ANIMAL GENETICS & BREEDING

UNIT – III
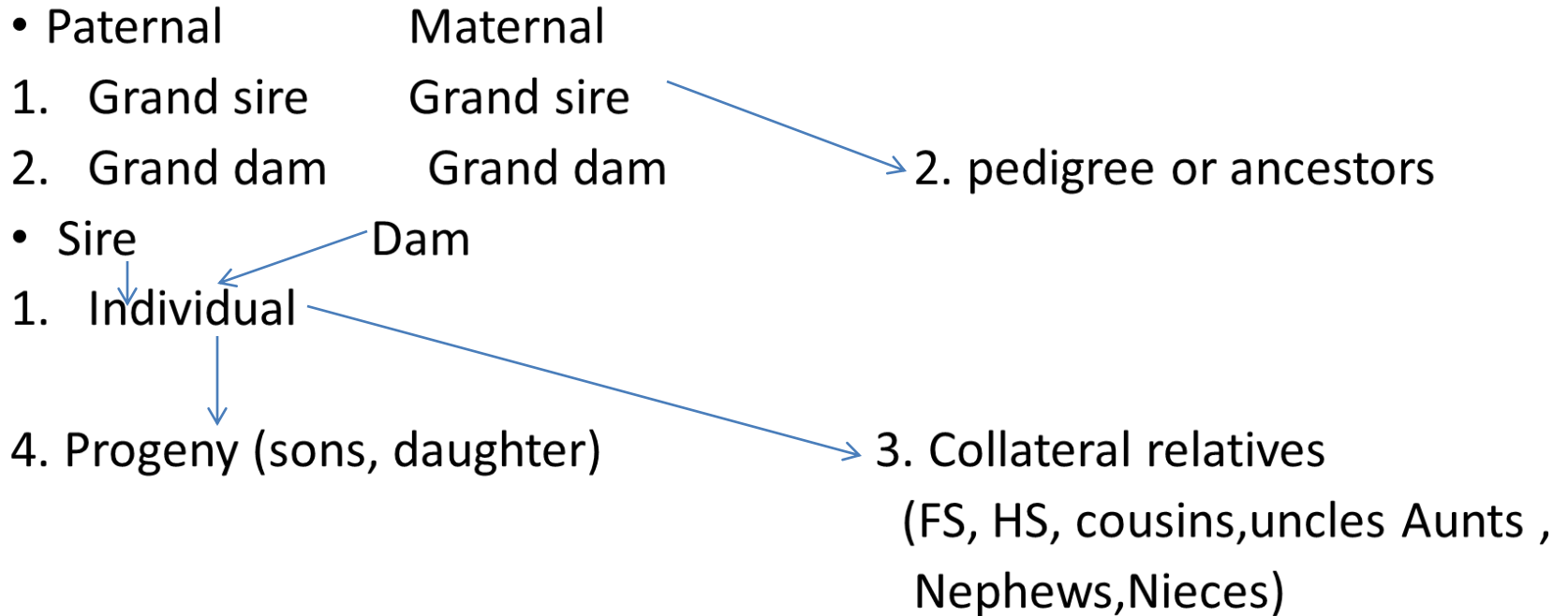### The Principles of Animal Breeding
Theory

Basis of selection

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BASIS OF SELECTION

- The sources of information based on which the breeding value of the individual is estimated are called as the basis of selection or aids to selection or criteria of selection which are the basis of estimating the breeding value.

- The breeding value so obtained is known as estimating breeding value(EBV)or probable breeding value(PBV).

- The different selection criteria to estimates the B.V. of an individuals for single trait can be diagrammatically shown as :

- Paternal   Maternal
1. Grand sire   Grand sire
2. Grand dam   Grand dam   2. pedigree or ancestors
- Sire   Dam
1. Individual

4. Progeny (sons, daughter)   3. Collateral relatives
                                                   (FS, HS, cousins,uncles Aunts ,
                                                   Nephews,Nieces)

Selection of males & females

Female selection: adult female animal are culled for a number of reason like-
1. Late maturity
2. Reproductive problems
3. Udder problem
4. Uterovaginal disorders and
5. For low milk production.
- The dairy cows & buffaloes are selected for-
1. Increase in milk production
2. Low age at first calving
3. Shorter service period
4. Normal lactation length etc.
- The final selection based on the expected producing ability(EPA) or on breeding value.
- EPA is estimated by the most probable producing ability(MPPA).
- EBV=$h^2(\bar{X}_c - \bar{X})$ for single record.
- EBV=$h^2(\bar{x}_c - \bar{x})\dfrac{n}{1+(n-1)r}$ for more record.

Male selection

- The individual selection is not possible in case of male .
- Males are selected on the basis of the performance of their relatives.
- Selection of sire is important rather than the dam.
- Dam leave limited no. of progeny whereas sire leave more no. of progeny thus sire has greater impact on the herd so it is called half of herd.
- Only few sires are needed for breeding a herd hence selection is more intense among the females.
- Sire selection criteria:- 3 steps
1. Selection of male based on pedigree.
2. Preliminary selection of males.
3. Progeny testing

Individual selection

- Breeding value of an individual is estimated based on individual's own phenotypic value of that trait. It is known as individual selection.
- The breeding value of an individual is estimated from the phenotypic value of that individual as a deviation from the population mean(selection differential) times the heritability of that trait is known as the probable breeding value(PBV).
- PBV= P + h^2 (Pi-P)
- P=population mean, Pi =phenotypic value of individual.
- Individual selection is used for high heritable traits.
- Accuracy of individual selection: The correlation between breeding value and phenotypic value(rap) is equal to the square root of heritability.
- rAP =√(h^2)

Advantage of individual selection

- Information of selected individual are easily available so it is easy method.

- It can be applied earlier to P.T. This is used when pedigree information are not available.

- The generation interval is shorter than P.T.

- It gives direct estimate of BV and not on the basis of relatives hence it is more accurate.

- This method minimizes the environmental effects.

Limitation of individual selection

- It cannot be applied in following condition.
- When the trait are not expressed by the individual(sex limited trait).
- When the trait are expressed in later life of the individual or after death of animal.
- When h^2 of the trait is low this selection is not effective.

Pedigree selection

- Pedigree: It is a list or record of ancestor in the past few generation of the individual.
- The estimation of BV of an individual based on ancestors performance is known as pedigree selection.
- Guide to pedigree selection:

   1. The degree of relationship of the individual with its ancestor.

   2. It is more accurate for traits of high h^2

   3. Environmental correlation among animals.

   4. Information available on ancestor

Merit of pedigree selection

1. It is less costly as only compilation of pedigree is required.

2. Allow selection at younger age.

3. it is helpful in multistage selection.

4. Useful for sex limited trait and trait expressed in later life or after death of animal.

5. It is helpful when two individual have similar performance but one belong to better pedigree.

Demerit of pedigree selection

- All animals of similar pedigree are culled out inspite of the fact that an individual may be of good merit and free from recessive allele causing defect.

- Environmental variance.

- Some pedigree gets undue emphasis and favoured irrespective of the true merit of the individual.

- It introduces non random biases.

- It provides no basis of selection among individuals which are descendants of the same ancestor.

- Breeding value based on pedigree record:

  $PBV = (P_C) + b_{AP} (P - (P_C))$

Ancestor	Regression coefficient	Accuracy of selection
A. For single record:		
Dam	$0.5\ h^2_D$	$0.5\ h_D$
Sire	$0.5\ h^2_S$	$0.5\ h_S$
Mean record of both parents	$\dfrac{1}{\sqrt{2}}\ h^2$	$\dfrac{1}{\sqrt{2}}\ h$
Parents and grand parents		$\sqrt{\dfrac{3-2h^2}{4-2h^4}}\ h$
One grand parents	$0.25\ h^2$	$0.25\ h$
A. For more record:		
Dam	$0.5\ h^2_D\ \dfrac{n}{1+(n-1)r}$	$0.5\sqrt{\dfrac{nh^2_D}{1+(n-1)r}}$
Sire	Same as for dam	Same as for dam
Both parents	$\dfrac{1}{\sqrt{2}}\dfrac{nh^2}{1+(n-1)r}$	$\dfrac{1}{\sqrt{2}}\sqrt{\dfrac{nh^2}{1+(n-1)r}}$
Parents and grand parents		$\sqrt{\dfrac{3-2h^2}{4-2h^4}\dfrac{h^2_n}{h^2_n}}\ h_n$
One grand parents	$0.25\ \dfrac{nh^2}{1+(n-1)r}$	$0.25\sqrt{\dfrac{nh^2}{1+(n-1)r}}$

Family Selection

- The estimation of BV of an individual based on collateral relatives which are commonly known as family members(sib etc.) is called family selection.

- The selection criteria is called as family selection when the individual's own record is included to estimate the family means but the selection criteria is called as the sib selection when the individual's own recorded is not included in estimating the family mean.

Sib selection

- It is the selection of an individual based on its sib performance.

- The sib may be full sibs or maternal half sib or paternal half sibs.

- The sib selection is practiced for the following traits for which are measurements on the individual are not available or recorded:- slaughter trait, sex limited trait , threshold trait ,trait which low h^2 in spp. With high reproductive rate.

- Full sib selection is less accurate than half sib because HS selection is favoured for following condition:-

- Half sib are easily available in more no. than full sib.

- The rate of inbreeding is more for FS selection than HS selection. The inbreeding counter balance the effect of selection.

- The FS correlation is more likely to be increased by C-effect. The intraclass correlation (t) is rh^2 for half sib and rh^2+c^2 for full sib where c^2 is added contribution of maternal or common environment effect. This reduce the accuracy of FS selection.

P.B.V.= $(\overline{P_C})+n/(1+(n-1)t)\,((\overline{Ps})-(\overline{P_C}))rh^2$

$(\overline{Ps})$ = Avg. of sibs

$(\overline{P_C})$ =Avg. of contemporaries

n= number of sibs

r= coefficient of relationship between sibs and individuals

t= Intraclass correlation among sibs

h2 = heritability of trait

The expected response to sib selection is:-

$R_S = i\sigma_P\, h^2\ nr/\sqrt{(n[1+(n-1)t]}\,)$

Accuracy $=rh\sqrt{(n/(1+(n-1)t))}$

Common environment(C-effect)

- The environmental effects which are different for different families but same for all members of one and the same family are known as common environmental effects denotes as c-effects.

- Family member share common environment during pre and post natal stage.

- C-effect are more for FS than for HS.

- When environmental similarities are present among family members the intraclass correlation among the phenotypic value of family members(t) is increased equal to the amount of c-effects as(t+ c^2) where c^2 is the portion of the total variation caused by differences in c-effects among families. This makes the denominator larger and hence the regression is decreased. Thus the c-effects decrease the accuracy of sib and family average

Factors affecting accuracy of sib and family selection:-

1.Heritability of trait.

2. Coefficient of relationship between sibs and individual(r).

3. Number of sibs (n) .

4. The degree of correlation(t) between the phenotypes of sibs.

Advantages of family selection

- The family selection can improve the character of low h^2 in spp. With high reproductive rates(pig, poultry) so as to get many sibs in a short time.

- Family selection does not allow the generation interval to increase.

- Family selection is a support to individual selection because it is better to select the individual from a superior family.

Disadvantage of family selection

- The limited facilities reduce the intensity of selection.

- The FS family selection can only be applied in spp. With high reproductive rates to get large family size.

- The family selection as a unit of selection results in inbreeding and thus limit the genetic diversity.

Within family selection

- It is the selection criteria when individuals are selected on the basis of their performance expressed as deviation from their family mean.
- The individuals that exceed their family mean by the greatest amount are selected
- This selection criteria is preferred when c-effects are important.
- The selection within family eliminates the environmental differences among families.
- It economizes the breeding space and minimizes the rate of inbreeding.

- In this selection each family contributes equally to the parents of next generation.

- It is better than individual selection when sib correlation is very high and caused largely by environmental effects.

- The within family selection operates a large amount of additive variance within families.

- The h^2 of within family deviations is: h^2 W = h^2 1-r .

- With accuracy of selection as square root of this heritability.

- It is rarely applied to HS families because c-effects are not important in case of HS families.

The B.V. of individual based on family mean is estimated as (Lasely,

$$P.B.V = \overline{P}_s + h^2\left[\frac{1-r}{1-t}(P_1 - \overline{P}_S) + \frac{1+(n-1)r}{1+(n-1)t}(\overline{P}_s - P_{Cs})\right]$$

Where, $\quad h^2 \dfrac{1+(n-1)r}{1+(n-1)t} = h^2$ of family mean

$h^2 \dfrac{1-r}{1-t} = h^2$ of within family mean

The accuracy of family selection (after Lasely, 1972) is estimated as:

$$\text{Accuracy} = \frac{h[1+(n-1)r]}{\sqrt{n[1+(n-1)t]}}$$

The expected response to family selection (R_f) is estimated as (Falcone

$$R_f = i\sigma_p h^2 \frac{[1+(n-1)r]}{\sqrt{n[1+(n-1)t]}}$$

Progeny selection

- The selection criteria for evaluating an individual based on his progeny performance is known as progeny selection or progeny testing.
- The progeny testing is the most imp. basis of selection.
- The selection criteria are the mean phenotypic value of the individual's progenies compared to the mean phenotypic values of the contemporaries.
- Genetic principles of PT :-

1.Each progeny inherits one-half of the genes from each parent due to the halving the nature of inheritance.

2. Second is the sampling nature of inheritance(chance at segregation and environmental factors cause greater deviation from true BV of a parent).

Sources of error in PT

1. Randomly distributes sources of variation-caused by mandalian segregation, environmental effects and the error in measurement of data. This error reduced by increasing the no. of progenies to estimate the BV.

2. Systematic error- aries by age and weight effect of cows, parity no., lactation length etc. This error reduced by adjustment of data for these effects.

Requirement for PT

- About 4-5 males should be tested for each required progeny tested sire for future breeding.

- The facilities should exist for frozen semen and to record information on progeny.

- The progeny should be tested in several herds and stations and comparison should be made with contemporaries from other sires. This increase the accuracy.

- No progeny should be culled until the end of the test.

- The PT should be completed as early as possible in the life of the males.

Advantages of PT

- The PT is a better method for sex limited traits ,the trait with low h², and slaughter traits in meat animals.

- The PT is useful to prove a sire whether he is free from any recessive allele.

- The main feature and principle advantage of PT is the increased selection intensity.

- Its accuracy increased with increase in progeny no.

Limitation of PT

- The time and cost required is the main limitation.
- It increases the generation interval. Due to larger generation interval the genetic gain per year is low.
- PT is effective on adequate no. of progeny.
- In this selection is needed among sire under test.

- The BV of bull based on its progeny performance is estimated by multiplying the regression of BV of parent

- On the phenotypic performance of its progeny with the selection differential of the progeny of ith sire from

- The mean of the contemporaries.

- $b = \dfrac{rnh^2}{1+(n-1)t}$

- r = coefficient 0f relationship between individual and his progeny

- t = intraclass correlation

- n = no. of progenies

- P.B.V.$=\bar{P}_C + \dfrac{2nh^2}{4+(n-1)h^2}(\bar{P}_i - \bar{P}_C)$

- **Accuracy of P.T.**

- $r_{Gp} -= r_{AP} = 0.5\sqrt{\dfrac{nh^2}{1+(n-1)t}}$

- It is expressed as the correlation of genotype of parent with the avg. phenotype of its progeny.

Precautions in PT

1.Allotment of superior dams to a particular sire overestimates the BV of that sire.

2. The progeny should be born in the same season and year as well as should be recorded at the same age/lactation.

3. All the healthy progeny should be included.

4. The data recorded should be adjusted/corrected for environmental effect such as age ,year ,season, lactation length etc.

5. More no. of progeny per sire is recorded.

THANK YOU