Response to selection
Basis for designing breed improvement programmes

Improving productivity of a population

• Existing animals
  – Optimum Nutrition
  – Managing health and comfort
  Quick response; Benefits fade away as soon as measure is withdrawn

• Future generations
  – Genetic Improvement
  Slow response; Benefits accumulate over generations

We can improve “Only” those traits/aspects which we measure and record.

Replace “Looking” by “Measuring”
Replace “an Intuition” by “Calculations, Comparisons and scientific prediction”

Genetic improvement in dairy cattle and buffaloes

• To make genetic progress in a population
  – Mate the “best” to the “best” and
  – Do that as quickly as possible

Breeder’s equation
Four selection paths and their genetic contribution

- Sire - Sire (younger bull) path:
  - Increasing accuracy: Accurately selecting sires of younger bulls
  - Increasing intensity: Selecting lower % of progeny tested bulls for nominated mating

- Dam - Sire (younger bull) path:
  - Increasing accuracy: Accurately selecting bull mothers
  - Increasing intensity: Lower % of recorded females selected for nominated mating

- Sire - Dam (Heifer) path:
  - Increasing accuracy: Accurately selecting AI bulls
  - Increasing intensity: Lower % of bulls selected for AI in field for production of replacement heifers

- Dam - Dam (Heifer) path: Accurately selecting mothers of replacement heifers

Genetic Improvement under NDP I

- Focus on breeds with milk production potential
- Breeds where AI network is strong – Progeny Testing Young Bull model
  - Gir, HF, HFCB, JCB, Murrah, Mehsana
- Breeds where AI is not popular but sufficient number of animals are available in breeding tract – Pedigree Selection program
  - Sahiwal, Kankrej, Rathi, Haryana, Tharparkar, Nili-Ravi, Pandharpuri, Jaffarabadi
- Breeds where numbers are low
  - Red Sindhi and Pure Jersey – no programme under NDP I

Progeny Testing

A classical progeny testing scheme

Adapted from Ducrocq, 2013
Breeding Design – Young Sire Model

- Bull sire
- Breed: HF, HF CB, Jersey CB, Gir, Mehsana, Murrab
- Selection EBV
- Genetic evaluation
- Year n+2: Progeny test
- Year n+6: Breeding Values
- Year n+7: Genomic Breeding Values

- Base Population: Bull sire × (young male calf × daughters)
- Year n+2.5: daughters born

- Breeding Values: 10-20 young bulls selected for AI based traditional breeding values
- Genomic Breeding Values: 10-20 young bulls selected for AI based on Genomic breeding values

Quantity of young bulls selected:
- Young bulls selected for AI based traditional breeding values
- Young bulls selected for AI based on Genomic breeding values
- Total young bulls: 20 in first year; 40 by 5th year

PT Project under NDP 1 (13)
- 14 projects
- 12 Agencies
- 9 States
- 6 breeds (4 cattle and 2 buffalo)

PT Programmes under NDP

<table>
<thead>
<tr>
<th>Breeds</th>
<th>EIA</th>
<th>State</th>
</tr>
</thead>
<tbody>
<tr>
<td>HF</td>
<td>KMF</td>
<td>Karnataka</td>
</tr>
<tr>
<td>HF CB</td>
<td>SAG</td>
<td>Gujarat</td>
</tr>
<tr>
<td>Jersey CB</td>
<td>TCLPF</td>
<td>Tamil Nadu</td>
</tr>
<tr>
<td>Gir</td>
<td>SAG</td>
<td>Gujarat</td>
</tr>
<tr>
<td>Mehsana</td>
<td>SAG</td>
<td>Gujarat</td>
</tr>
<tr>
<td>Murrab</td>
<td>ABRO</td>
<td>Uttar Pradesh</td>
</tr>
<tr>
<td></td>
<td>HDDB</td>
<td>Haryana</td>
</tr>
<tr>
<td></td>
<td>PLDB</td>
<td>Punjab</td>
</tr>
<tr>
<td></td>
<td>SAG</td>
<td>Gujarat</td>
</tr>
</tbody>
</table>

These six breeds constitute about 75% of the total semen dose production.
Distribution of test doses

- Distribute 2000 doses per bull of all bulls put under test in as many villages as possible within one year; about 1000 breedable females per bull under test
- Prepare bull wise test dose distribution schedule
- Store minimum 3000 doses per bull till the progeny test results of bulls available
NDDB

A Herd of Mehsana Buffaloes

Body measurement of daughter being taken
Measurement of monthly Milk Yields

Measurement by jars
Electronic Weighing Machine for Milk Recording

Measurement of milk components

Centralized - Milkoscan
Decentralized Lactoscan
Type traits

Measurable (Objective) Traits

<table>
<thead>
<tr>
<th>Trait</th>
<th>Instrument</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stature</td>
<td>Retractable measuring tape with levelling bubble and telescoping rod-like attachment</td>
</tr>
<tr>
<td>Udder Depth</td>
<td>Measuring tape</td>
</tr>
<tr>
<td>Body Depth</td>
<td>Measuring tape</td>
</tr>
<tr>
<td>Rump Angle</td>
<td>Measuring tape</td>
</tr>
<tr>
<td>Rump Width</td>
<td>Ruler</td>
</tr>
<tr>
<td>Rear Udder Height</td>
<td>Vernier Caliper with digital scale</td>
</tr>
<tr>
<td>Teat Length</td>
<td>Measuring by Tape</td>
</tr>
<tr>
<td>Teat Width</td>
<td></td>
</tr>
<tr>
<td>Teat Thickness</td>
<td></td>
</tr>
<tr>
<td>Angularity</td>
<td>Device using two wooden pieces and a protractor</td>
</tr>
</tbody>
</table>

Subjective Assessment

- Rear Legs Set,
- Rear Legs Rear View,
- Foot Angle,
- Fore Udder Attachment,
- Central Ligament,
- Front Teat Placement,
- Rear Teat Placement and
- Body Condition Score.
1. Rump Width
2. Rear Udder Height
3. Teat Length
4. Rear Udder Width

Measurement by Ruler

Vernier Calliper with digital scale

Teat Thickness

Type traits - Subjective Assessment on 1-9 score:
- Rear Legs Set,
- Rear Legs Rear View,
- Foot Angle,
- Fore Udder Attachment,

Angularity
Type traits - Subjective Assessment on 1-9 score

- Central Ligament
- Front Teat Placement
- Rear Teat Placement and
- Body Condition Score

Traits measured

<table>
<thead>
<tr>
<th>Production Traits</th>
<th>Reproduction Traits</th>
<th>Type traits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test day yield</td>
<td>Age at first AI</td>
<td>Stature</td>
</tr>
<tr>
<td>305 day yield</td>
<td>Age at first calving</td>
<td>Heart Girth</td>
</tr>
<tr>
<td>Test day fat %</td>
<td>No. of AIs per conception – heifers and cows</td>
<td>Body Length</td>
</tr>
<tr>
<td>305 day fat yield</td>
<td>Bull conception rate</td>
<td>Central Ligament</td>
</tr>
<tr>
<td>305 day fat %</td>
<td>Service period for cows</td>
<td>Angularity</td>
</tr>
<tr>
<td>Test day fat yield</td>
<td>Near calving period</td>
<td>Front Teat Placement</td>
</tr>
<tr>
<td>Protein, Lactose and SNF %</td>
<td>Calving Ease</td>
<td>Rump Width</td>
</tr>
<tr>
<td>Protein test day yield</td>
<td>Near Leg Set</td>
<td>Rear Udder Width</td>
</tr>
<tr>
<td>Protein 305 day yield</td>
<td>Near Leg Rear View</td>
<td>Test Thickness</td>
</tr>
<tr>
<td>Test day fat yield</td>
<td>Foot Angle</td>
<td>Body Length</td>
</tr>
<tr>
<td>Test day fat yield</td>
<td>Body Depth</td>
<td>Central Ligament</td>
</tr>
<tr>
<td>Test day fat yield</td>
<td>Udder Depth</td>
<td>Body Length</td>
</tr>
<tr>
<td>Test day fat yield</td>
<td>Body Depth</td>
<td>Central Ligament</td>
</tr>
<tr>
<td>Test day fat yield</td>
<td>Udder Depth</td>
<td>Body Length</td>
</tr>
<tr>
<td>Test day fat yield</td>
<td>Body Depth</td>
<td>Central Ligament</td>
</tr>
</tbody>
</table>

Minimum standards for daughters born

- No. of daughters born and registered per bull should not be less than 200 and spread over minimum 5 villages
- Complete first lactation records of minimum 70 daughters per bull spread over a minimum of 5 villages available for breeding values estimation
- Breeding values will not be estimated unless complete first lactation records of minimum 30 daughters per bull spread over 5 villages available
- At least 80% of the daughters that are tested for DNA based parentage tests should have correct parentage as recorded.
Breeding Value Estimation

Defining Contemporaries

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Number of observations</td>
</tr>
<tr>
<td>2</td>
<td>Number of villages</td>
</tr>
<tr>
<td>3</td>
<td>Mean First Lactation Yield (kgs.)</td>
</tr>
<tr>
<td>4</td>
<td>Standard Deviation (kgs.)</td>
</tr>
<tr>
<td>5</td>
<td>Mean fat %</td>
</tr>
<tr>
<td>6</td>
<td>Standard Deviation (fat %)</td>
</tr>
<tr>
<td>7</td>
<td>No. of observations for fat %</td>
</tr>
</tbody>
</table>
Village wise average daughter first lactation yields

Average first lactation yields in villages having more than 200 observations

<table>
<thead>
<tr>
<th>AI Centre No.</th>
<th>N</th>
<th>Mean</th>
<th>SD</th>
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<tbody>
<tr>
<td>2</td>
<td>362</td>
<td>1825</td>
<td>368</td>
</tr>
<tr>
<td>10</td>
<td>288</td>
<td>1791</td>
<td>334</td>
</tr>
<tr>
<td>15</td>
<td>300</td>
<td>1784</td>
<td>376</td>
</tr>
<tr>
<td>26</td>
<td>208</td>
<td>1938</td>
<td>610</td>
</tr>
<tr>
<td>53</td>
<td>267</td>
<td>1746</td>
<td>330</td>
</tr>
<tr>
<td>78</td>
<td>206</td>
<td>1774</td>
<td>266</td>
</tr>
<tr>
<td>82</td>
<td>124</td>
<td>1790</td>
<td>378</td>
</tr>
<tr>
<td>84</td>
<td>225</td>
<td>1835</td>
<td>292</td>
</tr>
<tr>
<td>85</td>
<td>210</td>
<td>1775</td>
<td>427</td>
</tr>
<tr>
<td>95</td>
<td>301</td>
<td>1931</td>
<td>602</td>
</tr>
<tr>
<td>96</td>
<td>254</td>
<td>1925</td>
<td>451</td>
</tr>
<tr>
<td>104</td>
<td>266</td>
<td>1852</td>
<td>370</td>
</tr>
<tr>
<td>106</td>
<td>263</td>
<td>1823</td>
<td>498</td>
</tr>
</tbody>
</table>

Distribution of first lactation yield within village 82 over years

Daughters' average first lactation yields by year of their calving
Average first lactation yields by month of calving

Distribution of age at first calving in months

<table>
<thead>
<tr>
<th>No. Of observations</th>
<th>7682</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean (in months)</td>
<td>45.7</td>
</tr>
<tr>
<td>Standard Deviation (in months)</td>
<td>10.1</td>
</tr>
</tbody>
</table>

Breeding Value Estimation Committee

A Committee has been constituted by GoI to:
• Decide on the model to be used for estimating breeding values,
• Oversee estimation of breeding values by a subcommittee of this committee, and
• Publish breeding values of all bulls used under PT projects every six months on NDDB/DADF sites.

<table>
<thead>
<tr>
<th>SN</th>
<th>Name</th>
<th>Designation</th>
<th>Role</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Dr. K R Trivedi</td>
<td>Advisor, NDDB</td>
<td>Chairman</td>
</tr>
<tr>
<td>2</td>
<td>Prof. Mogens Sand-Lund</td>
<td>Center Leader, Center for Quantitative Genetics and Genomics, Aarhus University, Denmark</td>
<td>Member</td>
</tr>
<tr>
<td>3</td>
<td>Dr. Bhusan Tyagi</td>
<td>Asst. Commissioner, DADF</td>
<td>Member</td>
</tr>
<tr>
<td>4</td>
<td>Dr. Chanda Rastkar</td>
<td>Director, Nimbkar Agri. Res. Institute</td>
<td>Member</td>
</tr>
<tr>
<td>5</td>
<td>Prof. D N Rank</td>
<td>Professor and Head (AGB), Veterinary College, ANR</td>
<td>Member</td>
</tr>
<tr>
<td>6</td>
<td>Dr. G R Gowani</td>
<td>Scientist, CSWRI, Ankanagar</td>
<td>Member</td>
</tr>
<tr>
<td>7</td>
<td>Dr. Jose James</td>
<td>Managing Director, KUDB</td>
<td>Member</td>
</tr>
<tr>
<td>8</td>
<td>Dr. C Titus</td>
<td>Project Coordinator, TCMPF Progeny Testing project</td>
<td>Member</td>
</tr>
<tr>
<td>9</td>
<td>Dr. Amrish Patel</td>
<td>General Manager, SAG, Bida</td>
<td>Member</td>
</tr>
<tr>
<td>10</td>
<td>Dr. Nilesh Nayak</td>
<td>St. Manager (AB), NDDB</td>
<td>Member Convenor</td>
</tr>
</tbody>
</table>

Model used for Breeding Value Estimation – Animal BLUP

\[ y = Xb + Za + e \]

Where:
- \( y = n \times 1 \) vector of observations; \( n \) = number of records
- \( b = p \times 1 \) vector of fixed effects; \( p \) = number of levels for fixed effects
- \( a = q \times 1 \) vector of random animal effects; \( q \) = number of levels of random effects
- \( e = n \times 1 \) vector of random residual effects
- \( X \) = design matrix of order \( n \times p \), which relates records to fixed effects
- \( Z \) = design matrix of order \( n \times q \), which relates records to random animal effects

\[ \begin{bmatrix} b^* \\ a^* \end{bmatrix} = \begin{bmatrix} X'X & X'Z \\ Z'X & Z'Z + A^{-1} \end{bmatrix} \begin{bmatrix} X'y \\ Z'y \end{bmatrix} \]

\( A \) is the relational matrix based on pedigree data and \( \alpha = \sigma^2_a / \sigma^2_e \)
**Model in practice**: for production traits - Test-day milk yield, Test-day fat yield, and test day protein yield

\[ Y_{\text{test}} = A_i + YS_j + O_m + HYMR_k + \sum_{t=1}^{n} Q_{t} \beta_{t} + \sum_{t=1}^{n} Q_{t} \theta_{t} + \sum_{t=1}^{n} u_{t} + p_{e} \]

- \( A \) = Age class
- \( YS \) = Year season of calving
- \( O \) = Owner
- \( HYMR \) = Herd-Year-Month of recording
- \( \beta \) = Fixed regression curve for lactation
- \( u \) = Animal effect
- \( p_e \) = Permanent environmental effect to account for multiple TD records per cow

Animal wise solutions

<table>
<thead>
<tr>
<th>Animal</th>
<th>Regression coefficients</th>
<th>305-day breeding value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>-0.0563 0.0552 0.0442</td>
<td>-12.3731</td>
</tr>
<tr>
<td>2</td>
<td>-0.0725 -0.0305 0.0244</td>
<td>-15.7347</td>
</tr>
<tr>
<td>3</td>
<td>0.1311 -0.0247 0.0686</td>
<td>28.1078</td>
</tr>
<tr>
<td>4</td>
<td>0.3445 0.0063 -0.3164</td>
<td>74.8132</td>
</tr>
<tr>
<td>5</td>
<td>-0.4537 -0.0520 0.2798</td>
<td>-98.4153</td>
</tr>
</tbody>
</table>

MME gives these solutions

Derived after post-processing of MME solutions

Breeding value Estimation

- Breeding values of sires and daughters are estimated on available records every six months
- Top 5-10% of bulls based on breeding value and top 2-5% of recorded female animals are used for production of bull calves
- Reliability of breeding values of bulls used for nominated mating should not be less than 75%.
Nominated AI

Male born is ear-tagged
Minimum standards for male calves

- All bull calves selected through nominated mating should have confirmed parentage through DNA testing.

- Both bull calves that are procured and their dams should be free from TB, JD, Brucellosis, and any physical deformities.

How are we making progress under PT Projects

- Top 5-10% of bulls based on breeding value (Sire-Sire) and top 2-5% of recorded female animals (Dam-Sire) are used for production of bull calves

- Some selection happens on Sire-Dam path – selection of sire to produce replacement heifers in field

Factors affecting accuracy of selection

- Accuracy of recording
- Correction for environmental factors (model)
- Sources of information used for evaluation
- Genetic connectedness among projects
- Statistical model for Genetic Evaluation

\[
\text{Genetic Gain/Yr} = \text{Intensity} \times \text{Accuracy} \times \frac{\text{Genetic St. dev.}}{\text{Generation Interval}}
\]
Measures taken for accurate records

- Advanced monthly recording schedule
- Surprise checks and post record validations
  - 4 level supervision/checks
    - Project supervisors
    - Project officers
    - NDDB monitoring officers
    - Annual external evaluation
- GPS enabled weighing scales and direct entry in INAPH

Impact of bull EBV reliabilities on daughter performance

<table>
<thead>
<tr>
<th>Bulls selected by DY Rel 0.1</th>
<th>Bulls selected by BV Rel &gt;70%</th>
</tr>
</thead>
<tbody>
<tr>
<td>High DY group – Avg. DY 7630</td>
<td>High DY group – Avg. DY 5989</td>
</tr>
<tr>
<td>Low DY group – Avg. DY 3654</td>
<td>Low DY group – Avg. DY 4773</td>
</tr>
</tbody>
</table>

Peak yield Vs Test day recording

We are interested in improving lactation yield of animals

How are we making progress under PT Projects

\[
\text{Genetic Gain/Yr} = \text{Intensity} \times \text{Accuracy} \times \text{Genetic St. dev.} / \text{Generation Interval}
\]
Reducing Generation interval

– Sire to Sire Path – Reliable BV at early age
  • First lot of semen produced for test mating
  • Collecting data at the earliest, focus on improving AFC of daughters
– Dam to sire Path – male calf at early age
  • Identify elite cows at the earliest (may be first lactation)
  • Nominate mating to heifers based on BV and select males in first lactation based on actual production
– Sire to Dam Path – semen production at early age
  • Select young bull – rear them to take early semen production
– Dam to Dam path – Improving AFC and ICP

Process of ranking animals at genetic level

Measure performance of a group of animals or progeny of the same environmental conditions
Correct each phenotype for environment’s effect
Take average of corrected phenotype
Take difference of each genotype based on corrected environment – this is genetic superiority
Rank each genotype by this genetic superiority

Sources of information used

Accurately recorded elite female
Proven bull r² 0.85
Young bull for semen production r² 0.25-0.3
Daughter records

Genetic connectedness among projects

• Put bulls across the projects for test mating
• Combine data across projects testing same breed
Is recording milk sufficient??

- Profitability of dairying involves
  - Increasing milk, fat and protein yield
  - Improving reproduction efficiency
  - Improving body structure to sustain production and adopt to particular mgmt. system
  - Increasing resistance to various diseases!!!!
  - Improving feed efficiency!!!!
  - Increasing adoption to environment!!!!

Need to record more traits

- Profitability
- Correlated response
  - Negatively related traits – must get appropriate weightage
  - Difficult to measure traits – correlated response may help

Multi trait Selection Index: differential emphasis on various economic traits

Why data collection is issue in our country?

- Farmers do not see benefit of recording data in smallholder conditions
- We have not been able to demonstrate use of information for farmer’s benefit
- Our services providers do not believe improving through data driven decisions

Source: Miglior, F. 2012. CDN
Pedigree Selection

**PS Programmes for production of HGM bulls of different breeds**

<table>
<thead>
<tr>
<th>Breeds</th>
<th>Breed</th>
<th>EIAs</th>
<th>State</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rathi</td>
<td></td>
<td>URMUL</td>
<td>Rajasthan</td>
</tr>
<tr>
<td>Kankrej</td>
<td></td>
<td>Bunas</td>
<td>Gujarat</td>
</tr>
<tr>
<td>Gir</td>
<td></td>
<td>SAG</td>
<td>Gujarat</td>
</tr>
<tr>
<td>Jaffrabadi</td>
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<td>SAG</td>
<td>Gujarat</td>
</tr>
<tr>
<td>Hariana</td>
<td></td>
<td>HLDB</td>
<td>Haryana</td>
</tr>
</tbody>
</table>

**Sahiwal**
- Sahiwal PS Project
- Punjab/ Rajasthan

**Tharparkar**
- RLDB
- Rajasthan

**Nili Ravi**
- PLDB
- Punjab

**Pandharpuri**
- MLDB
- Maharashtra

**PS Project under NDP I (10)**
- 10 projects
- 10 Agencies
- 5 States
- 9 breeds (6 cattle and 3 buffalo)
Multiplier villages – 50-100

Base Population
about 100,000 animals

Semen Station

AI Service

Indigenous cows

Milk recording
of elite cows

Improved breeds
programs

Bull calves

Selection of elite cows
and documented records

Quarantine
Station

Bull Rearing
Station

AI services

Bulls for Natural Service

Identification of elite animals and creation of infrastructure for milk recording

Progress Report of PS Projects as on 16th Nov 2018

<table>
<thead>
<tr>
<th>Project</th>
<th>Species</th>
<th>Nos of AIC</th>
<th>Animal Registration</th>
<th>AI Done</th>
<th>PD</th>
<th>Calving Reported</th>
<th>Milk Records</th>
<th>Nos of animal</th>
<th>AI Services</th>
</tr>
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<tbody>
<tr>
<td>PLDB Nili-Ravi PS Project - NDP1</td>
<td>Buffalo</td>
<td>65</td>
<td>15,352</td>
<td>26,708</td>
<td>9,023</td>
<td>3,042</td>
<td>22,333</td>
<td>2,473</td>
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<tr>
<td>MLDB Pandharpuri PS Project - NDP1</td>
<td>Buffalo</td>
<td>35</td>
<td>18,576</td>
<td>22,703</td>
<td>14,621</td>
<td>4,172</td>
<td>26,251</td>
<td>2,863</td>
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<tr>
<td>SAG PS Project</td>
<td>Buffalo</td>
<td>151</td>
<td>52,209</td>
<td>64,628</td>
<td>44,386</td>
<td>13,534</td>
<td>28,520</td>
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<tr>
<td>PLDB PS Sahiwal Project - NDP1</td>
<td>Cattle</td>
<td>30</td>
<td>9,517</td>
<td>14,999</td>
<td>6,573</td>
<td>1,779</td>
<td>10,085</td>
<td>1,273</td>
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<tr>
<td>HLDB Haryana PS Project - NDP1</td>
<td>Cattle</td>
<td>51</td>
<td>10,569</td>
<td>9,496</td>
<td>6,106</td>
<td>2,665</td>
<td>41,200</td>
<td>4,836</td>
<td></td>
</tr>
<tr>
<td>RLDB Tharparkar PS Project - NDP1</td>
<td>Cattle</td>
<td>90</td>
<td>18,774</td>
<td>21,660</td>
<td>13,620</td>
<td>3,751</td>
<td>13,369</td>
<td>1,722</td>
<td></td>
</tr>
<tr>
<td>Gangmul Sahiwal PS Project - NDP1</td>
<td>Cattle</td>
<td>34</td>
<td>25,847</td>
<td>28,577</td>
<td>21,584</td>
<td>7,694</td>
<td>25,378</td>
<td>2,941</td>
<td></td>
</tr>
<tr>
<td>NDDB Banaskantha Breed Development Project</td>
<td>Cattle</td>
<td>100</td>
<td>28,607</td>
<td>51,672</td>
<td>29,347</td>
<td>15,335</td>
<td>27,933</td>
<td>3,030</td>
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</tr>
<tr>
<td>SAG PS Project</td>
<td>Cattle</td>
<td>150</td>
<td>57,566</td>
<td>69,073</td>
<td>47,588</td>
<td>17,309</td>
<td>68,429</td>
<td>9,303</td>
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<tr>
<td>NDDB Rathi Breed Development Project</td>
<td>Cattle</td>
<td>88</td>
<td>58,839</td>
<td>63,466</td>
<td>52,291</td>
<td>20,447</td>
<td>32,261</td>
<td>3,788</td>
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</tr>
<tr>
<td>Total</td>
<td>794</td>
<td>295,856</td>
<td>372,982</td>
<td>245,139</td>
<td>89,728</td>
<td>295,759</td>
<td>35,361</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Import of Bulls and Embryos

- Under NDP-I, 76 High Genetic Merit HF bull calves imported in 2014-15 from Germany
- 82 HGM bulls of HF and Jersey breed imported from Denmark in 2015-16
- 480 embryos for bull production imported from Canada in 2014-15
Transferring Embryos

HF calves born through ETT

Jersey calves born through ETT

Field ET programme for bull production
**Dissemination of Genetics - Young bulls supplied to semen stations from NDP**

<table>
<thead>
<tr>
<th>Programme</th>
<th>Total bulls distributed</th>
</tr>
</thead>
<tbody>
<tr>
<td>1  Progeny Testing</td>
<td>3566</td>
</tr>
<tr>
<td>2  Pedigree Selection</td>
<td>154</td>
</tr>
<tr>
<td>3  ET – Imported Embryos</td>
<td>65</td>
</tr>
<tr>
<td>4  Imported live bulls</td>
<td>133</td>
</tr>
<tr>
<td><strong>Total Bulls supplied</strong></td>
<td><strong>1918</strong></td>
</tr>
<tr>
<td><strong>Total Bulls under collection 2017-18 all Semen Stations</strong></td>
<td><strong>4338</strong></td>
</tr>
<tr>
<td>% of bulls replaced by bulls supplied from NDP</td>
<td><strong>44 %</strong></td>
</tr>
</tbody>
</table>

**Information Systems**

**Research Areas**
Differentiate between Routine services and Research areas

Probable research areas

- Ways to measure various traits effectively in small holder situations
  - Fertility
  - Disease resistance (which disease?)
  - Feed efficiency
  - Heat tolerance
  - Methane emission

- How number of observations could be maximised without compromising quality and not much modifying existing service structure

- How to connect data across breeds (e.g. CB and purebreds, two buffalo breeds??) and compare

Probable research areas

- How a system similar to INTERBULL can be established in the country
- Economic weights for selection index
- Purpose specific or area specific selection index
- Economics of cost of trait measurement Vs expected benefits for a particular trait to be included in index
- Estimation of Genetic and economic cost of compromising recording accuracy

Probable research areas

- Devising Communication material for semen stations, policy makers and farmers on genetic improvement process and its benefits
- Extension on concept of breeding goal, policy and plan
- Breeding goals, breeding plans and their cost benefit analysis for dairy and draft purpose cattle
Thank You