Genetic Evaluation
Sire Selection
And
Corrective Mating
Of Dairy Cattle

AS/AVS 472

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Presented By

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"If you can't measure it, you can't manage it."

Bliss Crandal, Ph.D (1913 – 2001)
DHIA Computing Services - Provo, Utah

This Series Will Look At

- Programs For Genetic Evaluation of Dairy Cattle.
- Sire Selection.
- Mating Decisions.

Every calf born receives:

- A sample half of its sire's genes.
- A sample half of its dam's genes.
- A sample of the environment into which it is born, raised and spends its productive life.

These three factors influence every aspect of a dairy animal's life and productivity.

Basic Genetic Principles

- Inheritance is governed by units called genes. Each gene produces an exact duplicate of itself.
- Genes occur in pairs.
- Random sampling occurs within each gene pair for the specific gene which is passed on to the next generation.

Three factors basically determine the rate of genetic change.

- Heritability
- Selection Differential
- Generation Interval

Heritability

- The portion of the variation among individuals in the same herd that is genetic.
- Each trait's heritability remains fairly constant and, therefore, sets a limit on the rate of genetic progress.

A LOOK AT HERITABILITIES

BODY TRAITS HERITABILITY

TRAIT	h^2
Stature	.42
Strength	.31
Body Depth	.37
Dairy Form	.29
Rump Angle	.33
Thurl Width	.26

FEET & LEG TRAITS HERITABILITY

TRAIT	h^2
Rear Legs – side view	.21
Rear Legs – rear view	.11
Foot Angle	.15
Feet & Leg Score	.17

UDDER TRAITS HERITABILITY

TRAIT	h^2
Fore Udder Attachment	.29
Rear Udder Height	.28
Rear Udder Width	.23
Udder Depth	.28
Udder Cleft	.24
Front Teat Placement	.26
Teat Length	.26

PRODUCTION TRAITS HERITABILITY
Holsteins

TRAIT	h^2
• Milk	.31 - .41
• Fat	.36 - .38
• Protein	.26 - .36

http://www.aipl.arsusda.gov/publish/other/1997/conf_itb16_104.pdf

MANAGEMENT TRAITS HERITABILITY

TRAIT	h^2
• Milking Speed	.20
• Birth Weight	.45
• Temperament	.10
• Fertility	.00 - .05

Selection Differential

- The superiority of the animals selected to be parents.
- Selected parents should be better than the present generation average for improvement to take place.
- Genetic differences provide the only opportunity for selection. If all cows were genetically the same, selection would not produce change.

SELECTION DIFFERENTIAL

1. Accuracy of selection
    - Heritability
    - Precision of measurement
    - Extent of environmental influences have been equalized
    - Extent to which uncontrolled environmental influences can be identified and removed by statistical adjustments

SELECTION DIFFERENTIAL

2. Intensity of Selection
    - The more intense the selection , the higher the selection differential.

SELECTION DIFFERENTIAL

3. Genetic Variation of Breed
    - The greater the variation the larger the selection differential possible.
        - Each trait has a different amount of genetic variation
        - Each breed has a different amount of genetic variation for each trait.

Genetic differences provide the only opportunity for selection. If all cows were genetically the same, selection would not produce change.

SELECTION DIFFERENTIAL

4. Number of traits under selection
    - When fewer traits are under selection there will be faster progress for any particular trait.

Generation Interval

- Represents the average age of parents at the birth of their progeny.
- can only be changed significantly through embryo transfer and other new technologies.

HISTORY OF GENETIC EVALUATONS

- 1862 - A Department of Agriculture is introduced by Lincoln and established by the 1865 Morrill Act.
- 1895 - USDA begins collecting milk and fat production records of individual cows.
- 1908 - USDA organizes a national milk-recording program after based on the first state program in Michigan .

HISTORY OF GENETIC EVALUATONS

- 1912 - An inbreeding experiment begins with repeated sire-daughter matings.
- 1918 - USDA leases many of its young bulls to other farmers to develop proven sires. A total of 1200 bulls were leased over the next 40 years.
- 1936 - The first national sire evaluations are calculated from DAUGHTER – DAM COMPARISONS.

HISTORY OF GENETIC EVALUATONS

- 1959 - An IBM 705 computer replaces more than 100 employees and 100 individual adding machines.
- 1962 - Sire evaluations are computed using DAUGHTER – HERDMATE COMPARISONS, which better account for differences in management.
- 1974 - The MODIFIED CONTEMPORAY COMPARISON, which better accounted for genetic trend, is used in computing genetic evaluations.

HISTORY OF GENETIC EVALUATONS

- 1981 - Maternal ancestors are incorporated in cow evaluation.
- 1989 - ANIMAL MODEL EVALUATIONS use the relationships among all cows and bulls.

http://aipl.arsusda.gov/aipl/history/hist_eval.htm

THE ANIMAL MODEL

- Derives genetic measures by combining information from these sources:
  - Information on the animal itself
  - Information from the parents
  - Information from the progeny.

PREDICTED TRANSMITTING ABILITY "PTA'S"

In Beef Cattle the term Estimated Progeny Difference, or EPD is used.

PTA

- The term applied to genetic values which rank individuals for traits transmitted to their progeny.
- An estimate of the transmitting ability of an individual, which is a prediction of the extra performance to expect from future offspring compared to future offspring of a zero PTA (breed average in the base year) individual.

PTA

- Calculated by the USDA for production traits Somatic Cell Score, Productive Life and Net Merit.
- Calculated by the breed associations for type traits type composites, and each breed's overall composite index.

PRODUCTION TRAITS

- Milk Pounds
- Fat Pounds
- Fat %
- Protein Pounds
- Protein %
- Somatic Cell Score
- Productive Life
- Net Merit
- Cheese Merit
- Fluid Merit
- Daughter Pregnancy Rate

PRODUCTIVE LIFE (LONGEVITY)

- Time in the milking herd before removal by voluntary culling, involuntary culling, or death. Calculated as months of milk in each lactation, summed across lactations, with full credit for complete records and partial credit for short records. Productive life is considered to be complete at 7 years of age.

PRODUCTIVE LIFE (LONGEVITY)

- Heritability is 8.5%.
- Correlations are:
- Milk .13, Fat .12, Protein .15, SCS -.35, DPR .59, SCE -.19, DCE -.24,
- Composites: Udder .30, Feet & leg .19, Size -.04.

NET MERIT

- Net Merit Dollars measures the expected lifetime profit that an offspring of an animal will provide over it's lifetime.

Components of NM$'s are:

- Milk, Fat, Protein, PL, SCS, DPR, SCE, DCE
- Udder, Feed & leg, Size

FLUID MERT & CHEESE MERIT

For producers who sell milk in fluid or cheese markets, two new indexes similar to net merit **(NM$)** were added in 1999. Economic values of productive life and SCS were added to the component net values to obtain fluid merit **(FM$)** and cheese merit **(CM$)**.

These indexes replaced Milk Fat Dollars (MF$), Cheese Yield Dollars (CY$), and Milk Fat Protein Dollars (MFP$).

DAUGHTER PREGNANCY RATE

Daughter Pregnancy Rate is defined as the percentage of non pregnant cows that become pregnant during each 21-day period. A DPR of '1' implies that daughters from this bull are 1% more likely to become pregnant during that estrus cycle than a bull with an evaluation of zero. Each increase of 1% in PTA DPR equals a decrease of 4 days in PTA days open.

HOLSTEIN COMPOSITE TPI™

- Protein: 36
- Fat: 18
- Type 15
- Productive Life 11
- Udders 10
- Feet & Legs 5
- Somatic Cells -5

HOLSTEIN UDDER COMPOSITE

- Udder Depth .30
- Fore Udder Attachment .16
- Front Teat Placement .16
- Rear Udder Height .16
- Rear Udder Width .12
- Udder Cleft .10

HOLSTEIN
Feet & Leg Composite

- Rear Legs – Side View
- Rear Legs – Rear View
- Foot Angle
- Feet & Legs Score

TYPE TRAITS

- Type Trait Information is collected by the breed associations through their classification programs.
- Additional information on bull daughters in commercial herds is collected through SET (Special Evaluation for Type) programs paid for by the AI organizations.
- The genetic merit of herdmates is considered in the evaluations.

TYPE TRAITS

- Type Trait PTA's are converted to a value called STA's - Standard Transmitting Abilities.
- Because the range of PTA values differs between traits due to differences in heritabilities for each trait, standardizing them to an STA value on the bell curve, with O representing a breed's average for that trait, makes it easier to evaluate a bull's trait information.

RELIABILITY

- The more information in the Animal Model, the greater the accuracy of a sire's PTA.
- The Animal Model measure for this accuracy is called *Reliability* or *REL*, and is expressed as a percent.
- It can also be expressed as a Confidence Range, which shows how much a PTA value might change when a bull's reliability increases. The higher the reliability, the narrower the Confidence Range.

RELIABIITY

- Determined by the total number of the bull's relatives with records.
- For proven bulls, milking daughters contribute most of the genetic information about their sire. Their reliability will be heavily dependent on the number of herds where daughters are located.

RELIABIITY

Is also determined on:

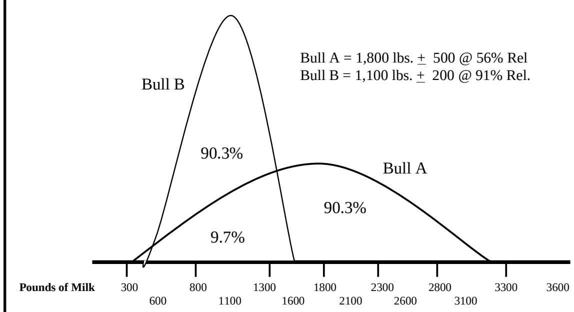
- How sire's daughters are distributed among herds
- The number of lactations each daughter has completed
- Number of days in milk for records that are in progress

All relatives with production records impact reliability. This would include contributions from parents, progeny, and other relatives.

RELIABIITY

• Young sires	36%
• Proven bulls (first-crop daughters)	84%
• Proven bulls (second-crop daughters)	99%

Probability Two Bulls Are Ranked Correctly



CALVING EASE

- Compiled by the National Association of Animal Breeders (NAAB) for Holstein bulls, from data provided by dairy producers, usually through their DHIA records, or on report forms provided by AI organizations.
- SCE – Service Sire Calving Ease. The average for all bulls with progeny evaluated is 8.3% DBH.
- DCE - Daughter Calving Ease a measure of the ability of a particular cow (daughter) to calve easily.

CALVING EASE

- % DBH is an estimate of the Percentage of Difficult Births in Heifers when they calve the first time.
- REL is the Reliability of % DBH. It indicates the amount pedigree and progeny information used in the calculation, and increases as the proof becomes more accurate.
- OBS is the number of calvings included in each bull's evaluation.

SAMPLING CODES

Sampling Codes provide information about the type of program through which a bull has been sampled.

- S indicates Stand Sampling, with progeny tested in 40 or more herds.
- O indicates Other Sampling, with progeny tested in less than 40 herds, or not reported to NAAB by three years of age.

MULTINATIONAL EVALUATIONS

- Bulls with daughters in more than one country may have proofs calculated by MACE (Multiple-trait Across Country Evaluation).
- US only proofs have no label.
- MACE proofs are labeled with M.
- Converted proofs are labeled with C.
- The proof with the highest reliability is generally the one published.

GENETIC CODES

- BD – Bulldog (recessive)
- BL – Bovine Leukocyte Adhesion Deficiency (BLAD) (recessive)
- TL – Tested free of BLAD
- CV – Complex Vertebral Malformation (CVM) (recessive)
- TV – Tested free of CVM
- DF – Dwarfism

GENETIC CODES

- DP – Deficiency of Uridine Monophosphate Synthase (DUMPS)
- TD – Tested free of DUMPS
- HL – Hairless (recessive)
- IS – Imperfect Skin
- MF – Mule-Foot (recessive)
- TM – Tested free of Mule-Foot

GENETIC CODES

- PC – Polled (dominant)
- PG – Prolonged Gestation (recessive
- PT – Pink Tooth (Porphyria) (recessive)
- RC – Red hair color (recessive)
- B/R – Black/Red (recessive)
- TR – Tested free of red hair color

Estimated **R**elative **C**onception **R**ate (ERCR)

- ERCRs evaluations of the fertility of A.I. Bulls
- First services used from the last three years reported to DRMS (Raleigh), AgSource and Pennsylvania
- Minimum of 50 first services needed on each sire.
- Includes adjustments for:
  - energy-corrected milk production
  - lactation number and stage of lactation
  - month of breeding
  - herd and year effects

On The Cow Side

The same genetic evaluations calculated for sires can also be calculated for cows, using the Animal Model. These programs are available through breed association programs.

SIRE SELECTION

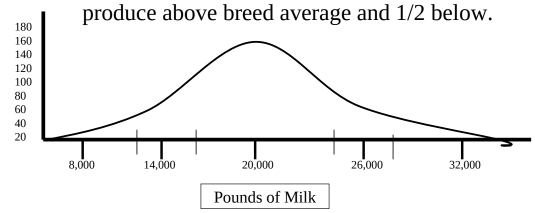
Genetic Change

- Is determined (almost exclusively) by the sires which are selected.
- In 3 generations 7/8 of the genes in a herd trace directly to the sires used in those 3 generations.

Understanding Genetic Expression

The range of production for any breed or for the progeny of a bull follows a pattern called a *normal distribution curve.*

- In the total population, 1/2 of the cows will produce above breed average and 1/2 below.

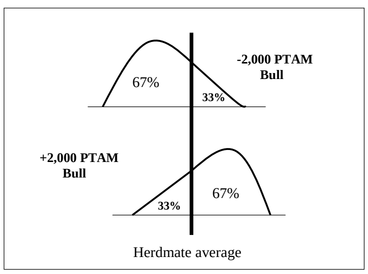


Understanding Genetic Expression

The most most important thing to remember is:

•The poorest bull will have some good daughters.

•The best bull will have some poor daughters.



SELECTION PRESSURE

Selection Pressure

Number of independent Traits	Relative Improvement for Milk
1 (Milk Prod.)	100%
2 (Milk Prod. + % Fat	71%
3(Milk Prod. + % Fat + Udder	58%
4 Milk Prod. + % Fat + Udder + Legs	50%

We do 3 kinds of jobs here: GOOD – FAST - CHEAP

- GOOD and FAST – Won't be cheap.
- FAST and CHEAP – Won't be good.
- GOOD and CHEAP – Won't be fast.

SIRE SELECTION

One philosophy would be to:

- Use PRODUCTION data (or composites such as TPI, NM$, PL) to select bulls.
- Use TYPE data to select which cows to mate a bull to.
- Use RELIABILITY to determine how much to use each bull.

SIRE SELECTION

- Decisions may be directed by the producer's market, and it's pricing scheme.
  - Is milk primarily used for fluid, cheese or other manufacturing uses?
  - Are there strong bonus programs for high components or low somatic cell scores?

SIRE SELECTION

- Producers also marketing genetics (bulls for AI, embryos, breeding stock) may have different criteria (and budgets) than strictly commercial producers.

SIRE SELECTION

- Identified herd needs may also impact the decision. (Particular type traits or milk components).
- Heifers should represent the animals of highest genetic merit in a herd and thereby where the best bulls should be used, with a consideration of Calving Ease.

THREE CATAGORIES OF DATA THAT CAN IMPACT A MATING DECISION

- ➢THE COW'S PERFORMANCE (*phenotype*)
- ➢THE COW'S PEDIGREE (*genotype*)
- ➢ENVIRONMENT and OTHER FACTORS

THE COW'S PERFORMANCE *phenotype*
PRODUCTION RECORDS

Milk, Fat, Protein, SCC, Mature Equivalent Values, Relative Value in Herd, etc.

- ➢ Determine which production traits to emphasis in this cow's mating.
- ➢ Determine cow's ranking in the mating sequence.

THE COW'S PERFORMANCE *phenotype*
PHYSICAL TRAIT APPRASIAL

Visual observation to identify 2 – 3 worst traits; or, linear scoring of all traits by herd staff, Breed Association Classifier or an AI organization evaluator.

THE COW'S PERFORMANCE
phenotype
PHYSICAL TRAIT APPRASIAL

- Provides data on an individual cow's needs and on the herd profile for conformation.
- Used to select an appropriate group of mating sires.
- A cow can be mated to a complimentary bull.

THE COW'S PEDIGREE
genotype

- Used to control inbreeding.
- Used to screen for undesirable genetic recessive traits.
- Can be used to make pedigree adjustments on the cow's linear trait scores.

THE COW'S PEDIGREE
genotype

- Used to estimate a cow's probable genetic profile for physical traits when doing pedigree matings.
- Can be used to calculate a cow's PTA values.
- Used to predict udder traits when mating heifers.

OTHER FACTORS

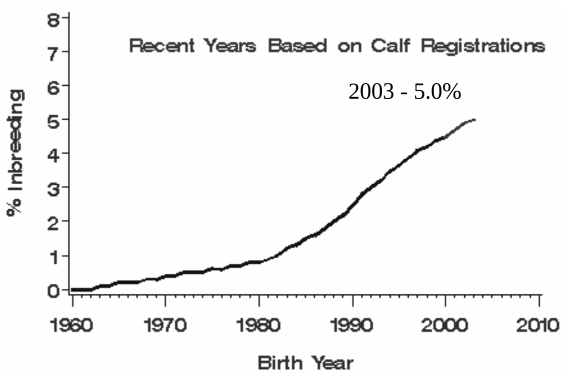
- The heritability of traits impacts genetic transmitting ability.
- The local milk market influences which production traits to emphasize.

OTHER FACTORS

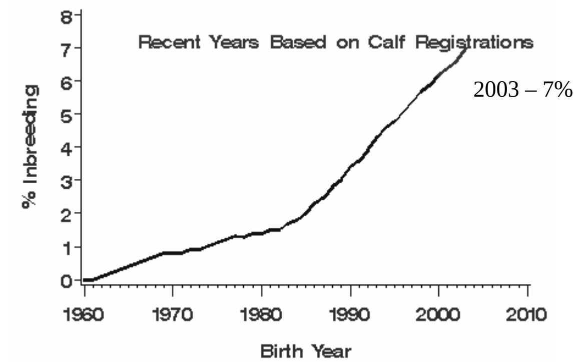
- The economic importance of a trait should impact the degree of emphasis on them;
  - *Fore udder attachment vs. stature.*
- Herd goals and management environment impact trait emphasis and sire selection;
  - *Commercial milk producers / intensive management;*
  - *Purebred herds that also marketing genetic material;*
  - *Grazing operations.*

A LOOK AT INBREEDING

HOLSTEIN BREED



JERSEY BREED



EFFECTS OF INBREEDING

Inbreeding depression per 1% increase in inbreeding

Lifetime total milk production (lbs.)	-790	First lactation milk production (lbs.)	-82
Lifetime total fat production (lbs.)	-29	First lactation fat production (lbs.)	-3
Lifetime total protein production (lbs.)	-25	First lactation protein production (lbs.)	-3

Bennet G. Cassell, Extension Dairy Scientist,, Virginia Tech
Publication Number 404-080, Posted May 1999
http://www.ext.vt.edu/pubs/dairy/404-080/404-080.html#pdc

EFFECTS OF INBREEDING

Inbreeding depression per 1% increase in inbreeding

Age at first freshening (days)	+.36	First calving interval (days)	+.26
Days of productive life	-13	Lifetime net income ($)	-24

Bennet G. Cassell, Extension Dairy Scientist,, Virginia Tech
Publication Number 404-080, Posted May 1999
http://www.ext.vt.edu/pubs/dairy/404-080/404-080.html#pdc

CONTROLING INBREEDING

“An additional financial incentive for grade herds to identify ancestry of cows is to avoid inbreeding, the economic consequences of which are documented … The recognition of the relationships between potential parents … can minimize inbreeding and the losses associated with it. Current trends toward increased relationships between influential sires … indicate that inbreeding will become increasingly difficult to avoid in the future.”

The Effects of Inbreeding on the Lifetime Performance of Dairy Cattle
L. A. Smith, B. G. Cassell, and R. E. Pearson
J. Dairy Sci. 1998 81: 2729-2737
http://jds.fass.org/cgi/reprint/81/10/2729.pdf

MASTER CATTLE BREEDER APPROACH

A. Evaluate the cow for physical traits most needing improvement, while also noting areas of extreme strength.
B. Evaluate the cow’s production records to determine which traits to emphasis (milk, fat, protein).
C. Review the cow’s pedigree to control inbreeding, genetic recessive traits, and to made “genetic adjustments” to her type traits.

DILEMMA FOR MODERN PRODUCERS

1. In large commercial herds, cows aren't known as individuals.
2. Reality focuses almost all management pressure on current issues (*daily production, herd health and fertility, monthly cash flow, personnel management, etc.*)
3. Managers and consultants are evaluated on current results, not genetic progress, which demonstrates itself gradually, over several years.

STRATEGIES

- Have a defined program for genetic improvement; *just as you would have defined protocols for other areas of herd management.*
- Continue to develop and enhance the quality and amount of data available for cows in the herd; *and the ability to apply and analyze that data.*
- Maintain consistent pressure on the genetic management of the herd.

PROCESS

- Make genetic management part of the *regular* herd management routine.
- Set criteria for sire selection.
- Evaluate information currently available and utilize it as completely as possible.
- Establish a process for making individual or group mating decisions.

MATING PROGRAMS

A. Random Mating
B. Visual Match
C. Computer Mating Programs

RANDOM MATING

- Simple – based only on sire selection criteria.
- Can achieve genetic progress for production traits. (*limited ability to focus on individual cow needs for fat or protein*).
- Limited or no ability to control inbreeding.
- No control over genetic recessive traits except through sire selection.
- Achieving progress in the herd type profile is dependent on selecting high type bulls, either raising semen cost or sacrificing production traits.

VISUAL MATCH

Herd mating sires are charted by category *(udders, feet & legs, body traits, high fat test, calving ease, etc.*). Individual cows are evaluated for their 2 – 3 areas needing most improvement, and a bull is selected who is listed in all those categories.

- Simple, but time consuming, and not generally useful in a large herd management environment.
- Extremely limited or no control over inbreeding and genetic recessive traits.

COMPUTER MATING PROGRAMS

- Offered by AI Companies.
- Offered by Breed Associations.
- Independent Web Based Programs.
- Software Programs for the farm computer.

The quality of the resulting mating will be dependent on the quality and completeness of the information inputted, and the sophistication of the program in utilizing that information.

COMPUTER MATING

1. How well are evaluators trained and how are they evaluated?
2. Is the program a 1 – 3 worst trait program, or does it use a selection index that evaluates all the cow's traits based on heritability, economic importance and the cow's need for improvement in a trait?

SELECTION INDEX

Mating decision is based on:

a) The economic importance of the trait;
b) The heritability of the trait;
c) The cow's need for improvement in the trait.

LIMITATION OF 2 – 3 WORST TRAITS PROGRAMS

KDC COW # 1876: Miss Whatcom Iris-ET
Mated to 200H0044: Stouder Morty-ET

Trait	ST	SG	BD	DF	RA	TW	LS
Cow	**40**	32	35	35	29	**15**	**16**
Bull	**+2.88**	+3.32	+2.77	+1.57	-1.51	**+1.93**	**-1.94**
Trait	FA	FU	UH	UW	UC	UD	TP
Cow	42	**15**	**15**	26	24	16	**32**
Bull	+2.88	**+3.51**	**+4.43**	+4.97	+2.30	+1.03	**+3.51**

COMPUTER MATING

3. If pedigree information is available, can the program:
   - Screen for inbreeding? (*How many generations can it use?*)
   - Screen for genetic recessives?
   - Make pedigree adjustments on the cow's linear scores?
4. Are scores adjusted for the cow's age (lactation) and stage of lactation (days in milk)?

PEDIGREE ADJUSTMENTS

3 Granddaughters of 7H4211 – Majic

Cow	FA	UD
2	35	35
864	26	16
968	32	18
His STA Values	- 1.42 low	- 0.38 deep

PEDIGREE ADJUSTMENTS

3 Granddaughters of 29H6995 - Duster

Cow	ST	SG	BD	TW
935	38	32	32	25
993	26	24	32	42
996	34	21	21	35
His STA	- 0.75	- 0.73	- 0.54	- 1.73
Values	short	frail	shallow	narrow

COMPUTER MATING

5. Does the program consider production in the mating process?
   - Can the producer set the emphasis between production and type in the mating decision?
   - Can emphasis be put on components (fat and/or protein test) for individual cows that are extremely low in this area?

COMPONENT SELECTION

DHIA Test Day, Knott Dairy Center 11/13/03

	AVG	RANGE
% Fat	4.0	2.7 - 7.0
% Protein	3.4	2.5 – 4.6

COMPUTER MATING

6. Does the program rank the cows based on a "total merit index" (production / type / genetics), so that the best cows can be mated to the best available bulls?
   - Makes it more practical for a producer to use a broader range of bulls, including some extreme high merit bulls that usually aren't included in commercial herd programs.
   - Genetics can be applied where it will have the most impact on the herd.

COMPUTER MATING

7. Does the program have a system for limiting usage of particular bulls?
   - Built in restrictions for low reliability bulls?
   - Allow the producer to restrict bulls by number of units or percentage of matings?

COMPUTER MATING

8. Will the program allow you to run different groups of bulls for 1st, 2nd and 3rd choice matings?
9. Can the program accept a file generated by your herd management software (pedigree, production, lactation, etc.) and will it generate a mating recommendations file that can be imported into your herd management software?
10. Will the program accept linear scores from another source? (*Herd staff, breed association classifiers, etc.*).

COMPUTER MATING

11. Can the producer get a copy of the linear scores for the herd?
12. Will the program generate analytical information showing the herd averages for traits, breakdowns by lactation groups, trends over time, etc.?

SUGGESTIONS

1. Identify offspring – build pedigree information at least to the maternal grandsire level, and beyond, if possible.
2. Use production records or a production/type index to identify superior individuals and mate them to the best sires.
3. Consider using Breed Association programs available to commercial producers to calculate genetic values and inbreeding data.

SUGGESTIONS

4. Select an appropriate mating service based on the criteria discussed, or consider a program like Multi-Mate.
5. Learn to do your own linear trait evaluations.
6. Provide an environment which will allow cows to express their optimal genetic potential for production.

SUGGESTIONS

7. Manage the herd fertility program so that an investment in genetic improvement is effective and economically feasible.
8. Manage the calf and heifer development program so that the investment in genetic improvement can be harvested.

TAKE HOME MESSAGE

- Genetic progress for both production and body conformation traits will impact a herd's functional ability and profitability over time.
- Controlling inbreeding will impact production and profitability in a positive manner.

TAKE HOME MESSAGE

- Progress in improving production traits can be primarily influenced through sire selection, and achieved throughout the herd by random mating.
- Progress in improving type traits and controlling inbreeding will not likely occur in a totally random manner.

TAKE HOME MESSAGE

- Both require a consistently applied, systematically organized breeding program.
- Both require the collection and archival of appropriate data.
- There are tools which can facilitate the ability of dairy producers to conveniently and effectively accelerate the rate of genetic improvement in their herds.

RESOURCES

Government & Industry

USDA Animal Improvement Laboratory
www.aipl.arsusda.gov
USDA National Animal Germplasm Program
www.ars-grin.gov/nag
National Association of Animal Breeders
www.naab-css.org
International Bull Evaluation Service (INTERBULL)
www-interbull.slu.se

Dairy Records

National DHIA
www.dhia.org
DHI Computing Service (Provo, UT)
www.dhiprovo.com
Dairy Records Management System (Raleigh, NC)
www.drms.org
AgriTech (Tulare, CA)
www.agritech.com

Breed Associations

Holstein	www.holsteinusa.com
Jersey	www.usjersey.com
Brown Swiss	www.brownswissusa.com
Guernsey	www.usguernsey.com
Ayrshire	www.usayrshire.com
Milking Shorthorn	www.milkingshorthorn.com
Red & White	www.redandwhitecattle.com

A.I. Organizations

ABS Global	www.absglobal.com
Select Sires	www.selectsires.com
Accelerated	www.accelgen.com
Alta Genetics	www.altagenetics.com
Genex / CRI	www.crinet.com
Semex	www.semexusa.com

Other Links

Bull Search Program

www.bullsearch.com

Using Mating Programs to Control Inbreeding

www.usjersey.com/Reference/inbreeding.pdf