How 90 years of poultry breeding has shaped today's industry

The history of modern poultry breeding goes back to the early years of the last century, right around the time that Watt Publishing started its first publications for the fledgling industry. The last nine decades have brought spectacular developments in poultry breeding to satisfy the growing demand for chicken. We take a nostalgic glance back to those early pioneering days and then look ahead, examining the techniques that will bring the industry further forward to meet the expectations of an ever more demanding market.

Dr John Hardiman

Handling and sorting pedigree stock still play an important role in selecting chickens, together with the data collected from increasingly hi-tech measurement and analysis.

Today's poultry industry has its foundations in pedigree breeding during the first half of the 20th century. With its origins in around 1916, it began just the year before Watt published its first magazine for the poultry industry.

An early pioneer in the industry was Robert Cobb senior, whose sights were set on improving pure breeds such as the Barred Plymouth Rocks and then in the 1940s, on developing a breeding line of all-white birds. In 1955, the White Rock line was introduced into the US market, exhibiting faster growth than had been seen previously. At the same time, male lines such as the Vantress were being developed from the original dominant white Cornish males. Through the 1960s, these American breeds began spreading out across the world.

The influence of retailer power on the industry began in the 1970s, particularly in the UK, where the growing popularity of fresh rather than frozen chicken led to more emphasis on conformation and meat yield. Both processors and retailers could also see the enormous potential in cut-up chicken and particularly value-added, processed products.

The complexity of broiler breeding increased significantly in the early 1980s when broilers were required to be ever leaner and higher yielding with continuing improvement in feed conversion and liveability. More sophisticated selection practices were introduced, encompassing breeding value estimation, feed conversion, carcass leanness, meat yield and disease resistance.

Fully pedigreed lines underwent multiple selection procedures to optimise breeder, broiler and processing performance. Computing technology was fast developing, enabling highly accurate estimation of breeding value, combining the performance of individuals with that of their progeny, brothers and sisters and half-sisters. Additionally, unique selection indices were created, balancing selection across all production, health and well-being traits.

Although feed conversion efficiency had been improving through selection for growth rate, a new method was introduced to collect and combine data from thousands of pedigree birds to enhance genetic improvement in feed conversion. State-of-the-art testing facilities minimised differences in temperature, humidity and ventilation between the birds. Individual measurements of body fat taken at the same time produced birds with better feed conversion and reduced carcass fat. The dividends of this are still being appreciated today when cereal prices and the subsequent cost of poultry feeds are on the rise.

Birds for the 21st century

Now the focus is on carcass evaluation and meat quality as well as those improving bird physiology and well-being. Progeny from each pedigree family are measured for several

Radiography is used in the selection of pedigree candidates, eliminating any abnormal joint or bone formation.

Colorimetry is used to assess meat colour, helping to achieve uniform colour in chicken parts.

Blood oximetry provides a measure of the cardiovascular health of birds, helping to reduce the incidence of ascites.

Ultra-sound assists in selection for meat yield, providing a profile of the shape of the breast muscle.

traits directly affecting product quality and potential application. These traits include meat quality, yield, discreet muscle shape and meat colour. These techniques produce continuous improvements in many aspects of factory performance to improve utilisation of chicken meat.

Concentrating on the cardiovascular health of poultry, blood oximetry measures the oxygen level in each pedigree and multiplier candidate with strict minimums for these values if a bird is to be considered as a potential selection candidate. This technique reduces the incidence of ascites and pre-disposition to develop ascites syndrome in broilers.

The well-being of chickens is critical to sustainability of broiler production, with strict skeletal and leg evaluations at selection, strong selection pressures and increased live and processed bird evaluations. Each pedigree selection candidate is evaluated by X-ray for abnormal joint or bone development including the presence of tibial dyschondroplasia and femoral head necrosis. In addition, the walking ability of each pedigree candidate is observed and scored. Any bird with impaired walking is eliminated from selection regardless of other performance characteristics, leading to better-walking broilers with improved leg health.

The development of chicken lines with enhanced disease resistance is also a major component of breeding programmes. This improved genetic resistance is associated with lower incidences of disease as well as less morbidity and mortality among chickens. Breeding for disease resistance benefits human health, too. For example, chickens with greater resistance to enteric pathogens help lower incidence of gut illness. Another benefit is long-term poultry health. Once a gene with positive effect on health is identified within a chicken line, its beneficial effect will last for years to come. Better response to vaccines and medications in genetically improved lines will lead to less therapeutic agents needed to treat or control diseases.

Molecular biology: the way ahead

In the future, breeding for disease resistance will utilise recent advances in avian molecular biology. The sequencing of the chicken genome has made it possible to identify genes associated with important diseases in chickens. For example, the Mx gene confers an element of resistance to avian influenza (AI) in various species, and this gene has been identified in several lines. Making use of this information and conducting further research to identify additional genes related to AI resistance will lead to improved natural resistance to the virus, bringing huge potential benefits to both chicken and human health.

Additionally, geneticists work with external researchers to develop breeding techniques that will apply innate immunity to improve genetic resistance to diseases. Innate immunity serves as the first line of defence through receptors embedded in cell walls. These receptors can recognise invading pathogens and alert an army of cells and substances, including cytokines, for action aimed at defeating the invaders.

One cytokine recently discovered is associated with genetic resistance to several bacterial diseases and coccidiosis, while another immune system factor has been linked with genetic resistance to viruses including Marek's disease. Innate immunity also activates the acquired immunity that includes B and T cells as well as antibodies that play an important role in destroying the invaders. The most attractive feature of innate immunity is its relative simplicity, making the geneticist's job of developing lines resistant to a variety of diseases more manageable.

It is hoped to identify proteins associated with immune responses and eventually genes that will specifically protect against gut bacteria like salmonella and campylobacter as well as genes associated with malignancies in chickens. All these genes will be incorporated into highly-refined breeding programmes for disease resistance in conjunction with the other important well-being and production-related traits.

New selection tools are being developed to include standard breeding values and genetic code information based on specific genetic markers linked to genes controlling variation of traits under improvement. The growing focus is on projects which can yield commercial field applications and which support new pedigree selection technologies.

Practical applications of genomics

Success of human and animal genome sequencing projects at public and private organisations has resulted in large volumes of information being available to academic and commercial researchers. Practical application of 'genomics' as a natural science extension of classical genetics has become possible for commercial poultry breeders based on the available chicken genome sequence. Multiple genetic marker technologies developed during the past 10 years are currently dominated by SNPs (Single Nucleotide Polymorphisms) – genetic markers of choice based on the chicken genome sequence available from several public databases.

SNPs explain basic variations in the genetic code serving as a matrix for continuous building of proteins referred to as the 'building blocks' of life and responsible for the structure and function of all organs within living creatures. Knowledge of SNP variations leads to an understanding of protein changes responsible for differences such as greater muscle mass, faster growth rate, better immune response, higher egg production and stronger bones.

SNP markers for the pedigree lines have been completely developed by evaluating more than 60 million data points generated for 50,000 SNPs on 1200 single chicken DNA samples from pedigree lines. This initial SNP development project was the largest chicken genome effort conducted to date. The aim is to identify unique sets of SNP markers linked to genes controlling variation of selected health and productivity traits. Identified SNPs will be incorporated into the genetic improvement programmes for current and future lines and commercial products.

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Future selection of pedigree lines will take advantage of a combination of breeding values based on continuously collected phenotypic measurements from live and processed birds and SNP marker genotypes derived from DNA samples collected from live birds for assessment of bird genetic value for traits that are difficult or costly to measure. This technology will help, for instance, to improve meat quality traits increasingly valued by processors and consumers.

Breeding programmes also need to take advantage of significant interactions between chicken genetics and management – particularly nutrition – to maximise benefits for producers and consumers such as superior production efficiency and maximisation of value-added traits. The latest trend in using crops for energy and bio-fuels is challenging all poultry producers. Application of the newest science-based technology will be increasingly required for the poultry industry to remain competitive, and smart innovations will be needed.

Throughout the past 90 years, breeding techniques have evolved at an accelerating rate, becoming increasingly complex yet also more responsive to demands of producers, retailers and consumers across the world. This progress will need to continue to meet the future needs of animal health and well-being, breeder and broiler production, feed conversion, food safety and product quality.

— Dr John Hardiman, vice president of research and development, Cobb