A simulation approach to optimize breeding programs with application to the introgression of the blue egg color into a high performing layer line

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Predicting and evaluating the genetic progress of a breeding program is essential to make optimal selection decisions. The variety of approaches for the deterministic assessment of genetic progress ranges from simple gene-flow approaches to statistically complex methodologies. These approaches, however, are limited with respect to certain model assumptions and only applicable to scenarios using either no or very simplistic selection strategies. This makes a realistic and precise evaluation of a complex breeding program difficult. Therefore, stochastic simulation has become a fundamental tool for this evaluation. To this end, we developed a highly flexible and computational efficient simulation tool based on the gene-dropping method that can incorporate real genetic information, such as genotype data and recombination maps, to account for the true genetic architecture of the actual population.

We applied our simulation tool for a selection program, which aims at introducing the blue egg shell color as single monogenic dominant trait from a gene bank population into a high performing, white egg layer chicken line. Initial crossing of gene bank population individuals carrying the blue egg shell genotype and white layer chickens will be followed by two generations of marker-assisted backcrossing, followed by an intercrossing to generate individuals that are homozygous for the blue egg color gene. Using the simulation tool, we aim to optimize each breeding step to construct a population, which is homozygous for the introgressed locus and at the same time shows maximum similarity to the recipient white egg layer line – especially in the proximity of the target locus – while maintaining a high genetic diversity. The results indicate the superiority of the simulation-based protocol compared to a non-optimized procedure.

Keywords: breeding program; simulation; blue egg shell color; introgression