Poultry genetics and breeding in developing countries

Commercial selection for meat and egg production

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Breeding for meat and egg production is an exceedingly complex process involving effective and accurate selection for numerous traits in the sire and dam lines to ensure that the final cross-bred commercial bird possesses all the required attributes. As a consequence, breeding programmes are very costly.

A large population with significant numbers of active and reserve sire and dam lines is required to permit the full exploitation of genetic variation in the component traits and to reduce the effects of inbreeding. This makes it difficult for smaller breeding operations to compete effectively with large global breeding companies, although smaller breeding companies are viable suppliers to niche markets in some areas.

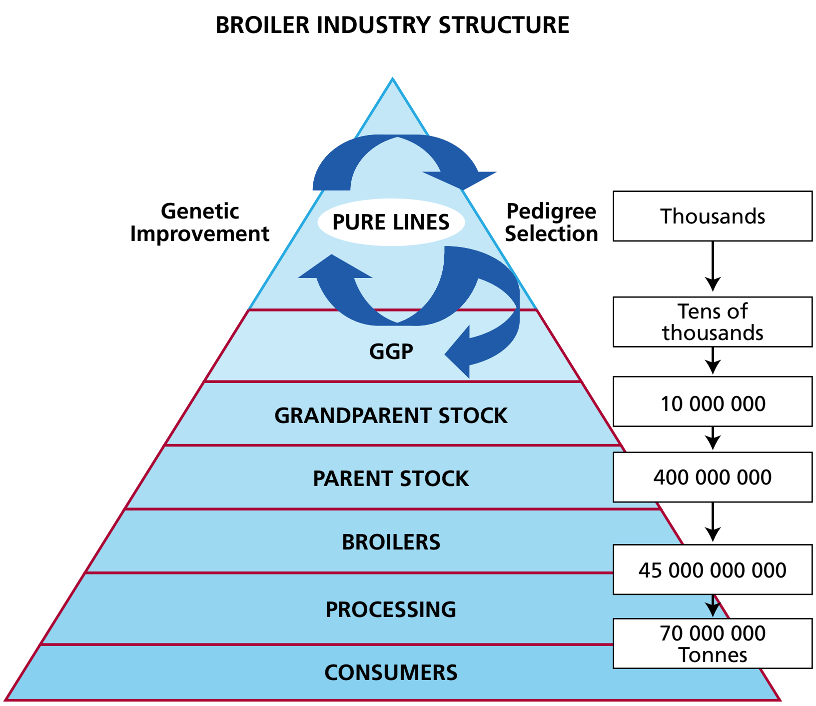
BROILER BREEDING PROGRAMMES

In commercial broiler breeding programmes, selection addresses the following areas:

- *Feed utilization efficiency:* As feed accounts for about 70 percent of production costs, the efficiency with which birds convert feed to body weight is an important trait for direct selection. To enable the selection of birds from the same conditions as their progeny are expected to perform in, some breeding companies have started to replace single-bird cage selection with selection of individual birds from group floor housing, using transponders on the birds and feeding stations to record food consumption.
- *Breast meat yield:* Because of the relatively high price of breast meat in developed countries, considerable efforts have been directed towards improving this trait. Approaches include sib selection based on conformation and, more recently, indirect measurement technologies involving real-time ultrasound, magnetic resonance imaging, computer-assisted tomography and echography.
- *Ascites:* Breeding for rapid growth and high breast meat yield resulted in an inadequacy in the cardio-pulmonary system's capacity to oxygenate the increased blood flow associated with the increased muscle mass. This led to a significant increase in ascites in broiler flocks during the 1990s, particularly during winter. Prior to this, ascites was normally encountered only un-

FIGURE 1

Numbers of birds and generations involved in the transmission of selection response from nucleus lines in commercial broiler breeding programmes to the commercial broiler progeny



Source: McKay, 2008.

der cold, high-altitude conditions. Selection based on oximetry and plasma levels of the cardiac-derived troponin-T enzyme was demonstrated to be effective in reducing susceptibility to ascites, and this procedure has been adopted by commercial broiler breeders. Levels of ascites in the field are now greatly decreased, even at high altitudes.

- *Skeletal abnormalities:* The very rapid growth rate of broiler chickens puts an enormous strain on their immature cartilaginous skeletons, resulting in high incidence of leg and skeletal abnormalities. Selection based on gait, morphology and X-ray imaging has done much to reduce the expression of conditions such as *tibial dyschondroplasia, spondylolisthesis* and *valgus* and *varus deformation* in most commercial strains of broilers, but skeletal abnormalities continue to be a major focus in most breeding programmes.

To permit the transmission of genetic improvement from the nucleus breeding populations (where all selection takes place) to the billions of cross-bred commercial broilers, significant multiplication through grandparent and parent populations is needed, as shown in Figure 1. The time lag between selection in the nucleus lines and gains in the commercial broiler is typically about four years.

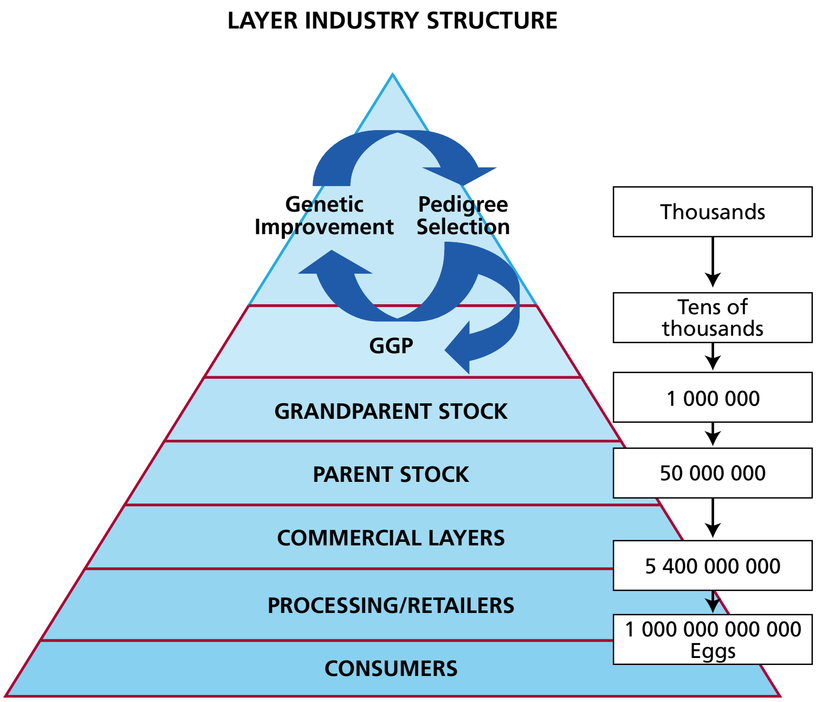
LAYER BREEDING PROGRAMMES

In commercial layer breeding programmes, selection addresses the following areas:

- *Egg production and size:* Genetic improvement in egg production and size is challenged by the highly canalized nature of the trait as determined by diurnal photoperiodic constraints; negative genetic correlations between egg production and early egg size; variation in the rate of increase in egg size with age; and the need to predict persistence of lay in birds selected for breeding before the third phase of production. High-capacity computers and sophisticated statistical packages involving Best Linear Unbiased Prediction (BLUP) procedures have been used to predict persistence in the laying performance of birds in current flocks, allowing selection to take place earlier and the maintenance of a relatively short generation interval.
- *Egg quality:* Shell quality is defined in terms of strength, colour, shape and texture; the first three have moderate to high heritabilities, so respond readily to selection. Shell colour is determined almost exclusively by genotype, and selection is typically based on measurement using reflectance spectophotometry. There are cultural preferences for eggs of different colours. Shell strength is a critical factor affecting profitability. Breeders have selected for improved shell strength by measuring shell thickness, specific gravity (of fresh eggs), shell deformation, and other indirect and direct parameters. Shell texture and shape aberrations and blood and meat spot inclusions are selected against by culling birds producing these eggs. Albumen quality has been improved by selecting for increased albumen height measured using a Haugh unit micrometer.
- *Selection in barn and free-range environments:* Effective selection for egg numbers and quality was not feasible in the past, when birds were housed under group pen conditions in barns, or free-range. Recently, technologies have been developed for attaching transponders to the birds and the nest box, with sensors that allow egg production to be recorded and eggs to be traced back to the hen that produced them, for quality measurement.

FIGURE 2

Numbers of birds and generations involved in the transmission of selection response from nucleus lines in commercial layer breeding programmes to the commercial layer progeny



Source: McKay, 2008.

The transmission of genetic improvement from the nucleus breeding populations (where all selection takes place) to the many millions of cross-bred layers involves significant multiplication through grandparent and parent populations, as shown in Figure 2.

RECENT EMPHASES IN COMMERCIAL BROILER AND LAYER BREEDING PROGRAMMES

Genomics: The sequencing of the chicken genome and the genetic variation map for chickens, developed in 2004, have had a profound impact on commercial broiler and layer breeding programmes. There are now some 3.3 million identified single nucleotide polymorphisms (SNPs) in the chicken genome, which provide large numbers of potential markers for quantitative trait loci (QTL) mapping and associated studies, allowing more accurate selection for multiple traits.

Genomics will not replace traditional selection methods, but will allow more accurate selection decisions to be made, and breeding companies have recently made considerable investments in bioinformatics. The greatest impact of this will be on difficult-to-measure traits such as disease resistance and sex-limited traits, and those with low heritability. Large international poultry breeding companies have recently committed to a combined initiative to evaluate and implement genome-wide selection in their respective breeding programmes.

Transgenics: There are three approaches to producing transgenic chickens: i) using viral vectors to introduce foreign DNA into the genome; ii) direct injection of DNA into the newly fertilized zygote; and iii) using a cell-based approach to make modifications to the genome. Of these, the last approach, using primordial germ cells, appears the most promising for successful targeted changes to the genome.

Although transgenic technologies open up exciting possibilities for poultry breeding, their application is impeded by consumers' reluctance to accept eggs and meat from transgenic commercial poultry.

Selection for disease resistance: Breeding for disease resistance can be effective through direct selection for resistance and immunity parameters by measuring the response of relatives. However, the use of molecular markers is preferred, to avoid the expensive and labour-intensive tests involved in defining resistance in the live bird. A huge global research programme is under way to identify the molecular basis of disease resistance to the wide array of viral, bacterial, protozoan and fungal diseases affecting poultry.

However, in spite of the enormous global effort involved, the molecular approach to disease resistance in poultry flocks has so far had only a modest impact. Two areas where relatively good response has been obtained are selection for resistance to Marek's disease, based on the Major Histocompatibility Complex (MHC) haplotypes, and selection for resistance to avian leukosis virus, based on receptor differences in the identified genes. Combined molecular and traditional sib-selection approaches have yielded significant improvements in general robustness in a number of commercial meat and egg strains.

REFERENCES

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