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Breeding Innovation : Exploring the role of Diallele and Combining Abilities in Livestock and poultry

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Abstract

Diallele crossing is a vital breeding methodology utilized in poultry genetics to evaluate the genetic potential and combining abilities of various lines or strains. By systematically mating each line with every other line, including itself, this approach helps to assess both general and specific combining abilities reflecting additive genetic effects and non-additive genetic effects. Additionally, reciprocal effects (RS) and reciprocal specific combining ability (RSS) are analyzed to understand the influence of maternal and paternal contributions to the traits under study. It highlights the importance of GCA and SCA in identifying superior lines and optimal crosses, facilitating genetic improvement and conservation efforts. Furthermore, it addresses the significance of RS and RSS in comprehending the genetic architecture and maternal-paternal interactions affecting trait expression. Through comprehensive evaluation and complex statistical analyses, diallele crossing serves as an essential tool for advancing poultry breeding programs and enhancing desirable traits in commercial poultry production.

Keywords: Diallele, Combining ability, Crossing, Poultry, Selection.

Introduction:

Diallele crossing involves the systematic crossing of two or more inbred lines derived from a base population in all possible combinations to evaluate their genotypes for specific quantitative traits. This method is a form of progeny testing and is used to identify and select breeds, strains, or lines that can be crossed to maximize heterosis. It provides valuable information on General Combining Ability (GCA), which assesses the overall genetic potential of a line, and Specific Combining Ability (SCA), which evaluates the performance of specific crosses.The main purposes are to determine the breeding value of different lines, understand how

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different lines perform when crossed, and identify the best combinations for specific traits. Diallele crosses can be complete, where every line is crossed with every other line including self-crosses, or incomplete, where not all possible crosses are made, usually excluding self-crosses. The process involves selecting the lines to be evaluated, developing a mating plan, performing the crosses, and assessing the offspring for desired traits like growth rate, egg production, and disease resistance. Analysis includes measuring general combining ability (GCA) for average performance across crosses, specific combining ability (SCA) for the performance of specific crosses, and heritability estimates to determine the genetic contribution to trait variation. For example, with three lines A, B, and C, a complete diallele cross involves matings such as A x A, A x B, A x C, B x A, B x B, B x C, C x A, C x B, and C x C.

General Combining Ability (GCA):

SCA refers to the performance of a specific cross, reflecting the non-additive genetic effects such as dominance and epistasis (interaction between genes). It measures the unique ability of a particular combination of lines to produce superior offspring.It is essential for identifying specific crosses that result in exceptional performance, even if the individual lines may not have high GCA. It highlights the potential of specific genetic interactions that lead to enhanced traits.

Specific Combining Ability (SCA):

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Selection for Combining Ability:

Heterosis, or hybrid vigor, requires a pair of lines with significantly different gene frequencies at loci affecting a trait, showing dominance. These lines must be test-crossed for General Combining Ability (GCA) and Specific Combining Ability (SCA). Given the high cost and time involved in producing inbred lines, selecting, and crossing, several shortcut selection methods have been developed to improve SCA in particular combinations and build genetic variation in breeding lines. Two key methods are:

1. **Recurrent Selection (RS) or Recurrent Selection to Inbred Tester**
2. **Reciprocal Recurrent Selection (RRS)**

RS and RRS are selection methods aimed at improving combining ability to enhance crossbred or hybrid progeny performance by crossing selected lines to exploit non-additive gene

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action (overdominance and epistasis). These methods combine inbreeding and crossbreeding with selection.

1. Recurrent Selection (RS)

Recurrent Selection (RS) is a method designed to improve SCA. Proposed by Hull (1945), this procedure aims to produce stock that combines well with a constant tester line. The tester line, which is a highly inbred line presumably homozygous at most loci and known to have good GCA, is used to test the value of a new line (A). The process involves:

1. **Crossing**: Large numbers of females from line A are crossed with males from the tester line.
2. **Evaluation**: The progenies from these crosses are evaluated (females of line A are usually crossed to inbred males to minimize the deleterious effects of inbreeding on fertility).
3. **Selection**: The tested females are selected based on the performance of their test cross progenies.
4. **Mating**: The selected females of line A are then mated with males from their own line to produce the next generation of parents for line A.

This cycle is repeated until the individuals in the population combine well with the tester line. In this method, the frequencies of alleles at heterotic loci that complement the alleles of the tester line are increased. For example, if the tester line is AA, recurrent selection will increase the frequency of the 'a' allele in the segregating population until it becomes 'aa,' making the segregating population homozygous in a manner complementary to the inbred tester line. This method improves the GCA of the tested line and the SCA of the cross. The crossbred progenies are then used for commercial production rather than further breeding. However, this method has practical challenges, including producing and maintaining the highly inbred tester line.

Reciprocal Recurrent Selection (RRS)

Reciprocal Recurrent Selection (RRS), proposed by Comstock and colleagues in 1949, is a method designed to improve both General Combining Ability (GCA) and Specific Combining Ability (SCA) as well as the nicking ability of two specific populations or inbred lines. RRS involves progeny testing by crossing each line with the other.

The procedure involves two segregating populations or lines (A and B), each serving both as the source material for selection and as the tester for the other population. The process includes:

1. **Crossing**: Males from line A are crossed with females from line B, and vice versa, resulting in reciprocal crosses.

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2. **Evaluation**: Males and females from each population are selected based on the performance of their test cross progenies (AB or BA). The test cross progenies are used solely to evaluate the combining ability of the parents.
3. **Selection and Mating**: The selected parents from lines A and B are remated within their own lines (A with A, B with B) to produce the next generation of parents.
4. **Cycle Repetition**: This cycle is repeated in each generation until the best possible results are obtained from crossing.

The ultimate goal of RRS is to produce commercial hybrids by crossing the two improved lines. The principle behind RRS assumes that individuals in the two segregating populations are not completely homozygous but have a high frequency of homozygosity in opposite directions for pairs of genes. By crossing and selecting individuals based on the performance of their progeny in test crosses, the two populations become more homozygous in complementary ways. This complementary adjustment of genotypes in the two populations enhances heterosis when they are crossed.

Application

Recurrent Selection (RS) and Reciprocal Recurrent Selection (RRS) are effective only when there is genetic variation between the two segregating populations. These methods are particularly useful if over-dominance or non-additive gene actions (both intra-allelic and inter-allelic) play a significant role.RS and RRS are widely applied in poultry and swine breeding. However, they are challenging to implement in large animals due to the difficulty and expense of producing truly inbred lines with high inbreeding coefficients. Additionally, because RS and RRS involve progeny testing, they extend the generation interval, which can slow down genetic progress.

Conclusion

Diallele crossing is a powerful tool in livestock genetics, enabling breeders to make informed decisions to improve and sustain livestock and poultry production. The importance of diallele crossing in advancing poultry breeding programs by providing detailed genetic evaluations.. Through the assessment of GCA, SCA, RS, and RSS, breeders can make informed decisions to optimize genetic gains, improve desired traits, and maintain genetic diversity. Despite the resource-intensive nature of diallele crossing and the complexity of data analysis, its application remains invaluable in the pursuit of genetic improvement in poultry.

References

Dubey, A., Jain, A., Barwa, D. K., Yadav, A., Bobade, M. K., Kumar, V., ... & Nanadanwar, A. K. (2020). Diallel Crossing in Farm Animals and Poultry: A Review. Int. J. Curr. Microbiol. App. Sci, 9(8), 153-161.

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Goto, E., & Nordskog, A. W. (1959). Heterosis in poultry: 4. Estimation of combining ability variance from diallel crosses of inbred lines in the fowl. *Poultry Science*, *38*(6), 1381-1388.

Khalil, M. H., Debes, A. A., & Shebl, M. K. (2018). Estimation of heterosis, combining ability and reciprocal effects for growth traits in Chickens from a full diallel cross. *International Journal of Research in Agricultural Sciences*, *5*, 2348-3997.

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