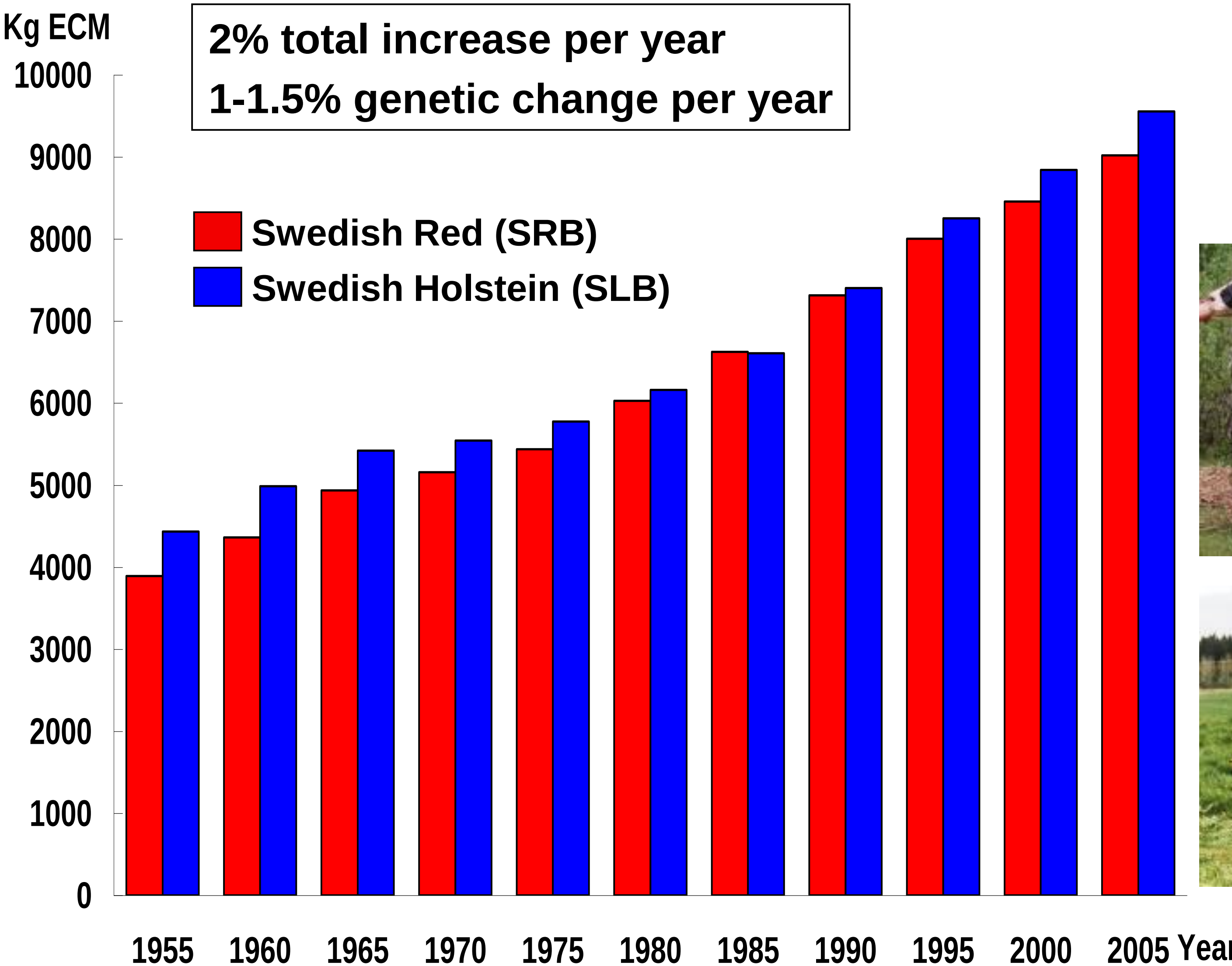
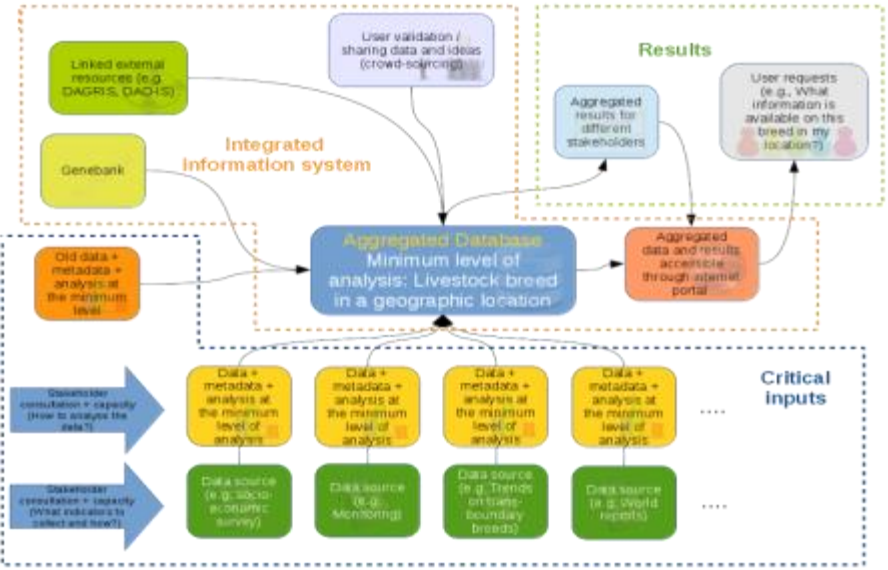
Change Takes Time and Effort (**good data & right analyses)**

Annual milk yield for SRB & SLB cows 1955-2005



Data: Technologies to accelerate information generation and sharing, but policies & access?

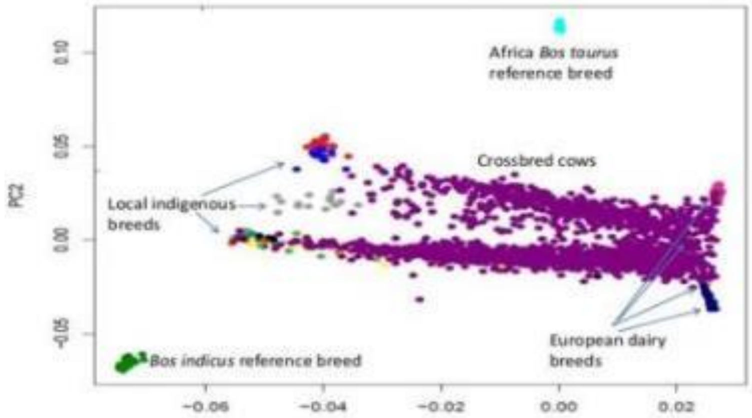
Smart data capture & feedback systems: ICT based Breeding platforms to systematically improve and deliver productivity gains



Use of Genomics and results from small-holder systems (DGEA)

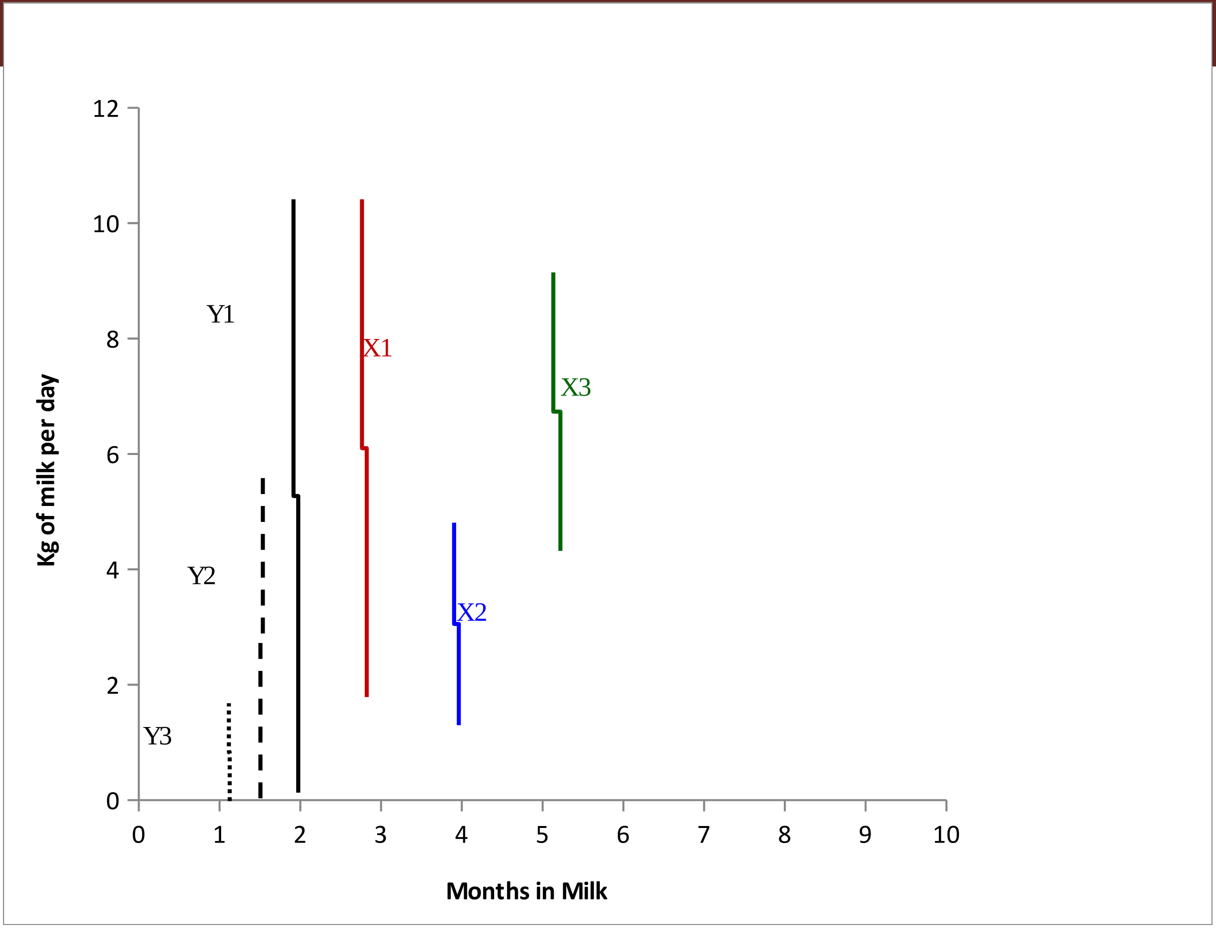
Milk production by % dairyness

- *High grade cattle only showed substantially better milk yields than other grades in the highest production environment*



PC1 vs PC2 from principal component analysis based on 566,000 snp

…Use of Genomics and results from small-holder systems (DGEA)



The lactation curves of dairy cows under different production systems in Kenya

Challenges and other potential application of genomics

- Are there desirable and undesirable GMOs?
  - Graft an Orange on lemon is ok but, gene from goat that improves nutritional value of cow milk is branded as undesirable (*the often uninformed GMO debate?)*
- Nutrient density: is 1 glass of Holsten milk < or > 1 glass of crossbred cow milk? *To whom and for who is important!*

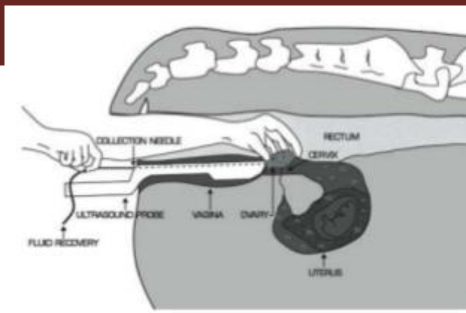
Opportunities & potential application of genomics

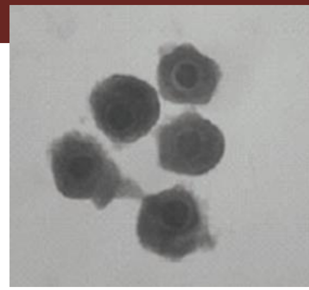
- Use of gene therapy to treat diseases (is this bad or desirable?)

- Understanding the underlying genetic control of traits that lead to threats to our wild life and use genomics to fix this (e.g. rhino horn)

- Use of Reproductive Technologies to Improve Productivity & Resilience

In-vitro production of bovine embryos of desired genetics





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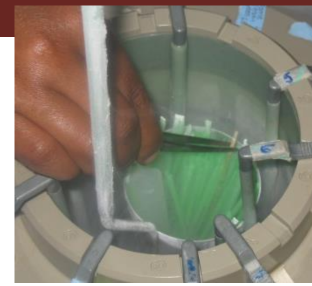


Oocytes by Ovum pick up (OPU)

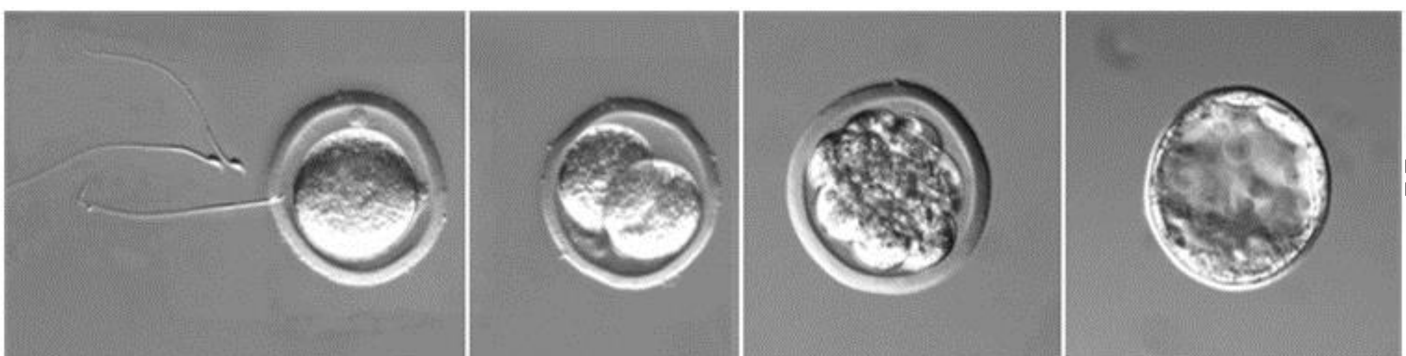
Frozen semen

IVF

2-cell

Morula
Day 3.5

Blastocyst
Day 7.5



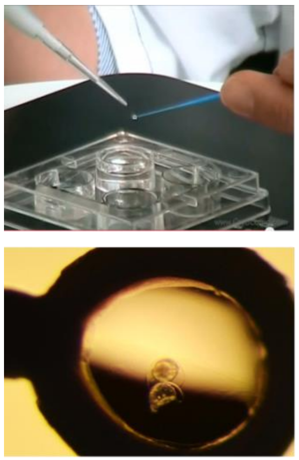
Embryo
Transfer (ET)

Cryopreservation

Can also be used to conserve the endangered African wildlife

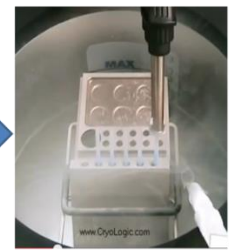
Bovine embryo vitrification with direct ET after warming

a) Solid Surface Vitrification (SSV)



Load embryos

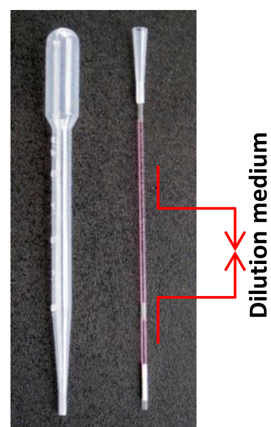
Vitrify on solid surface



Insert into sleeve & Seal

Store

Cut the straw



Pre-load the straw for recovery

Insert the plug into the straw immediately

ET

Bovine embryo vitrification with direct ET after warming

b) In-straw Dilution (ISD)

Same principles can be used to conserve the endangered African wildlife

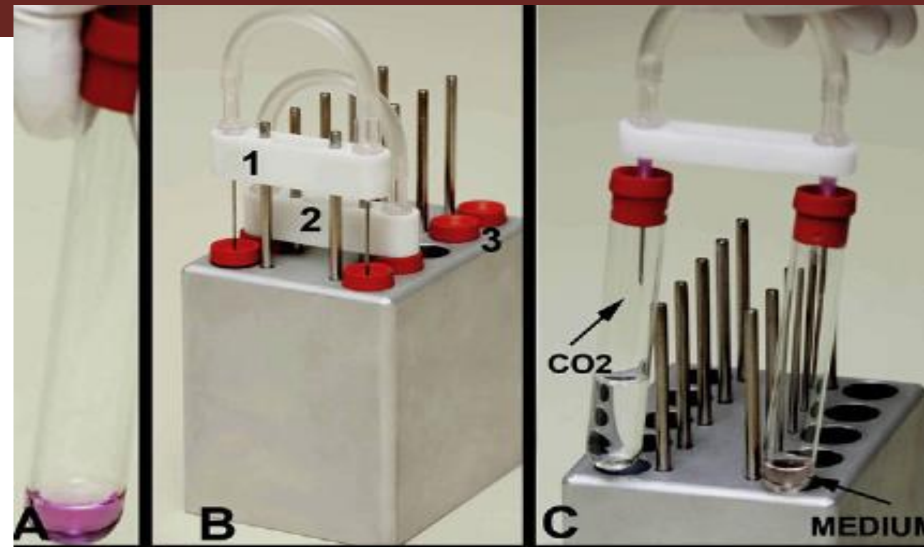
Results: *Bovine embryo vitrification with direct ET after warming*

Method	No. of Blastocysts	Re-expansion Rate (24 hr)	Hatch Rate (48 hr)
Control (fresh embryos)	25 (G1)	N/A	19 (76%)
	47 (G2)	N/A	34 (72%)
Solid Surface Vitrification (SSV)	28 (G1)	23 (82%)	16 (57%)
	40 (G2)	30 (75%)	16 (40%)
In-Straw Dilution (ISD)	21 (G1)	13 (62%)	7 (33%)
	54 (G2)	39 (72%)	16 (30%)

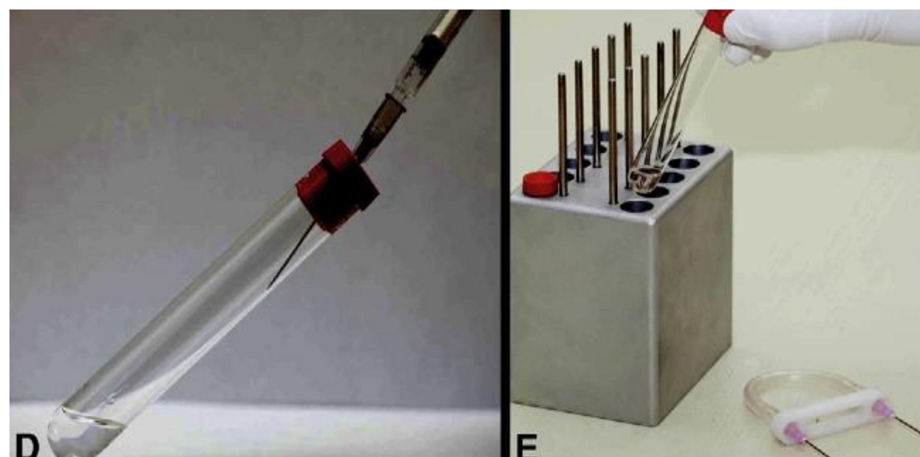
Simplified In Vitro Fertilization (IVF) System

Advantages

- **Simple & field-applicable**: no need of special equipment and the system can be transported by car to the field within 7 days.
- **Affordable**: the cost is 10 times less
- **Sub-centers for IVF** can be easily established with simple settings for villages.



Equilibration of culture medium



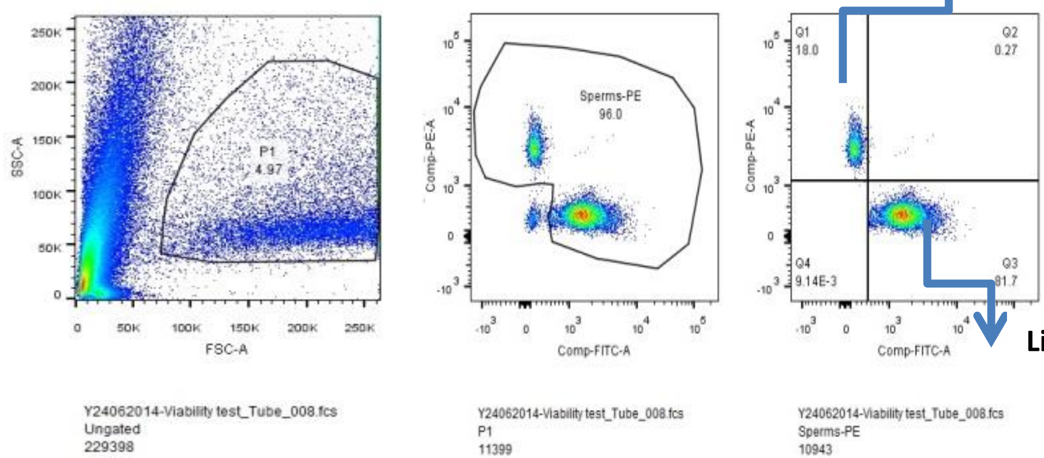
Injection of oocytes & sperm

Embryo Culture

Sperm Analysis by Fluorescence staining and Flow Cytometery

Viability test – PE & SYBR double staining

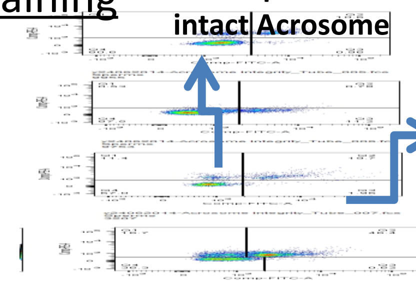
Dead sperm (red)



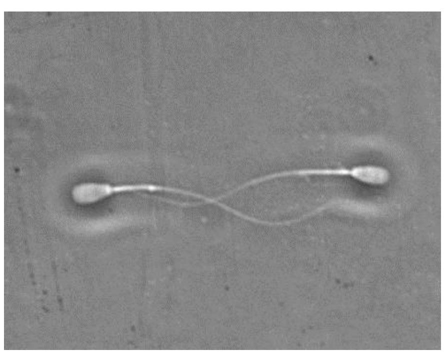
Live sperm (green)

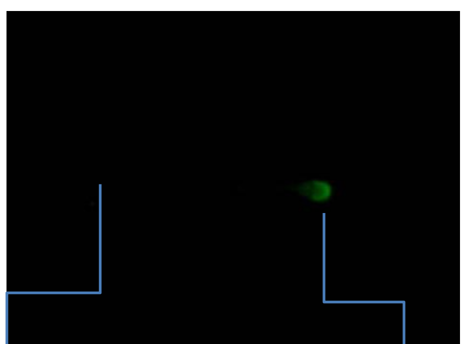
Acrosome integrity test – PSA-FITC, Hoechst & PE triple staining

Dead sperm with intact Acrosome



Dead sperm with broken Acrosome





Intact Acrosome (no staining)

Broken Acrosome (green)

Live sperm with intact Acrosome

Live sperm with broken Acrosome

Note:

Consumption of even small amounts of animal-source foods:

- combats under nutrition
- improves cognitive development
- increases physical growth and activity

To feed the hungry mouths the moral question is different!

- *Do we have enabling policies and appropriate policy frameworks in place to allow biotechnology and information technologies to effectively solve Africa’s food scarcity & safety problems?*

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Strategy materials: www.ilri.org/mission

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