Breeding for better egg quality

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The genetic improvement of egg laying chickens using systematic breeding principles dates back to the early part of the 20th Century. Initially, selection focused on egg production, with no particular attention paid to egg quality. In the 1930s, breeders began to improve egg weight. The size of the egg determined in nature is that which provides optimum hatchability. This tends to be below the most popular size for consumption, so continuing pressure has been required through the years to keep egg size from slipping back to a smaller weight.

Subsequently, breeders turned their attention to improving the quality of the shell, so that flocks could be kept for a longer time before they had to be sold or moulted.

Poultry geneticists also began to assess ways to improve Haugh units and reduce the percentage of bloodspots and other inclusions. As the years passed, firms providing breeding stock for egg type chickens became better at assessing the egg quality needs of their customers and developed more sophisticated methods to improve that quality.

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To determine the current situation in the breeding of chickens for the external and internal features of the egg, this article will review the methods used at Hy-Line International. Hy-Line has developed a highly sophisticated laboratory at Dallas Center, Iowa to measure egg quality.

Two members of the Hy-Line genetic team were interviewed. First we talked to Dr Neil O’Sullivan, director of research and development, and then we spoke with Dr Petek Settar, geneticist and statistician.

As selection progresses for darker shells in brown egg varieties, there is a tendency toward the increased incidence of eggs with dark brown spots. Selection against speckling is needed to keep the incidence low.

What is the significance of genetic egg quality for the commercial poultryman?

Each aspect of selection for egg quality affects the marketability of the egg. An attractive, uniform appearance is critical for acceptance by the consumer. For example, the shell colour of white eggs must be pure white, and hens that produce tinted shells are removed from the breeding flock. Our brown shelled varieties are selected for dark, uniform shells. Albumen height must be optimised to assure that eggs remain grade AA until they are sold.

The percent solids content of the egg is receiving increasing emphasis as more eggs are sold in liquid form. The same is true for percent lipids, which are important in markets where the egg product is used as an ingredient in pastas. It is not possible at this point to select directly for percent solids or percent lipids because the measurement is too labour intensive. For that reason, Hy-Line is selecting for yolk weight, which increases yolk percentage, which is highly correlated to percent solids and percent lipids.

Selection for yolk weight also permits selection for the strength of the yolk membrane (the vitelline membrane). As we separate the yolk from the white to weigh the yolk, some yolks will rupture. This is noted on the record for that hen, and hens with an excessive number of broken yolks are not used to reproduce the population. The strength of the vitelline membrane is important to buyers of separated eggs and egg white. If there is contamination of the egg white with yolk, it will harm the functional properties of the white, including its whipping volume.

Sometimes egg quality is improved as a result of the improvement of other traits. For example, there is increasing use of alternative housing, including litter floored houses and free range operations. This is particularly true in Europe. For this type of environment we are selecting to reduce the incidence of hens that lay their eggs on the floor. This influences egg quality in that there are less soiled eggs. Eggs laid in the nest are not only cleaner in appearance, but are less likely to carry manure or organisms on the shell.

We must also be aware of correlated responses to selection. As breeding is conducted for darker shells in brown egg varieties, there is a tendency toward the increased incidence of eggs with dark brown spots, which are referred to as speckles.

The genetic correlation between shell colour and degree of speckling ranges from 0.23-0.69. Speckled eggs are not acceptable.
Shell strength has also had a priority role throughout Hy-Line’s history. We have continually refined our methods of measuring eggshell strength. We now use both puncture strength and breaking strength in our programme.

What do you mean by these terms?
Puncture strength is a measure of the resistance of the shell to penetration by a sharp point. We measure the force that it takes to cause the tip of a needle to punch a small hole in the shell. This gives a simultaneous measure of shell strength and flexibility, which are influenced by both shell thickness and the integration of the shell into the shell membrane.

Uniformity of the egg weight is improved by selection for increased early egg size coupled with subsequent removal of breeders that have an excessively large egg late in lay.

Breaking strength is evaluated as the force required to crack an egg using a flat plate. It is primarily affected by the thickness of the palisade layer of the shell. Therefore, puncture strength is a dynamic measurement of the shell strength and flexibility and breaking strength is a static measurement of shell thickness only.

Have there been any new traits added to the list under selection in recent years?
A characteristic that has been recently incorporated in our selection programme is ‘fishy taint’. When brown egg chickens are fed certain feedstuffs, including rapeseed meal, some hens will produce eggs with a fishy odour. This has been found to be caused by a genetic mutation that affects the ability of the bird to metabolise trimethylamine (TMA). There is a genetic marker for this mutant, and Dr Janet Fulton in Hy-Line’s molecular genetic laboratory is providing our geneticists with the genotypes of birds in the breeding populations at Dallas Center. Using this marker, we are systematically removing the mutant allele from our breeders and by 2009, our commercials will be free of this trait.

It would be possible to remove the muta-
Eggs coming in to the Hy-Line laboratory carry a sticker on which is printed a bar code giving the bird’s identification. This is scanned and stored with the egg quality data in their central computer.

In one generation, the trait is already at a very low level in our stock and we feel that it is important not to move too quickly in changing this or any other simply controlled trait.

Undesirable changes may occur in other traits if portions of a population are hastily discarded. This could negatively impact variation in future generations and result in slower progress on other important traits.

By moving slowly we retain the genetic variation and only discard the undesirable allele for fishy taint.

How does Hy-Line structure its populations to maximise progress?
Effective population size has been optimised and at the same time, actual bird numbers have been increased. This allows us to maximise the rate of improvement and minimise inbreeding.

What do you mean by ‘optimised effective population size’?
To optimise effective population size, you want a balance between the number of selected males and the number of females to which each selected male is mated.

The proper balance between number of sires and number of dams can reduce the total numbers of birds needed while still achieving the same rate of genetic improvement.

Egg quality has been under selection by Hy-Line for many years, is it continuing to improve?
Yes, there continues to be usable genetic variation, and egg quality continues to improve in response to our selection. For example, egg weight early in lay is increasing by about 0.25g per generation.

On a scale that places the whitest of eggs at 0 and those with the darkest brown shell colour at about 100, the shell of the Hy-Line variety Brown is 0.8 units darker each generation.

Our eggshells continue to increase in resistance to breakage so that it takes approximately 3g more force to punch a hole in them each generation.

The other traits under selection are gener-
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- Missshapen shells.
- Internal defects:
  - Broken yolks.
  - Intermixture of the white and yolk that had occurred before break-out (added eggs).
  - Pale coloured yolks.

- What are some of the challenges in measuring egg quality?
  First of all, measurement of all the traits of importance is time consuming. We evaluate more than one million eggs each year. We have four egg quality stations in our laboratory in Dallas Center, and for much of the year all four of these stations are busy all day long. We also have an egg quality laboratory at our facility near Birmingham, England for evaluation of eggs from our field tests units in Europe.

  Our staff must be carefully trained to measure each egg quality trait properly. There must be consistency among operators and uniformity of technique from egg to egg within operator. For example, albumen height must be measured on the thick white, midway between the yolk and the edge of the thick white. Under the pressure of a long day, with many eggs to do, it is tempting to hurry this measurement, but our staff are trained to carefully place the instrument at the same position over the white for each egg assessed.

  Another trait requiring particular care is yolk weight. We select for increased yolk weight because it is associated with both egg solids, which are important in marketing eggs for further processing, and because yolk weight is positively correlated with total egg weight. In separating the yolk from the white in order to measure the weight of the yolk, care must be taken that only a minimum amount of residual white is allowed to cling to the yolk and, of course, care must be taken that the yolk is not accidentally broken by the operator as the yolk and white are separated. If the yolk breaks in the course of normal handling, this is recorded and is used to select for stronger vitelline membranes.

  Another challenging trait is the direct measurement of egg solids. This involves weighing wet egg product, drying it down in a consistent manner and then determining the weight of the dried material. In practice, a team of two people can only measure percent solids for about 100 eggs per day.

- How is genetic uniformity in egg quality achieved?
  We measure egg quality at three different ages, and select for uniform quality throughout the life of the hen. For example, the natural tendency is for the colour of the shell in brown egg stock to become lighter as the hen ages.

  We eliminate those families in which the shell whitens excessively with the aging of the hen. The change in colour from first to last egg is reduced. In operations where eggs are combined from flocks of several ages, this uniformity across the life of the hen is important in producing a pack of eggs with a homogeneous appearance.

  In the same way, we are improving the uniformity of egg weight across ages. Those hens that lay very small eggs at the beginning of lay are eliminated from the breeding population.

- Among those hens with acceptable egg weight early in life, we remove any with an excessive increase in egg size as they age. The natural genetic tendency is for a correlated increase in late egg size with selection for early egg weight. By selecting against this, we achieve a more uniform egg size throughout the life of the flock.

- Do statistical indices play a role in Hy-Line’s programme?
  Yes, we calculate an index for each bird that is a candidate for selection. The index includes the genetic correlation among traits plus information on the performance of related individuals. It is weighted in a way to take into account the economic importance of each trait for the commercial producer. By using this index we can avoid selecting too heavily for one trait to the detriment of others.

- Does Hy-Line rely entirely on the index in making selection decisions?
  No, for some traits we make decisions independent of the index. These are primarily traits with a very low level of occurrence, or which are all or none in nature. Inclusions, like blood spots or meat spots, are an example.

**Hy-Line’s emphasis has been to increase egg size early in the production cycle without increasing it later in the hen’s life. As a result, there has been an increase in egg size at 30 weeks with little change in egg weight at 60 weeks and older.**

[Graph showing egg size increase from 1984 to 2005]

**In separating the yolk from the white in order to measure the weight of the yolk, care must be taken that only a minimum amount of residual white is allowed to cling to the yolk.**

Other such traits include speckles on brown shelled eggs and double yolked eggs. For these traits we utilise ‘independent culling levels’, removing birds from the breeding population with excessive occurrence of the undesirable traits.

Finally, after the selections are completed using our standard statistical methods, we look through the list of hens and roosters slated for the breeding pens to make sure that each one seems like a reasonable choice.

As this review of Hy-Line’s programme shows, it is clear that the genetic improvement of the hen’s egg quality is becoming increasingly complex and that the methods used are ever more sophisticated.

As more eggs are used for further processing and in specialty markets, it can be expected that additional traits will be added to the breeders’ lists.

The result will be eggs of better and better quality.

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