Genes for better eggs – genomic selection for adaptability

In a world where the population is growing at the rate of 220,000 people per day, the demand for animal protein is increasing constantly. Eggs are a relatively cheap protein source with a high nutritional value and are already in their 'final packaging', which makes the global egg market (mainly 'local for local') grow at a steady pace of 2-3% per year.

by Mickaël Le Helloco, and Thierry Burlot, Novogen. www.novogen-layers.com

As the distribution of world egg production is following the growth of the population and the growth of the egg consumption per capita, Asia represents a major part of the total egg production with local production for local consumption. Indeed, export is really limited (2%) when we compare it to global trade of broiler meat (17%).

In order to be able to produce commercial layers which are performing well in the various conditions of production and to continue to transfer generation after generation the genetic progress expected by the egg industry, the geneticists have to take into account those evolutions in the breeding program and have to secure the fact that the final ranking determining the final choice to reproduce the next generation is well balanced. Over many decades breeding companies have selected for efficient layers by increasing egg production, egg mass and liveability and by reducing feed consumption. Since the end of the last century, the market asks more and more for egg quality as hens are kept longer and longer in production.

Adaptability of layers

Nowadays, as the production environment is becoming more and more varied, another trait is becoming important: the adaptability of layers. Today, it is not only the genetic potential in a specific environment, but also the ability of the layer breeds to perform well in the various conditions of production. Previously it was believed that technical adjustments would compensate for the natural lack of adaptation to a local environment. But, in fact, the combination of genotype and genotype by environment remain important. Layers have to adapt themselves to different environments and even to changes during their life cycle:

- **Housing system** is one of the environmental factors. Different kinds of housing systems exist over the world. Cage systems are the most important in many countries, but they can still be very different (conventional cages or enriched cages). Alternative systems, like floor or aviary systems and free range farms are coming up in some specific developed countries. Birds have to perform well in different production systems, as it is not known beforehand in which system they will be placed.
- **Feed characteristics** are also an important environmental factor. It could vary a lot from one country to another according to available raw materials and the technology used to produce this feed. Also, feed characteristics can change due to the raw material price. So, birds have to adapt themselves to those quick changes.
- **Climate and temperature** variations are also very different from one country to another. The climate conditions are not the same in a controlled environment in North America as in an open housed farm in Indonesia. Even, in one specific country, climate can change according to season. So, birds will be challenged by different situations during their life cycle and have to be able to adapt themselves to different climates.
- **Health status** is also an important factor, which differs not only from country to country, but also from farm to farm. It can even evolve during the production cycle. So, layers have to be strong and able to adapt, once again.

Those are examples of various environments that layers will meet during their life. To perform well in different regions, birds have to adapt to every specific situation. Therefore, to select for better adaptability, breeding companies have developed different ways of selection.

In addition to the pure line farm, progeny tests have been implemented to take into account various production environments. These field tests are really useful for geneticists in choosing the best breeders. Nevertheless, although very informative, they are difficult to implement on a large scale, for each specific environment.

In addition to phenotypic data, genomic information is now becoming available. Development of new technologies will probably give better understanding of different mechanisms, such as adaptability of birds to their environment.

The Utopige project

In order to develop a breeding program according to field conditions, Novogen has developed (in collaboration with the French institute INRA) a specific genomic study taking into account pure line and crossbred performances in various conditions of production.

This Utopige project aims at elaborating realistic strategies for the implementation of genomic selection in breeding schemes which use crossbreeding through a pyramid structure with selection in pure breeds and production by crossbred animals.

The ultimate objective is to improve the breeding scheme efficiency by increasing the accuracy of breeding values considering the opportunity offered by high density genotyping provided by the recently released SNP Chips.

A total of 500 males from a specific line have been used as a resource population for the estimation of SNP-effects on traits in pure breeds and crossbreeds. From all these sires blood has been collected for DNA extraction. Those males have then

Continued on page 25

Continued from page 23
been evaluated from pure breed information. Performances used for this genetic evaluation will concern the full sisters of these males, with a total of 5,000 hens. Phenotypic data like egg number, egg size, egg quality, bodyweight, behaviour in colony cages, mortality and reasons for mortality have been collected. Secondly, progenies of the same males are tested in a crossbred trial (A*CD). Furthermore, progenies are split in two groups of around 40 progenies. Those two groups are fed with extreme levels of energy in a production environment, one with a high energy level similar to North America (2,900 Kcal), the other with a low energy level similar to India (2,400 Kcal).

Again phenotypic data (egg number, egg size, body weight, egg quality, mortality and reasons for it) are collected. Now, for each sire, two genetic evaluations are computed according to the environment.

The last phase has been dedicated to the validation of genomic selection. 600 young males of the line A born in one hatching group have been used for blood collection for DNA extraction at 10 weeks of age.

Two Genomic Estimated Breeding Values (GEBV) may be estimated for each male, one in the high energy environment and one in the low energy environment.

Among the 600 young males, the 15 best and 15 worst males for each environment have been selected at 30 weeks of age (60 males selected) considering the global objective of selection of the A line.

Each of these males has been progeny tested by a crossbred on 80 progenies per feed formula (4,800 layers per feed formula, 9,600 layers controlled) to estimate the response to selection.

Genomic analyses done on mean and standard deviation of performances have shown numerous 'Quantitative Trait Loci' (QTL) interacting with diet and age. For the study of mean, 45% of the QTL have a significant interaction with diet and/or age, although the average phenotypic performance varied only slightly with diet and age at collection. This shows that laying hens have the ability to adapt to their environment and probably involves different genetic pathways.

These complex 'Genotype x Environment' (G x E) interactions could have an effect on genetic selection, since the best candidates may differ depending on the environmental conditions in which the hens are reared. The study pinpoints the existence of non-robust QTL, which raises the question which QTL are expressed in the commercial hybrids.

Concerning the study of standard-deviation, 98% of the detected QTL have a significant interaction with the environment. So it seems that the variance of traits is more sensitive to the genotype-environment interactions than the mean of traits. Different genomic regions interact on the ability of layers to adapt to their environment in which they have to produce. This Utopige project has demonstrated the existence of adaptation mechanisms and differences between birds' families. Many pathways could be involved to give the same results. Many questions are still open, but it is an excellent start to a better knowledge of genomic information and the influence of specific genes in different environments.

The Chickstress project

Following this Utopige project, Novogen is now part of a new project, called 'Chickstress', focusing on the adaptation of the bird to a change of temperature and feed formulation.

This new project aims at describing pathways responsible for adaptation to heat and feed stress in layers.

A comprehensive understanding of the genetic influence on adaptation to climate and feed changes is particularly important in selection schemes for the sustainability of the egg industry in a changing ecological and economic context.

As new tools, transcriptomic analysis and DNA methylation will be used to analyse different mechanisms. ■