# Breeder management and its relation to commercial chick quality and layer performance

Antonio Paraguassu and Jesus Arango

*Hy-Line International, P.O.Box 310, Dallas Center, IA 50063, USA*

*aparaguassu@hyline.com*

## Introduction

The productivity of a breeding operation can be measured by the number of quality eggs produced and the number of quality chicks obtained from hatching these eggs. This is a complex process, which starts at the pure line level and makes its way through the multiplication process (**Figure 1**) to GP (grandparents) and then to PS (parent stock), most commonly referred as breeders. As the gene flow proceeds, specific matings are used to produce the male and female lines that are ultimately crossed to produce the final commercial product. Careful development of experimental crosses and evaluation for many years in the field results in the right genetic package expressing the desired combination of performance traits.

The genetic potential delivered to the commercial day old chick (DOC) is the basis of profitable commercial egg production The stock used in the genetic process must be kept free of important vertically transmitted pathogens that could affect poultry or human health. Biosecure-designed facilities and strictly enforced biosecurity procedures must be in place. Breeding flocks must receive adequate nutrition, management and environmental conditions in order for the biological potential contained in the specific mix of genes in the PS to be adequately exploited, resulting in a good quality day-old commercial pullet.

The breeder's goal is to deliver a clean chick with high genetic potential to the farmer. Afterwards, it is up to the commercial producer to care for these pullets so that they develop as sound, productive and profitable layers. In the presentation herein, we will try to convey some concepts about PS- breeder management and how they can relate to the performance of the commercial pullets and layers.

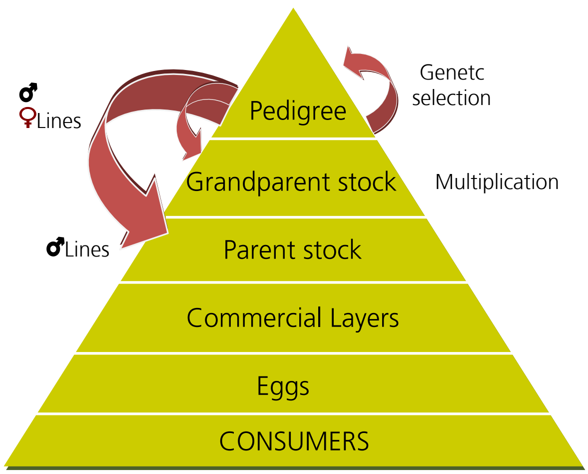


**Figure 1** - Genetic multiplication flow of layer type chicken.

## Breeding program objectives and layer performance

The objective of a livestock breeding company is to maximize genetic progress in elite pedigreed populations (pure lines) and to find the right combination of these pure lines to produce the final commercial product (**Figure 1**). Several biological processes are involved in the design and implementation of a breeding program. The most important one is selection at the pure line level. Once the best individuals are chosen to reproduce the elite populations, a robust multiplication process needs to be in place to ensure that: **(a)** the best combination of lines is used to produce commercials, and **(b)** new combinations of lines are tested in a continual basis to search for final product improvement or to develop new products. To maximize the results of crossbreeding (a and b) other biological processes play important roles: **(i)** heterosis (or hybrid vigor) ensures that the performance of the hybrids is better than the performance of the average improved pure line parents, **(ii)** combining ability ensures that the right combination of lines is used to maximize performance of the crossbred progeny (i.e., by choosing the right lines contributing to the male and female sides of the commercial hybrid), and (iii) line complementarity, by choosing lines that balance advantages and disadvantages (i.e., no line is best for all traits of importance but the right combination of lines allows for harmonizing a good combination of desirable characteristics).

The performance of the commercial layers depends not only on all the selection and crossbreeding that occurs upstream in the genetic flow (**Figure 1**) but also of the complex interaction of several non-genetic or environmental factors (**Figure 2**). It is generally accepted that the extraordinary performance of modern poultry (broiler and layers) is mainly the result of a long implementation of successful breeding programs by the genetic companies.

The final expression of genetic potential depends on a complex interaction of multiple factors, among which genetic is only one. Nutrition, environment, health status, and management are the most important drivers of commercial performance. These drivers are composed of many factors that interact together, producing a wide variety of effects in the field that can be positive or negative to performance. Examples of important interaction are genetics-x-nutrition, genetics-x-health, health-x-nutrition, and so on. These interactions contribute to the variable expression of performance seen under the array of environmental conditions. Major environmental factors having fundamental roles in the expression of the performance include: macro- and microclimate, housing system, lighting programs and light types, ventilation, relative humidity and temperature control by the use of fans, foggers, etc., the adequacy of feeding and drinking systems, and space allowance.

A more detailed description of these factors and their impact in commercial pullet and layer performance will now be examined.

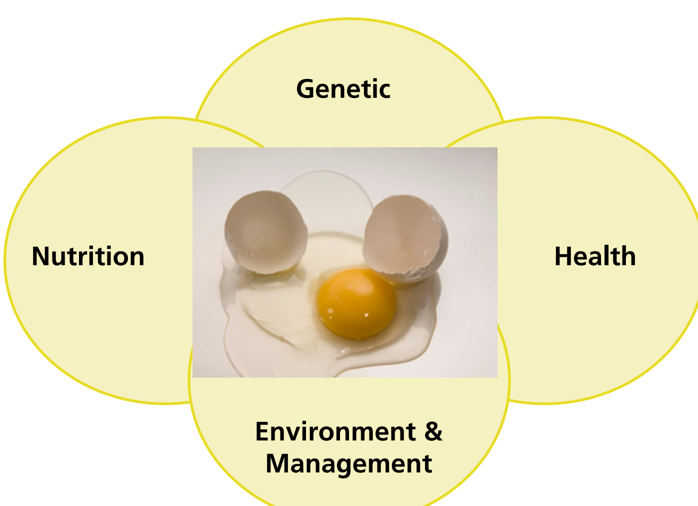


**Figure 2** - Factors that affect performance and product quality in egg production.

## Chick quality and layer performance

Chick quality has proven to be a difficult and subjective matter to define (Willemsen *et al*., 2008). In general, it is commonly agreed that high quality chicks are: clean when removed from the hatcher (free from adhering dried yolk, shell and membranes), dry with a completely sealed navel, free of deformities (straight feet and legs with no lesions or swellings), and alert and ready to explore its environment (Decuypere *et al*., 2001). DOA chicks should be of the correct size and possess the vigor needed to survive transport and quickly adapt to the poultry house environment.

Chick quality can be directly influenced by the quality of hatching eggs. The size, shape, and shell integrity of the hatching egg are influenced by nutrition, genetics, age of flock, disease and house temperature. It is important that the hatching eggs used for incubation are clean and free of shell contamination. Shell contamination is affected by house temperature, relative humidity, ventilation, drinker height, drinker flow rate and the frequency of egg collection. Embryo development and time of collection, egg storage, incubation temperature, incubation carbon dioxide concentration and spread of hatch time can also influence chick quality (Wilson, 2001).

In practice, good chick quality is the crucial first step to optimizing commercial performance and profitability. Modern strains of layers and broilers are selected for high genetic potential, and relatively small imbalances in chick quality can have a major impact on subsequent performance (Molenaar, 2009).

Feeding and management of pullets during the growing period profoundly affect pullet development and subsequent egg production and egg weights during the laying period. Mistakes made during the growing period can lead to poor production during the laying period and cannot be easily corrected. Therefore, flexibility in pullet diet formulation and in the timing of diet changes is necessary to ensure that body weight and uniformity targets are met.

Feeding the starter diet as crumbles can improve body weight gain and uniformity by increasing the chicks' feed consumption and avoiding selective feeding.

Young pullets do not regulate feed consumption according to energy intake as well as mature laying hens. Pullets will usually respond to higher energy diets with an increase in body weight gain. Increasing the dietary energy content to promote growth at higher environmental temperatures (when feed consumption is depressed) may not be as effective as observed at lower temperatures, therefore the concentrations of amino acids, minerals, and vitamins should also be increased proportionally, following the principles of formulating feed intake for laying hens.

Although high-density diets can be used to improve body weight gain, the sustained feeding of diets with higher-than-recommended energy content or with a low fiber content can result in inadequate development of the bird's digestive capacity for feed consumption, leading to low feed intakes and egg production during lay. As long as body weight targets can be met, the energy content of the pre-lay diet should be lower than that of the preceding (developer) and subsequent (peaking) diet to encourage increased feed consumption and build capacity for feed consumption during lay. A midnight feeding can be used to increase feed intake and body weight gain, which is especially beneficial in hot weather.

## Breeder management

### • Nutrition

Maternal diets can influence early chick performance primarily through their effect on egg size. Maternal diets should be well fortified with vitamins and trace minerals to support good fertility and hatchability. There are reports that higher levels of vitamin D and E in maternal diets can improve chick performance, but further work is needed in this area (Waldroup, 2011). Feeding the embryo in ovo is being explored as another area where future gains in chick performance may be developed, but at the present is still under investigation. One limitation of in ovo vaccination or feeding in layers is that only one sex is used for production, and no embryo sexing technologies are currently available at the commercial level.

Providing access to feed and water as quickly as possible post-hatch is one of the most practical and effective tools in stimulating early digestive function and establishing a beneficent intestinal flora that promotes growth and resistance to enteric pathogens throughout the growing period of the chick. Early diets for chicks should be highly nutritious and composed of good quality ingredients to avoid problems with mycotoxins, rancidity, etc. However, economical ingredients that might substitute for corn and soybean meal as primary sources of energy and protein for young chicks have not yet been clearly demonstrated.

### • Egg Weight

There is a clear difference in the hatching ability of eggs of different weight. The correlation between egg weight and hatchability differs among different lines of layers; however, a general trend indicates that eggs outside the optimum egg weight range have poor hatchability (i.e., too small or too big). For the specific case of some Hy-Line varieties: **(a)** W-36 hatching eggs should come from a flock about 25 weeks of age that is laying eggs weighing a minimum of 49 g, and, **(b)** W-98 hatching eggs should come from a flock that is 24 weeks of age or older and weigh a minimum of 49 g per egg, and **(c)** Hy-Line Brown and Silver Brown hatching eggs should come from flocks that are at least 24 weeks of age and weigh a minimum of 49 g per egg (Hy-Line International, 2010). Chick weight at hatch is directly related to the weight of the hatching egg. Smaller eggs from younger flocks will produce smaller chicks, with sub-optimal livability. Uniformity of commercial pullets is extremely important in attaining future production goals. To improve hatching egg uniformity, eggs should be set according to parent source flock and these groupings maintained until chicks are placed in the brooder house. Research indicates that grouping hatching eggs in 4-g increments and maintaining chicks hatched from each group separately can significantly reduce the size variability of chicks at 4 weeks of age (Hy-Line International, 2010).

### • Flock age

Flock age affects egg size, hatchability and chick size. Management practices should ensure good egg production while maintaining egg size within the optimum range. This will have positive benefits not only for breeder performance but also for chick quality, survival and growing ability. In particular, flock nutrition and lighting programs have to be adjusted so young flocks show early egg size that is as large as possible, while body weights and egg sizes are controlled as the flock ages. Flock age and egg size profile can also that affect hatchability, which can be optimized by using alternative lighting programs (see section "d" below).

### • Lighting Program and egg weight

Lighting programs during the growing period have long lasting effects on growth, body weight and the egg weight profile during the life of the flock (Arango *et al*., 2007; Settar *et al*., 2007); this is also true in breeder stocks (P. Settar, unpublished data). In general, pullets subjected to a slow step-down lighting program (20 h week 1, then ½ h decrease per week to reach 13 h thru week 16) will have delayed sexual maturity; but lay larger eggs during the entire laying period compared to hens subjected to fast step-down lighting programs (20 h week1, then 4 h decrease per week to reach 12 h thru week 3). Therefore, the lighting program can be used to fine tune the most desirable egg weight profile to optimize hatchability and chick quality. Depending on the line, the difference in egg weight can be up to 2 to 4 g for the first three eggs, and persisting thru lay by 1 to 2 g, when comparing a slow vs. a fast step-down lighting program during grow.

### • Beak treatment

Beak trimming is a routine practice used in laying hens to prevent feather pecking, cannibalism and reduce feed waste in breeder and commercial flocks. The effect of beak trimming on bird well-being depends on multiple factors, including the amount of beak removed and the quality of the procedure (Fahey *et al*., 2007).

Beak trimming by trained personnel improves livability, reduces cannibalism, and should be used in commercial strains and when light intensity cannot be controlled (Hester, 2005).

A study developed to determine the relationship between body weight (BW) and beak characteristics in Hy-Line W-36 one day-old chicks indicated that BW cannot be used as a reliable predicator of beak size, showing very low correlation (Fahey *et al*., 2007).

Beak trimming is not necessary in all management systems. However, if beak trimming is performed, proper procedures should be followed. The pullets are most successfully beak trimmed at hatch by infrared beak treatment or between 7 and 10 days of age by using a precision cam-activated beak trimmer (Hy-Line International, 2010).

### • Nesting behavior

Good quality hatching eggs should be clean and sanitized as soon as possible after collection from the nest box area. In order to get the best quality at the farm, only eggs laid in the nest should be used for hatching. Pullet and young layer management practices should be designed to provide "nest training" to the flock. They include: **(a)** provide the growing pullets with perches to encourage the jumping behavior needed to enter nests. **(b)** Confine the pullets to the slats (where the water and feeder lines are) at housing and allow the pullets' access to the nests during the day when they arrive. **(c)** Walk the birds several times daily, particularly in the morning, to ensure the birds are moving to find feed and water; this pullet training should be consistent for the first 8 weeks after the birds are placed in the laying house. **(d)** To reduce stress and ensure a trouble-free transfer, water-soluble vitamins, probiotics, and vitamin C (ascorbic acid) can be added to the drinking water 3 days before and 3 days after the transfer. **(e)** Open a few of the nest box curtains to encourage nest exploration in young laying flocks. **(f)** Nest lights can be used to train birds to explore the nests and should be turned on for 2 hours per day, starting 1 hour before the house lights are turned on and remain on for 1 hour after the house lights have been turned on. Nest lights will help prevent overcrowding and smothering inside the nests. False walls that are 1-2 m (3-6 ft) in length every 12 m (39 ft) along the line of and perpendicular to the nest boxes will reduce nest overcrowding.

It is important to eliminate shadows in the lay house, as dark areas outside the nest will encourage floor eggs. Lights should be positioned to eliminate shadows on the litter below the slat area. The lights should be brightest over the litter or resting areas and dimmest at the front of the nest boxes.

Some breeding companies also incorporate nesting behavior in their selection program. Hy-Line has done extensive research in this area for several years and has implemented selection to reduce outof-nest eggs after finding genetic variability for this trait (Settar *et al*., 2006).

### •Floor *vs.* Cage systems

Depending on the production system, breeders can be kept in cages (large and environmentally enriched types) or floor systems. Both systems can be used successfully, but management differs significantly for these two systems and has to be carefully adjusted to ensure maximum flock performance. One of the main factors is male:female ratio and sires' mating performance (see section below). The breeding pens should be walked frequently (e.g., every 2 hours) in the afternoon while mating is occurring. This will prevent males from corralling hens when the birds come into production. Diets should be adjusted accordingly, since birds in floor pens are more active, and in cold climates may require higher levels of energy for maintenance.

### •Male ratio

Suggested male:female ratios are a function of genetic lines and mating behaviors. For Hy-Line varieties, there are specific recommendations for each product, with ratios varying from 7 to 11% males (Hy-Line International, 2010). It is important to carefully adhere to these recommendations to maintain a good balance of mating expression, with low aggressive behavior. Too few or too many males may lead to poor fertility and substandard performance.

### •Hatchability

Hatchability is a complex flock age dependent trait, comprised of several genetic and environmental factors arising from various sources (Wolc and Olori, 2009). In a study that examined the genetic basis of egg production, fertility and egg quality traits and how these relate to hatchability, both sire and dam genetic components were important in overall hatchability, mostly because of the significance of these components on fertility and early embryo mortality. The dam that laid the egg is the main source of genetic variation in hatch of fertile eggs, suggesting a huge impact of egg quality traits. Paternal and maternal genetic effects vary with the age of the flock (Wolc and Olori, 2009).

Predictable hatchability of first quality chicks within a narrow hatching time window is a common objective for commercial hatcheries. To improve reproductive traits by genetic selection, they must be included in the selection index, with proper attention to all genetic correlations to other traits. In view of the negative correlation with egg weight, focus on hatchability should be limited to female lines, while selection for desirable egg weight is practiced in male lines. With this strategy, egg weight could decline in the female lines toward a level determined by chick quality standards. Persistent egg production and high yolk percentage are positively related to hatchability, and only the negative correlation with albumen height indicates a conflict with traditional breeding goals in White Leghorns (Cavero *et al*., 2011).

### • Egg Age

After oviposition, $CO_2$ and $H_2O$ are lost from the egg, the albumen pH increases from about 7.6 to about 9.0, the yolk pH increases from about 6.0 to about 6.5, the albumen height decreases, and the strength of the yolk membrane decreases as well. Because these changes in the embryo and the egg properties both occur during egg storage, it is difficult to determine which of these changes causes the negative effects of prolonged egg storage on hatchability and chick quality (Reijrink, 2009). Carbon dioxide level in the albumen is inversely related to albumen pH and is influenced by storage time. Carbon dioxide level is high when an egg is laid and decreases with time, causing the pH of the albumen to increase. Eggs stored less than 6 hours have too low a pH, decreasing hatchability. Too high a pH impedes the initiation of embryo development once eggs are placed in the incubator. The higher the storage temperature, the faster albumen pH will increase (Deceuypere *et al*., 2001). The effect of storage may be explained by the deterioration of the egg internal quality, especially albumen height during storage (Tona *et al*., 2002).

The stage of embryo development at the time the egg is laid differs by genetic strain in cell division rates. The embryos in the more advanced stages (gastrulation) prior to being laid by the hen withstand storage better and restart development more successfully when placed in the incubator. Egg cooling stops embryo development. House temperature and collection frequency affect the time needed to cool the eggs. Gastrulation stage is preferred for good embryo survival after storage and exposing newly laid eggs to prolonged high temperatures before storage causes continued development past this preferred stage (Wilson, 2001).

Under practical conditions there appears to be an empirical relationship between storage time and temperature. Short-term storage benefits from the higher temperatures (15-16 °C) and storage times in excess of 5 days benefit from lower temperatures (11-12 °C) (Hesna, 2009).

**• Egg temperature**

For optimum hatchability a consistent setter temperature between 37.5 °C to 37.8 °C is necessary, which is influenced by machine size, incubator type (single or multi-stage), design, tray position, ventilation rate and space between eggs. Temperature fluctuations during incubation should be kept to 0.3 °C. The challenge during this phase is to prevent variations within the machine that would result in advancement or delay in embryo development. Depending on breed and stage of development, variations might not be proportional, causing reduced hatchability and chick quality and performance problems (Wilson, 2001).

Incubation climate can significantly influence hatchability, chick quality, and later performance. One of the most important factors is the incubation temperature. For practical application of prenatal 'temperature training' as introduced by Tzschentke and Halle (2010), the questions of interest are: **(1)** which pattern of temperature variation is optimum, **(2)** are there differences in the effect of prenatal 'temperature training' between poultry breeds and lines as well as between males and females, and **(3)** what is the influence of factors like breeder age and egg storage time on the outcome of prenatal 'temperature training'?

The temperature experienced by the developing embryo is dependent on the incubator temperature, the metabolic heat production of the embryo, and the thermal conductance of the egg and surrounding air. Studies investigating the effects of temperature on the development and hatchability of embryos have concentrated mainly on the effects of incubator temperature and have ignored the other two factors. The equation below provides an accurate description of egg temperature than can be achieved by equating egg and incubator temperature. The model can also be used to predict the effects of incubator design on egg temperature and highlights the importance of air flow within the machine (French, 1997).

$$T_{egg} = T_{inc} + (H_{emb} - H_{water\ loss})/K$$

Where $T_{egg}$ = temperature of the egg (Celsius); $T_{inc}$ = temperature of incubator (Celsius); $H_{emb}$ = heat production of embryo at a given moment of incubation (Watts); $H_{water\ loss}$ = heat loss from evaporative cooling (Watts); and K= thermal conductance of egg and surrounding boundary of air around the egg (Watts per degree Celsius).

# Conclusions

The productivity of a breeding operation can be measured by the number of quality eggs produced and the number of quality chicks obtained from these eggs. This is a complex process in the layer chicken, which starts at the pure line level of the elite populations, and then makes its way down the gene flow thru the multiplication process. Many factors can affect final commercial hybrid performance. Future improvements in the productivity of the laying hen come from continual genetic improvements made by the primary breeding companies, along with advances in the areas of flock management, health status, nutrition, housing, production system.

# References

ARANGO J., SETTAR, P., SAXENA, S., ARTHUR, J.A. and O'SULLIVAN N. P. (2007) Effect of three lighting programs during growth on the performance of commercial egg laying varieties. 1. Laying period. *International Poultry Scientific Forum*. Atlanta.

CAVERO D., SCHMUTZ, M., ICKEN, W. and PREISINGER R. (2011) Improving hatchability in white egg layer strains through breeding. *Lohmann Information* 46(1):44-54.

DECUYPERE E., TONA, K., BRUGGEMAN V. and BAMELIS, F. (2001) The day-old chick: a crucial hinge between breeders and broilers. *World's Poultry Science Journal* 57:127-138.

FAHEY A.G., MARCHANT-FORDE, R.M. and CHENG H.W. (2007) Relationship between body weight and beak characteristics in one-day-old White Leghorn chicks: Its Implications for beak trimming. *Poultry Science* 86:1312–1315.

FRENCH, N.A. (1997) Modeling Incubation Temperature: The Effects of Incubator Design, Embryonic Development, and Egg Size. *Poultry Science* 76:124–133.

HESNA S.E., SENGOR, E., YARDIMCI, M. and CETINGUL I.S. (2009) Relationship between pre-Incubation egg Parameters, egg hatchability and chick weight from old breeder hens. *Journal of Animal and Veterinary Advances* 8(1):115-119.

HESTER P.Y. (2005) Impact of science and management on the welfare of egg laying strains of hens. *Poultry Science* 84(5):687-96.

HY-LINE INTERNATIONAL (2010) Online Management Guide. Copyright 2010 by Hy-Line International. May 2010. Available at: http://www.hyline.com/redbook/

MOLENAAR, R. (2009) Evaluation of chick quality: Which method do you choose? *Technical Information Hatchtech Incubation Technology*.

REIJRINK, I. (2009) Effects of storage and early incubation conditions on egg characteristics, embryonic development, hatchability, and chick quality. *Technical Information Hatchtech Incubation Technology*.

SETTAR, P., ARANGO J., O'SULLIVAN, N.P. and ARTHUR J.A. (2006) Evidence of genetic variability for floor and nest egg laying behavior in floor pens. *Proceedings European Poultry Genetic Symposium*. Verona, Italy.

SETTAR, P., ARANGO, J., SAXENA, S., ARTHUR J.A., and O'SULLIVAN N.P. (2007) Effect of three lighting programs during growth on the performance of commercial egg laying varieties. 1. Growing period. *International Poultry Scientific Forum*. Atlanta.

TONA, K., BAMELIS, F., DE KETELAERE B., BRUGGEMAN, V. and DECUYPERE E. (2002) Effect of induced molting on albumen quality, hatchability, and chick body weight from broiler breeders. *Poultry Science* 81:327–332.

TZSCHENTKE, B. and HALLE I. (2010) "Temperature training" during the last days of incubation: a new method to improve poultry performance. *Lohmann Information* 45(1):27-33.

WALDROUP, P.W. (2011) Early *Broiler Nutrition as Influenced by Maternal Diet and Post-Hatch Feeding*. Poultry Science Department, University of Arkansas, Fayetteville Arkansas, USA.

WILLEMSEN H., EVERAERT, N., WITTERS, A., DE SMIT L., DEBONNE, M., VERSCHUERE F., GARAIN P.P., BERCKMANS, D., DECUYPERE E., and BRUGGEMAN V. (2008) Critical Assessment of Chick Quality Measurements as an Indicator of Posthatch Performance. *Poultry Science* 87:2358–2366.

WILSON, J.L. (2001) *Extension Poultry Scientist.* The University of Georgia Cooperative Extension Service, College of Agricultural and Environmental Sciences. Athens, Georgia.

WOLC, A. and OLORI. V.E. (2009) Genetics of hatchability—Egg quality from the perspective of a chick. *Proccedins 6th European Poultry Genetics Symposium*, Bdlewo, Poland.