ANIMAL GENETICS & BREEDING

UNIT – III

The Principles of Animal Breeding

Theory

Selection for combining ability

Dr Anil Meel
Department of Animal Genetics & Breeding
MJF Veterinary college

SELECTION FOR COMBINING ABILITY

- COMBINING ABILITY:-CA is the capacity of an individual to transmit superior performance to its offspring.
- It is the phenomenon with which inbred lines when crossed give rise to hybrid vigour.

- Progeny tests should be performed to predict combining ability of the characters governed by recessive genes.

- Aim of combining ability:-
  1. Identification of best perfomance lines
  2. Lines are used as parents in future

- CA is the measure/estimate of the values of genotypes on the basis of their offspring performance in some definite mating design.

Techniques for estimation of CA

S.N.	Techniques	Scientists
1	Top cross	Davis
2	Poly cross	Tysdal et al
3	Diallel cross	Griffing
4	Line cross tester	Kempthorne
5	Partial diallel	Kempthorne & Curnow
6	North carolina design	Comstock & Robinson
7	Triallel cross	Ravlings & Lockerhan

SELECTION FOR COMBINING ABILITY

- The concept of combining ability was first given by Sprague and Tatum in 1942.
- Types of combining ability:-
  1. General combining ability(GCA)
  2. Specific combining ability(SCA)
- GCA is the average performance of a line in hybrid combinations.
- SCA is to designate those cases in which certain combination do relatively better or worse then would be expected on the basis of the average performance of the line involved .

- The inbred lines are evaluated in crosses and selected those which give the best cross.
- Crosses are made between different breed or mildly inbreed lines of farm animals .
- The amount of variation between the crosses and the intensity of selection determines the amount of improvement through selection.
- The additive genetic variance present in base population determines the amount of improvement by preliminary selection of the lines for their GCA.
- The GCA of the lines can be tested without the necessity of making all possible crosses.

- GCA is an effective tool used in selection of parents based on performance of their progenies.
- SCA is important for development of new crosses.

GCA	Parents, Additive genetic variance, Narrow sense heritability
SCA	Specific cross, Non additive genetic variance, Broad sense heritability

- SCA utilizes the non additive genetic variance.
- This need to make crosses and select the best cross.
- In order to select for SCA to gain much improvement , the line must have reached a high level of inbreeding.
- For fully inbred lines the variance of GCA and SCA equals to the additive variance and non additive variance in the base population , respectively .

Combining Ability Estimation

- Crosses made in a definite fashion is a pre-requisite for combining ability estimation.
- Estimated by half sib (GCA) and full sib (SCA) mating.
- Various steps like parent selection for crosses, performing crosses, their evaluation and interpretation are involved while estimation of combining ability.
- For analysis of crosses , biometrical techniques like diallel analysis, partial diallel, Line x tester analysis are used.

- If GCA variance are higher than SCA variance there is importance of AGA & parent selection will be effective for improvement of such traits.
- If SCA variance are higher than GCA variance there is importance of NAGA(dominance & epistasis) & Heterosis breeding may be rewarding.
- If GCA=SCA variance than AGA & NAGA are equally importance in the expression of character, In this situation reciprocal recurrent selection may be adopted for population improvement.

Selection for GCA

- General combining ability (GCA) is an average value of the inbred line based on its behavior in crosses with other lines.
- Mean performance of line expressed as deviation from the mean of all crosses
- GCA is owing to the activity of genes which are largely additive in their effects as well as additive × additive interactions.
- GCA value +ve,-ve,zero
- Overall GCA value =0
- GCA variance denoted by σ_g^2.It is equal to half of additive genetic variance.

- GCA is the mean performance of F_1 offsprings of a line with other lines & it is due to additive genetic variance.

Line	X1	X2	X3	GCA
Y1	X1Y1	X2Y1	X3Y1	GCA(Y1)
Y2	X1Y2	X2Y2	X3Y2	GCA(Y2)
Y3	X1Y3	X2Y3	X3Y3	GCA(Y3)
GCA	GCA(X1)	GCA(X2)	GCA(X3)	∑gi=0

Line	X1	X2	X3	mean	GCA
Y1	X1Y1(50)	X2Y1(40)	X3Y1(60)	50	GCA(Y1) = -20
Y2	X1Y2(60)	X2Y2(70)	X3Y2(50)	60	GCA(Y2) = -10
Y3	X1Y3(100)	X2Y3(110)	X3Y3(90)	100	GCA(Y3) = +30
mean	70	73.33	66.6	70	
GCA	GCA(X1) =0	GCA(X2) = +3.3	GCA(X3) = -3.3		∑gi=0

Feature of General Combining Ability

- General combining ability is an average performance of a individual in a particular series of crosses.
- It is due to additive genetic variance and additive x additive gene interaction.
- It denotes combining ability of genotype esp. inbred with various testers.
- Helps in identification and selection of best genotype to use it in hybridization, as a parent.
- Estimated by half sib mating
- Have relationship with narrow sense heritability

Recurrent selection for GCA

- The recurrent selection includes the crossing of a large number of individuals with a tester line which is highly inbred and to evaluate the progeny.
- Those individuals giving best result are selected and intermated.
- A form of recurrent selection used to improve the general combining ability of population for a character and the heterozygous tester is referred as RSGCA.
- Also known as half sib RS .
- Developed by Jenkins in 1940 .
- The progeny for progeny testing are obtained by crossing these selected parent to a tester strain with a broad genetic base .
- A tester strain with broad genetic variability is the common parent mated to number of lines , strain .

- Selection based on the individuals breeding merit , this is because the correlation between performance of parental inbred lines and the crossed bred progeny is generally high for traits with large additive genetic effect.
- The superior individual must be mated with superior .
- The selection for improvement of GCA is through individual selection with pedigrees , progeny tests and family selection without inbreeding as a supplement to make selection more accurate .
- The selected individuals are mated to individuals of their own population to produce the next generation.
- The line being selected become homozygous for genes different from those in the tester lines provided the heterosis is due to over dominance.

Selection for SCA

- Specific combining ability (SCA) is the value of the line in crossing in a specific cross.
- SCA is the superiority of a particular cross over the average GCA of the two lines.
- Cross deviate from expected value which is the sum of the GCA of its two parental line , to a greater or lesser extent.
- Specific combining ability is regarded as an indication of loci with dominance variance (non-additive effects) and all the three types of epistatic interaction components if epistasis were present.
- They include additive × dominance and dominance × dominance interactions.

SCA is estimated as deviation from population mean & corrected for GCA value.

Line	X1	X2	X3	mean	GCA
Y1	X1Y1(50)	X2Y1(40)	X3Y1(60)	50	GCA(Y1) = -20
Y2	X1Y2(60)	X2Y2(70)	X3Y2(50)	60	GCA(Y2) = -10
Y3	X1Y3(100)	X2Y3(110)	X3Y3(90)	100	GCA(Y3) = +30
mean	70	73.33	66.6	70	
GCA	GCA(X1) =0	GCA(X2) = +3.3	GCA(X3) = -3.3		∑gi=0

- SCA is estimated as deviation from population mean & corrected for GCA value.

  SCA(X1Y1) = 50-(70)-(0)-(-20)=0

  SCA(X2Y1) =40-(70)-(3.3)-(-20)=-13.3

- SCA variance equals dominance variance.

Features of Specific Combining Ability

- Specific combining ability is a performance of a parent under consideration, in a specific cross.
- It represents deviation from GCA.
- It is due to dominance genetic variance and all the three types of gene interactions
- Helps into identification and hence selection of best cross combinations i.e. those with the desired output.
- When we see that a inbred line combines well in any cross, it is due to specific combining ability.
- Estimated by full sib mating
- Have relationship with heterosis

Recurrent Selection for SCA

- It was originally proposed by Hull in 1945.
- Its a form of recurrent selection that is used to improve the SCA of a population for a character by using homozygous tester is referred as (RSSCA) recurrent selection for specific combining ability.
- It is also known as half sib recurrent selection with homozygous tester.
- Procedure: The selection procedure of this method is same as for RSGCA, except that the tester is an inbred line which has narrow genetic base i.e tester used must be an outstanding inbred.
- The differences in the performance of test cross are due to difference in their specific combining ability.

- Highly inbreed line is selected as a tester , “tester line”.
- Large number of individuals of a line under testing are tested in crosses with this tester line.
- Females are selected on performance of their test cross progeny.
- Selected females are then mated with male of their own line to produce next generation of parents to be tested with inbred tester line.
- Crossed bred progeny are not used for breeding.
- Selected individual from source population are mated again and again among themselves to produce next generation of complementary stock to the tester inbreed line.

Comparison of recurrent selection for *gca* and recurrent selection for *sca*

Particulars	*Recurrent selection for gca*	*Recurrent selection for sca*
Application	Used to improve polygenic traits	Also used to improve polygenic traits
Basis of selection	Test cross performance	Test cross performance
Tester used	Heterozygous	Homozygous
Effectiveness	More effective with incomplete dominance	More effective with complete and overdominance
Condition of use	Used when additive gene action is improtant	Used when non-additive gene action is important
Impact	It improves *gca* of a character	It improves *sca* of a character

Reciprocal Recurrent Selection (RRS):

- A form of recurrent selection used to improve both GCA and SCA of a population for a character using two heterozygous testers is known as RRS.
- It is also known as recurrent reciprocal half sib selection.
- Comstock et al. in 1949, proposed this method.
- Main Features of these Methods:

1) It is used for improvement of polygenic characters.
2) Selection is made on the basis of test cross performance.
3) Two heterozygous tester are used as a source of population.
4) It is used for improving population for GCA and SCA for specific characters.
5) It is equally effective with incomplete, complete and over dominance.
6) It is used for improvement of those characters, which are governed by both additive and non-additive gene action.

- Progeny testing of each of the two lines by crossing with each other.
- Crosses are made reciprocally.
- Parents are evaluated on crossbred progeny performance.
- Best parents of both lines are selected and the rest parent as well as all the crossbred progeny are culled.
- Selected parents are remated to members of own lines to produce the next generation of individuals which are to be tested by mating them with individual of second line produce in the same way.
- They are evaluated based on their crossbred progeny and the best parents of both lines are selected to produce next generation.
- This cycle repeated over and over.

- Initial difference in gene frequency between the two line is pre requisite.
- Deliberate inbreeding is avoided as far as possible(using all females in line , intensify male selection).
- Performance of the lines for the character under selection reduce.
- Selection progress is more or less uniform over a number of generations and depends on the initial gene frequency and the relative amount of AGA and NAGA.

SELECTION FOR DIFFERENT KINDS OF GENEACTION

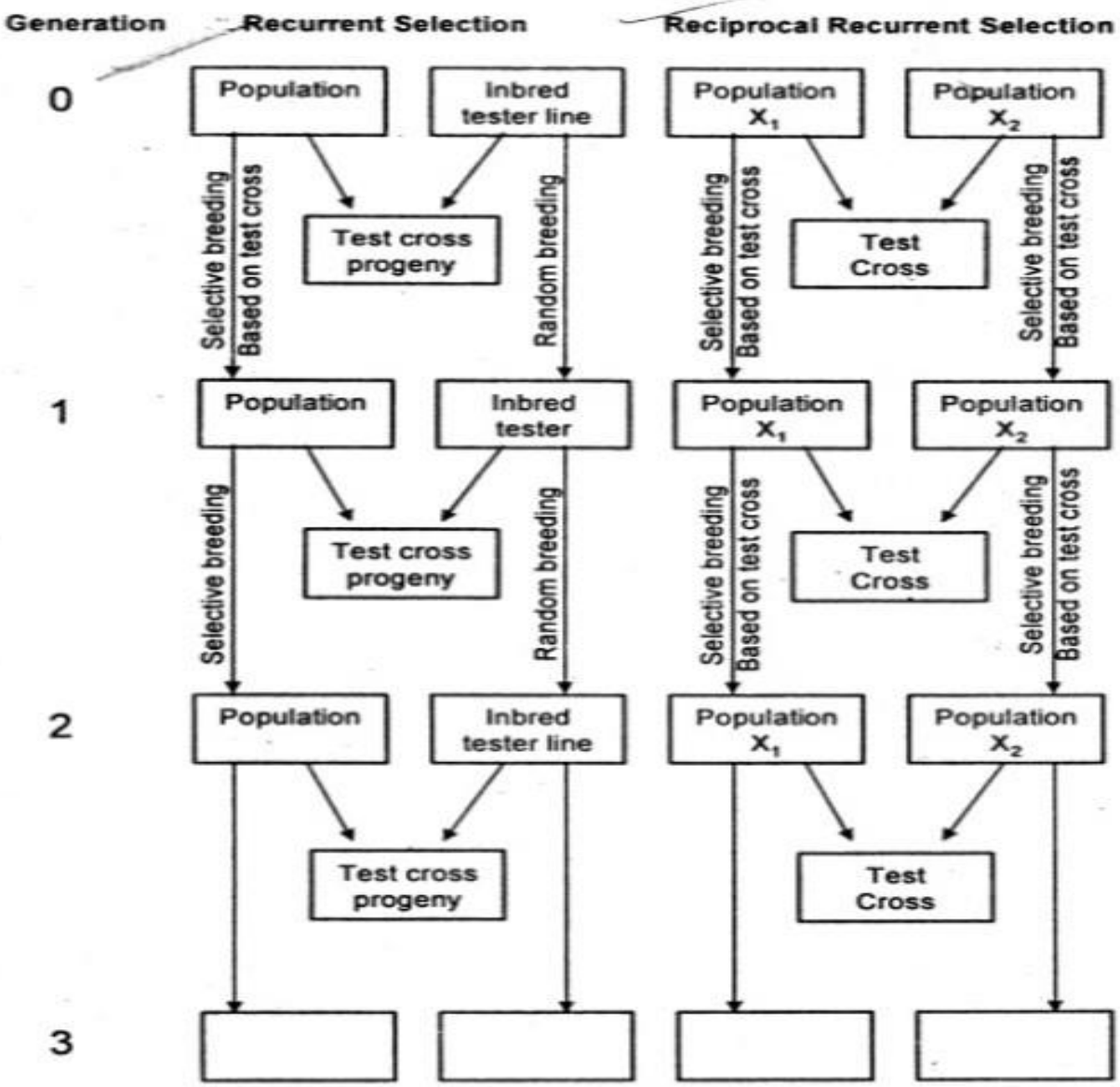

Fig. 12.1. Showing comparison of R.S. and R.R.S.

Relative importance of combining ability

- Different methods have been used to evaluate relative importance of GCA and SCA .
- The first step is to check whether or not both GCA and SCA are significant at P=0.05 or at higher probability levels (0.01 or 0.001 etc.).
- If both the GCA and SCA values are not significant, epistatic gene effects may play a remarkable role in determining these characters.
- The ratio of combining ability variance components (predictability ratio) determines the type of gene action involved in the expression of traits and allows inferences about optimum allocation of resources in hybrid breeding:

- $2\sigma^2GCA/2\sigma^2GCA+\sigma^2SCA$

- In which σ^2gca refers to general combining ability variance and σ^2sca refers to specific combining ability variance.
- The closer this ratio is to one, the greater the prediction of GCA alone, whereas a ratio with a value less than 1 shows SCA action.
- However, because in many cases only a few parents are used in crosses, the magnitude of GCA and SCA has been evaluated using the ratio of their sum of squares to total sum of squares for crosses.


Thank
you!