Response to selection

Basis for designing breed improvement programmes

National Dairy Development Board

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  Quick response ; Benefits fade away as soon as measure is withdrawn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

$$\text{Genetic Gain/Yr} = \frac{\text{Genetic superiority of selected parents}}{\text{Generation interval}}$$

$$\boxed{\text{Genetic Gain/Yr} = \frac{\text{Intensity X Accuracy X Genetic St. dev.}}{\text{Generation Interval}}}$$

Breeder's equation

Four selection paths and their genetic contribution

$$\begin{tikzcd} \text{Dam} \arrow[d] \arrow[dr] & \text{Sire} \arrow[d] \arrow[dl] \\ \text{Dam} & \text{Sire} \end{tikzcd}$$

$$R_{Year} = \frac{(i_{SS}.r_{SS} + i_{DS}.r_{DS} + i_{SD}.r_{SD} + i_{DD}.r_{DD})}{L_{SS} + L_{DS} + L_{SD} + L_{DD}} * \sigma_g$$

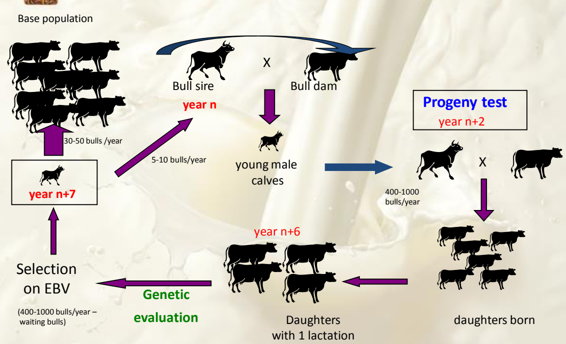
- **Sire – Sire(young bull) path**:
  - **Increasing accuracy** - Accurately selecting sires of young bulls
  - **Increasing intensity of selection** - Selecting lesser % of progeny tested bulls for nominated mating
- **Dam-Sire(young bull) path**:
  - **Increasing accuracy** - Accurately selecting bull mothers
  - **Increasing intensity of selection** - lesser % of recorded females selected for nominated mating
- **Sire-Dam (Heifer) path**:
  - **Increasing accuracy** - Accurately selecting AI bulls;
  - **Increasing intensity** - lesser % 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 programm
  - Sahiwal, Kankrej, Rathi, Haryana, Tharparkar, Nili-Ravi, Pandharpuri, Jaffarabadi
- Breeds where numbers are low
  - Red Sindhi and Pure Jersey – no programme under NDP I

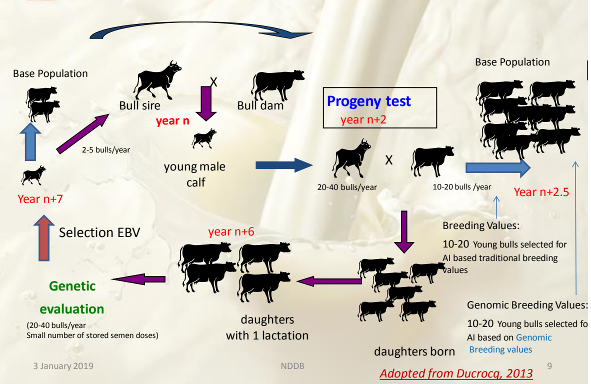
Progeny Testing

A classical progeny testing scheme



Adopted from Ducrocq, 2013

Breeding Design – Young Sire Model

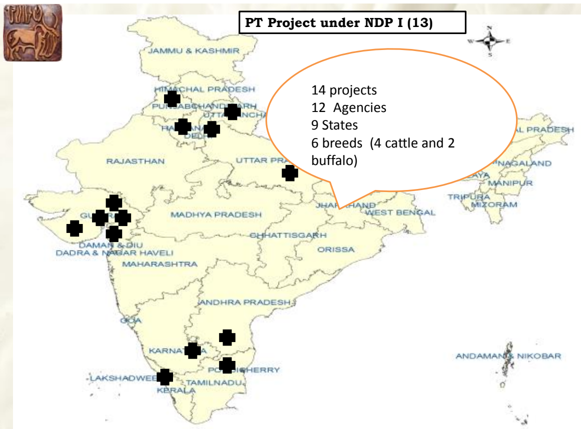


PT Programmes under NDP

Breeds	Breed	EIAs	State
	HF	KMF	Karnataka
	HF CB	SAG	Gujarat
		ULDB	Uttarakhand
		BAIF	Uttar Pradesh
		KLDB	Kerala
	Jersey CB	TCMPF	Tamil Nadu
		APLDA	Andhra Pradesh
	Gir	SAG	Gujarat
	Mehsana	Mehsana Union	Gujarat
		Banas Union	Gujarat
	Murrah	ABRO	Uttar Pradesh
		HLDB	Haryana
		PLDB	Punjab
		SAG	Gujarat

These six breeds constitute about 75% of the total semen dose production in 2017-18

PT Project under NDP I (13)



Putting young bulls under test programme

20 in first year; 40 by 5^{th} year

1/3/2019 NDDB 12

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

1/3/2019 NDDB 15


Body measurement of
daughter being taken


Milk recording
NDDB
21


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

Trait	Instrument
Stature	Retractable measuring tape with levelling bubble and telescoping rod-like attachment
Rump Angle	
Udder Depth	
Body Depth	Measuring tape
Body Length	
Heart Girth	
Rump Width	Ruler
Rear Udder Height	
Teat Length	
Rear Udder Width	
Teat Thickness	Vernier Calliper with digital scale
Angularity	Device using two wooden pieces and a protractor

Subjective Assessment

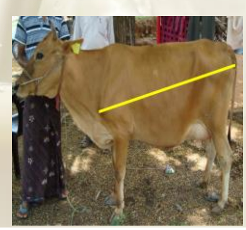
- Rear Legs Set,
- Rear Legs Rear View,
- Foot Angle,
- Fore Udder Attachment,
- Central Ligament,
- Front Teat Placement,
- Rear Teat Placement and
- Body Condition Score.

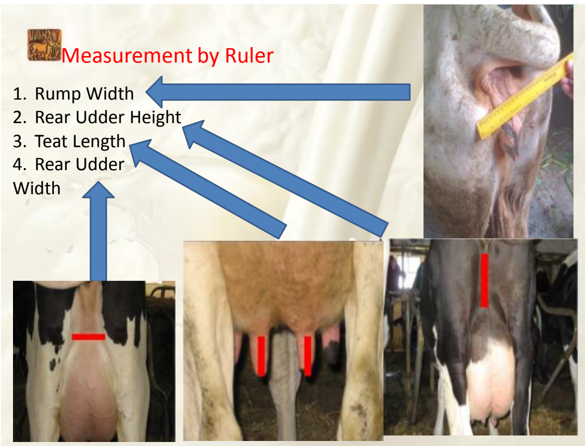
Retractable measuring tape with levelling bubble and telescoping rod-like attachment

1. Stature
2. Udder Depth
3. Rump Angle

Measuring by Tape

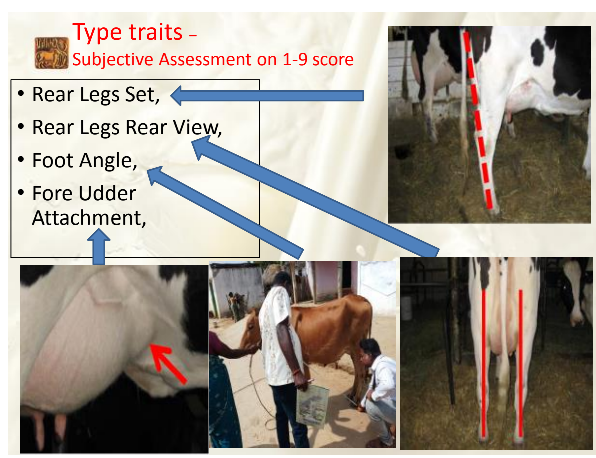
1. Heart Girth
2. Body Length
3. Body Depth




Measurement by Ruler
1. Rump Width
2. Rear Udder Height
3. Teat Length
4. Rear Udder Width


Vernier Calliper with digital scale
Teat Thickness


Angularity


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

Type traits –
Subjective Assessment on 1-9 score

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

Traits measured

Production Traits	Reproduction Traits	Type traits	
Test day yield	Age at first AI	Stature	Fore Udder Attachment
305 day yield	Age at first calving	Heart Girth	Rear Udder Height
Test day fat %	No. of AIs per conception – heifers and cows	Body Length	Central Ligament
Test day fat yield	Bull conception rate	Body Depth	Udder Depth
305 day fat %	Service period for cows	Angularity	Front Teat Placement
305 day fat yield	Inter-calving period	Rump Angle	Teat Length
Protein, Lactose and SNF %	Calving Ease	Rump Width	Rear Teat Placement
Protein test day yield		Rear Leg Set	Rear Udder Width
Protein 305 day yield		Rear Leg Rear View	Teat Thickness
		Foot Angle	Body Condition Score

Progress report of PT Projects as on 16th November 2018

Sr No	Project	Species	Animal Registration	AI Done	PD+	Calving Reported	Daughter Born	Daughter Tagged	Daughter Inseminated	Daughter PD+	Daughter Calved	Daughter Put To MR	Daughter Complted MR
1	ABRO Murrah Buffalo	Buffalo	138,541	224,140	70,602	40,551	16,814	14,473	1,421	655	417	346	115
2	Banas	Buffalo	61,479	186,095	71,746	51,542	23,314	21,954	4,518	2,728	2,105	1,509	1,154
3	HLDB Murrah Buffalo	Buffalo	314,508	311,787	114,412	69,495	30,981	20,350	1,454	500	188	100	6
4	Mehsana Buffalo	Buffalo	49,388	299,035	85,858	60,822	28,302	22,684	7,371	5,057	4,023	3,455	2,801
5	NDDB-SAG-Buffalo	Buffalo	97,917	386,270	157,632	125,328	57,444	55,214	9,953	6,953	5,630	4,875	3,548
6	PLDB Murrah	Buffalo	222,730	240,638	87,267	60,331	25,711	23,859	2,572	1,062	609	409	128
7	APLDA CB Jersey	Cattle	136,806	254,164	100,869	62,318	28,772	28,532	5,898	3,762	1,770	1,560	705
8	BAIF CB HF	Cattle	74,104	122,036	52,009	34,120	14,992	12,961	3,002	1,971	978	775	358
9	KLDB HF Crossbred	Cattle	59,530	82,194	30,157	19,865	9,546	8,894	1,953	968	484	371	79
10	TCMPF JCB	Cattle	272,532	659,725	271,834	190,532	84,864	82,012	21,290	16,170	11,374	10,731	7,640
11	NDDB-KMF	Cattle	159,763	493,407	196,381	118,887	48,062	47,116	15,662	12,093	7,955	6,020	4,061
12	SAG- HFCB	Cattle	151,124	627,670	242,776	192,220	89,991	85,585	22,885	17,981	13,976	12,202	9,482
13	ULDB HF Crossbred	Cattle	70,086	123,345	46,691	29,114	12,672	11,749	1,788	941	391	232	90
14	SAG Gir PT	Cattle	18,484	27,361	9,753	3,893	1,592	1,506	0	0	0	0	0
		Total	**1,826,992**	**4,037,867**	**1,537,987**	**1,059,018**	**473,057**	**436,889**	**99,767**	**70,841**	**49,900**	**42,585**	**30,167**

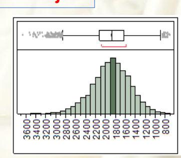
Minimum standards for daughters born

- 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

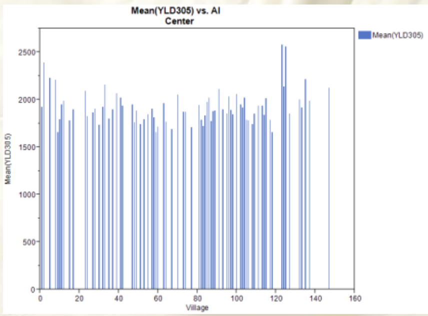
Defining Contemporaries

Mehsana Buffalo PT Project

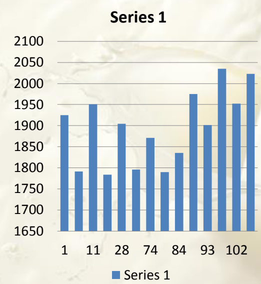


1	Number of observations	7687
2	Number of villages	77
3	Mean First Lactation Yield (kgs.)	1887.4
4	Standard Deviation (kgs.)	392.9
5	Mean fat %	6.98
6	Standard Deviation (fat %)	0.61
7	No. of observations for fat%	5346

Village wise average daughter first lactation yields

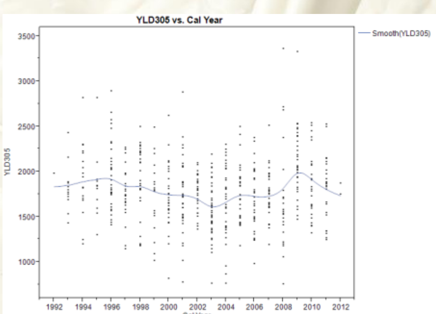


Average first lactation yields in villages having more than 200 observations

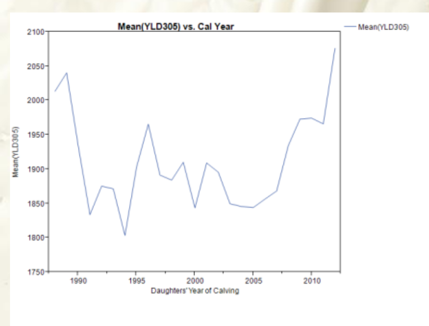


AI Centre No.	N	Mean	SD
1	342	1925	368
10	288	1791	334
11	209	1951	369
15	300	1784	376
28	208	1904	433
53	397	1796	330
74	205	1871	396
82	524	1790	378
84	225	1835	390
85	210	1975	437
93	301	1901	402
96	254	2035	451
102	366	1952	379
104	263	2023	446

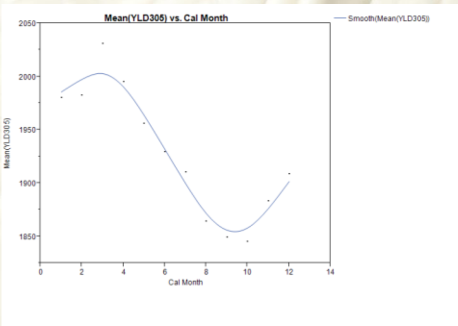
Distribution of first lactation yield within village 82 over years



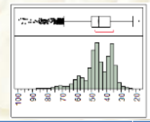
Daughters' average first lactation yields by year of their calving



Average first lactation yields by month of calving



Distribution of age at first calving in months



1	No. Of observations	7682
2	Mean (in months)	45.7
3	Standard Deviation (in months)	10.1

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.

SN	Name	Designation	Role
Members of the Committee			
1	Dr. K R Trivedi	Advisor, NDDB	Chairman
2	Prof. Mogens Sandø Lund	Center Leader, Center for Quantitative Genetics and Genomics, Aarhus University, Denmark	Member
3	Dr. Bhusan Tyagi	Asst. Commissioner, DADF	Member
4	Dr. Chanda Nimbkar	Director, Nimbkar Agri. Res. Institute	Member
5	Prof. D N Rank	Professor and Head (AGB), Veterinary College, AAU, Anand	Member
6	Dr. G R Gowane	Scientist, CSWRI, Avikanagar	Member
7	Dr. Jose James	Managing Director, KLDB	Member
8	Dr. C Titus	Project Coordinator, TCMPF Progeny Testing project	Member
9	Dr. Amrish Patel	General Manager, SAG, Bidaj	Member
10	Dr. Nilesh Nayee	Sr. Manager (AB), NDDB	Member Convenor

Model used for Breeding Value Estimation – Animal BLUP

$$y = Xb + Za + e$$

Where:

y = n x 1 vector of observations; n= number of records
b= p x 1 vector of fixed effects; p=number of levels for fixed effects
a= q x 1 vector of random animal effects; q= number of levels of random effects
e= n x1 vector of random residual effects
X= design matrix of order n x p, which relates records to fixed effects
Z= design matrix of order n x q, which relates records to random animal effects

$$\begin{bmatrix} \hat{b} \\ \hat{a} \end{bmatrix} = \begin{bmatrix} X'X & X'Z \\ Z'X & Z'Z + A^{-1}\alpha \end{bmatrix}^{-1} \begin{bmatrix} X'y \\ Z'y \end{bmatrix}$$

A is the relational matrix based on pedigree data and $\alpha = \sigma^2_e / \sigma^2_a$

Model in practice : for production traits - Test-day milk yield, Test-day fat yield, and test day protein yield

$$y_{thijklm} = A_i + YS_j + O_m + HYMR_h + \sum_{l=0}^{nf} \phi_{ktl}\beta_l + \sum_{l=0}^{nr} \phi_{ktl}u_{kl} + \sum_{l=0}^{nr} \phi_{ktl}pe_{kl} + e_{thijklm}$$

A= Age class
YS=Year season of calving
O= Owner
HYMR=Herd-Year-Month of recording
$\boldsymbol{\beta}$=Fixed regression curve for lactation
u=animal effect
pe=Permanent environmental effect to account for multiple TD records per cow

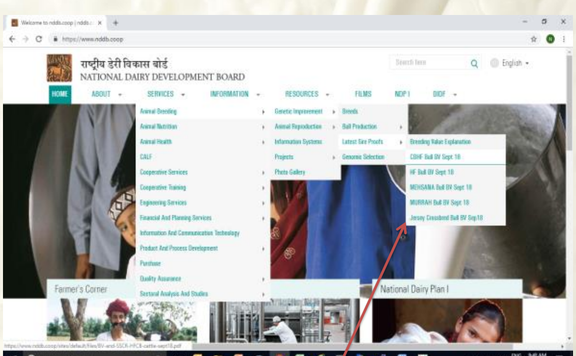
$$\begin{pmatrix} X'R^{-1}X & X'R^{-1}Q & X'R^{-1}Z \\ Q'R^{-1}X & Q'R^{-1}Q + A^{-1}\otimes G & Q'R^{-1}Z \\ Z'R^{-1}X & Z'R^{-1}Q & Z'R^{-1}Z + P \end{pmatrix} \begin{pmatrix} \hat{b} \\ \hat{u} \\ \hat{pe} \end{pmatrix} = \begin{pmatrix} X'R^{-1}y \\ Q'R^{-1}y \\ Z'R^{-1}y \end{pmatrix}$$

Animal wise solutions

Animal	Regression coeffients			305-day breeding value
1	−0.0583	0.0552	0.0442	−12.3731
2	−0.0728	−0.0305	−0.0244	−15.7347
3	0.1311	−0.0247	0.0686	28.1078
4	0.3445	0.0063	−0.3164	74.8132
5	−0.4537	−0.0520	0.2798	−98.4153

MME gives these solutions

Derived after post-processing of MME solutions

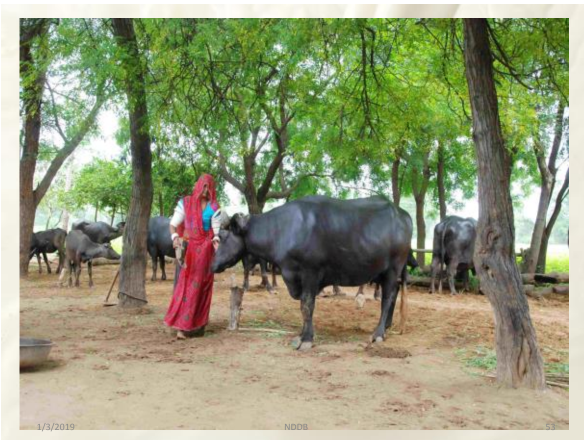


Estimated breeding and genomic breeding values:
- HF crossbreds
- Jersey crossbreds

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%.

1/3/2019 NDDB 52




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

$$\text{Genetic Gain/Yr} = \frac{\textbf{Intensity} \times \text{Accuracy} \times \text{Genetic St. dev.}}{\text{Generation Interval}}$$

- 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

How are we making progress under PT Projects

$$\text{Genetic Gain/Yr} = \frac{\text{Intensity} \times \textbf{Accuracy} \times \text{Genetic St. dev.}}{\text{Generation Interval}}$$

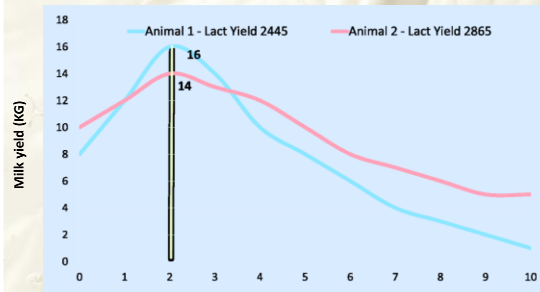
Factors affecting accuracy of selection

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

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

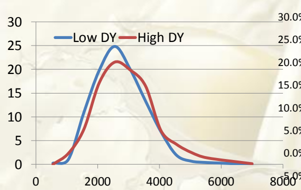
Peak yield Vs Test day recording

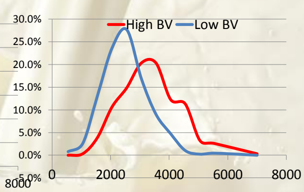


Months after calving

We are interested in improving lactation yield of animals

Impact of bull EBV reliabilities on daughter performance





Bulls selected by DY Rel 0.1

High DY group – Avg. DY 7630
Low DY group – Avg. DY 3654

Bulls selected by BV Rel >70%

High DY group – Avg. DY 5989
Low DY group – Avg. DY 4771

How are we making progress under PT Projects

$$\text{Genetic Gain/Yr} = \frac{\text{Intensity X Accuracy X Genetic St. dev.}}{\textbf{Generation Interval}}$$

Reducing Generation interval

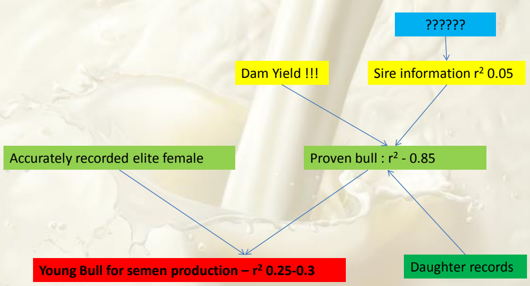
- Sire to Sire Path– Reliable BV at early age
  - First lot of semen produced for test mating
  - Collecting data at the earliest, focus on improving AFC of daughters
- Dam to sire Path- male calf at early age
  - Identify elite cows at the earliest (may be first lactation)
  - Nominate mating to heifers 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

1. Measure performance of a group of animals or Progenies of the animal in different environments
2. Estimate effect of environments
3. Correct each phenotype for environment's effect
4. Take average of corrected phenotypes
5. Take difference of each genotype based on corrected environment – this is genetic superiority
6. Rank each genotype (animal) by this genetic superiority

Progenies are random sample of genetic material of father and mother – more the number of samples, more close you reach to actual genetic material

Sources of information used



Genetic connectedness among projects

- Put bulls across the projects for test mating
- Combine data across projects testing same breed

Is recording milk sufficient??

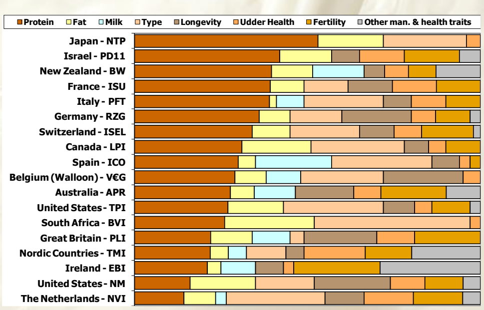
- Profitability of dairying involves
  - Increasing milk, fat and protein yield
  - Improving reproduction efficiency
  - Improving body structure to sustain production and adopt to particular mgt. system
  - Increasing resistance to various diseases!!!!
  - Improving feed efficiency!!!!
  - Increasing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



Source: Miglior, F. 2012. CDN

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

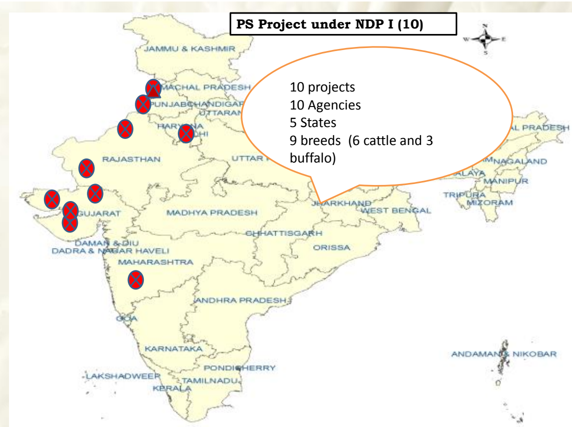
Pedigree Selection

PS Programmes for production of HGM bulls of different breeds

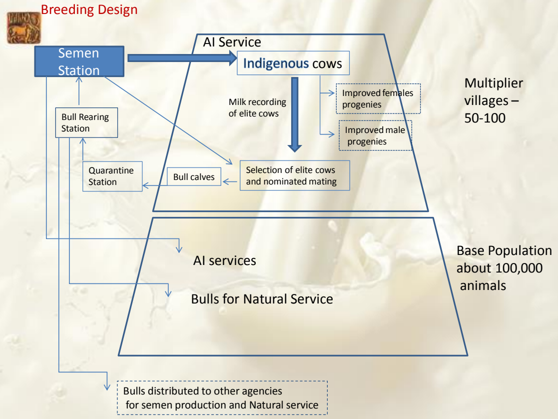
Breeds	Breed	EIAs	State
	**Rathi**	URMUL	Rajasthan
	**Kankrej**	Banas	Gujarat
	**Gir**	SAG	Gujarat
	**Jaffrabadi**	SAG	Gujarat
	**Hariana**	HLDB	Haryana

PS Programmes for production of HGM bulls of different breeds

Breeds	Breed	EIAs	State
	**Sahiwal**	Sahiwal PS Project	Punjab/ Rajasthan
	**Tharparkar**	RLDB	Rajasthan
	**Nili Ravi**	PLDB	Punjab
	**Pandharpuri**	MLDB	Maharashtra



Breeding Design



AI Infrastructure in Multiplier villages

- Minimum 100 villages in the native tract of the breed having better animals to be identified and AI infrastructure to be set up
- Semen from "A" or "B" graded semen station only to be used
- Very best bulls meeting "Standards of Genetic Merit of Breeding Bulls" as specified by DADF, GOI shall only be used for AI

Identification of elite animals and creation of infrastructure for milk recording

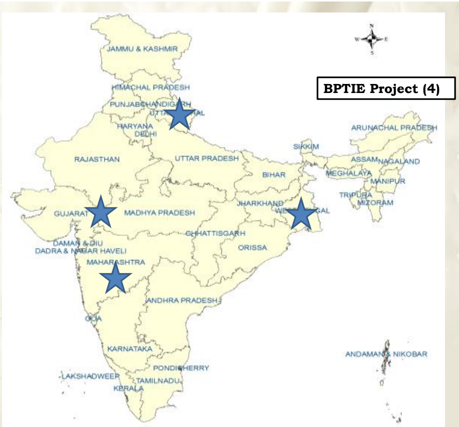
Progress Report of PS Projects as on 16th Nov. 2018

Project	Species	Nos of AIC	Animal Registration	AI Done	PD	Calving Reported	Nos of Milk Records	Nos of animal put to MR
PLDB Nili-Ravi PS Project - NDP1	Buffalo	65	15,352	26,708	9,023	3,042	22,333	2,473
MLDB Pandharpuri PS Project - NDP1	Buffalo	35	18,576	22,703	14,621	4,172	26,251	2,863
SAG PS Project	Buffalo	151	52,209	64,628	44,386	13,534	28,520	3,132
PLDB PS Sahiwal Project - NDP1	Cattle	30	9,517	14,999	6,573	1,779	10,085	1,273
HLDB Haryana PS Project - NDP1	Cattle	51	10,569	9,496	6,106	2,665	41,200	4,836
RLDB Tharparkar PS Project - NDP1	Cattle	90	18,774	21,660	13,620	3,751	13,369	1,722
Gangmul Sahiwal PS Project -NDP1	Cattle	34	25,847	28,577	21,584	7,694	25,378	2,941
NDDB - Banas Kankrej Breed Development Project	Cattle	100	28,607	51,672	29,347	15,335	27,933	3,030
SAG PS Project	Cattle	150	57,566	69,073	47,588	17,309	68,429	9,303
NDDB - Rathi Breed Development Project	Cattle	88	58,839	63,466	52,291	20,447	32,261	3,788
	Total	**794**	**295,856**	**372,982**	**245,139**	**89,728**	**295,759**	**35,361**

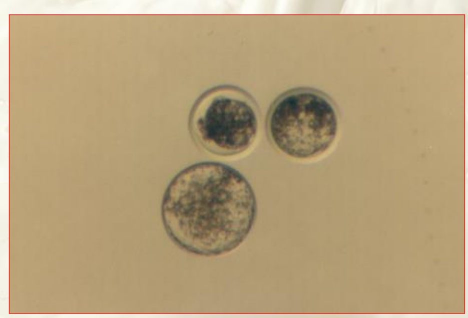
Import of Bulls and Embryos

Import of Bulls/ Embryo

- 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



Embryos



Transferring Embryos

HF calves born through ETT

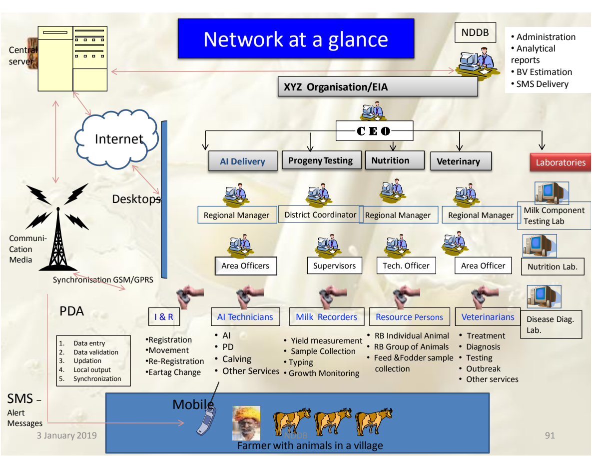
Jersey calves born through ETT

Field ET programme for bull production

Dissemination of Genetics - Young bulls supplied to semen stations from NDP

	Programme	Total bulls distributed
1	Progeny Testing	1566
2	Pedigree Selection	154
3	ET – Imported Embryos	65
4	Imported live bulls	133
	Total Bulls supplied	1918
	Total Bulls under collection 2017-18 all Semen Statations	4338
	% of bulls replaced by bulls supplied from NDP	44 %

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