Genetic improvement in layers for egg production and quality

During the last few decades commercial layer flocks have shown significant improvements in terms of egg production and egg quality. The final goal of all breeding companies is to maximise the number of saleable eggs per hens housed taking into account other aspects like health and welfare. For example, breeding companies mention that yearly genetic progress in total number of eggs produced at 80 weeks are between two and three eggs and for shell strength between 25g and 100g.

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This improvement has two origins: environment (housing system, feed, hygiene status and all other zootechnical aspects) and genetics, the component that will be discussed and analysed in this article.

Back to basics

The key point to improve egg production and egg quality is phenotyping. Whatever the statistical method used, phenotypes need to be collected in a very accurate way.

For egg number, counting the eggs is simple. But period length of data collection is key. In the past, breeding companies kept their pure line birds until 60 weeks of age, then they moved to 80 weeks and now even more (100 weeks for Hendrix Genetics, which keep them longer).

Period length of data collection needs to be longer than what is done in the field. Indeed how could we be sure that birds will still have a good laying rate at 90 weeks or even 100 weeks if we stop measuring and select at 80 weeks?

For egg quality traits, some can easily be measured because they are the final breeding goal like egg weight or breaking strength. But sometime a choice needs to be done between the real measurement and a correlated one.

This situation occurs when measuring the real trait under selection is time consuming and only one measurement can be done. Then it could be more accurate to measure a correlated one but several times. For example dry matter content is not directly measured for the pure line selection but estimated with the yolk weight ratio.

Of course phenotyping is also key for other traits like feed behaviour (feed intake, feed efficiency).

The environment where data collection is done is also important. Pure line animals are kept in house with high biosecurity standards to be able to produce product (GP) which are free from disease to meet the international veterinary demands. That means that data collected at pure line level are done in ideal circumstances and only on females. For international breeding companies this is not enough.

Measurements need to be done in real practical circumstances. This is why so called 'field tests' are used. The test environment will be the one where birds have to perform (housing system, sanitary pressure, different water and feed quality, different temperature and humidity). All traits measured on pure line birds will also be measured on field test birds and such circumstances give the opportunity to work traits like liveability and robustness.

All those birds are wing banded and linked in the database through pedigree information. Another advantage of the field test is that it gives the opportunity to measure the genetic potential in egg number and egg quality of the pure line males.

Indeed males do not lay eggs but, like the females, they have a genetic potential for egg number and quality. To know it we produce pedigreed crossbred daughter groups on which data collection will be done.

Analyses and breeding goal

The breeding goal of genetic companies is led by customer demands. To improve pure lines in a given direction, data needs to be analysed.

For each trait minimum, maximum, average, variability and correlation with other traits will be calculated. Then a statistical model will be used to estimate genetic parameters like heritability (which is the part of the phenotypic variability explained by the genetic variability – values are from 0 to 1) and the breeding values for each animal and each trait. These values will be used in the selection process.

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Fig. 1. Breaking strength trend over the year measured at 40 and 80 weeks.

Fig. 2. Expected genetic improvement in egg production in future years.

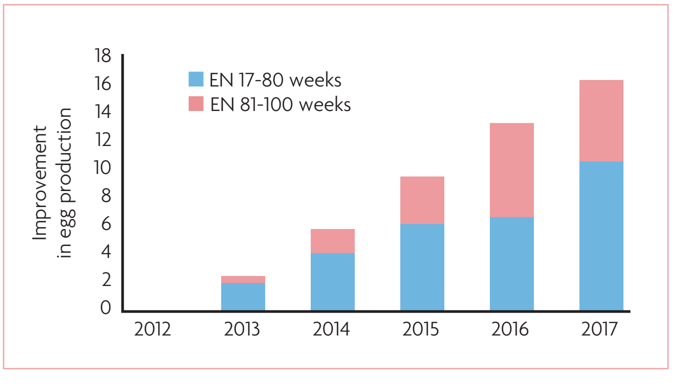
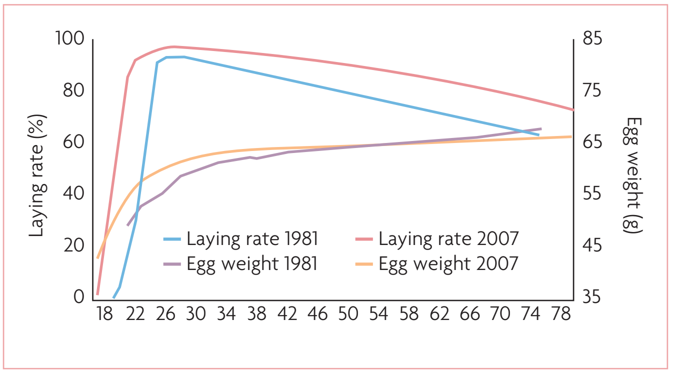


Fig. 3. Laying rate and egg weight curve of ISA Brown. 1981 versus 2007.



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Correlations need to be analysed, indeed according to the breeding goal it can influence the selection process. For example correlation between egg shell colour and breaking strength in brown layers is around -0.06. However, sometimes there could be strong positive correlation between two traits, such as early egg weight and late egg weight.

Past and future improvement

Field conditions can change over the years so it could be difficult to know if improvement is coming from genetic or environment factors. Breeding companies have facilities where the environment stays the same over the years. This gives the opportunity to see improvements that only come from genetics. As an example, in Fig. 1 you will find real improvement in breaking strength due to genetics.

As we can see, breaking strength measured at 80 weeks in 2013 is at the same level as the one measured at 40 weeks in 2001 (around 3950g).

The laying rate and egg weight curve have shown significant changes due to genetics. In Fig. 3 we can see improvement (1981 vs 2007 at 80 weeks).

To produce commercial laying hens from pure line animals, first grandparent stocks need to be produced and also parent stocks. This requires 3-4 years. With all data collected in pure line farms and in field test conditions, breeding companies are able to predict the future improvement of their products for all measured traits.

As an example, Fig. 2 shows the genetic improvement expected in the coming years (average over brown egg shell product of Hendrix Genetics).

New technologies

Genetic improvement is the result of the work done by the R&D team of the breeding company.

Geneticists in collaboration with research institutes also work on new technologies to speed up the improvement.

Today some breeding companies are using the genome wide marker assisted selection (or so called genomic) which gives a real advantage compared to 'traditional' selection. Indeed by reading DNA information of each bird with at least a medium density SNP (single nucleotide polymorphism = DNA marker) array, geneticists are able to predict breeding values sooner with high accuracy.

Of course companies which have their own SNP array have a higher advantage compared to the one that uses the referential panel which has not been developed for their own gene pool.

Genetic improvement, whatever the trait, is linked to :

- Selection intensity (positive correlation).
- Genetic variability (positive correlation) .
- Accuracy (positive correlation).
- Generation interval (negative correlation).

The first two points are directly linked to the capacity of breeding companies to have a big population size. The last two points are the ones that are impacted by genomics. Indeed in 'traditional' selection to increase accuracy, more data needs to be collected. For example, to be accurate on egg shell colour between 80 and 100 weeks, data would be collected on breeding candidate and sibs and then selection will be done. This impacts directly generation interval that will dramatically increase.

With genomic selection breeding value estimation can be done as soon as genotypes are analysed with a high accuracy. This is true especially for late traits compared to 'traditional' selection. Generally genotyped information are analysed during the rearing period to give the opportunities to select animals when they move into laying houses.

Assuming that accuracy stays the same and generation interval is decreasing by two, does it means that genetic improvement for egg number and quality will double? The answer is: yes, it could, but the chance that it will happen is low.

Genomics will be used to increase the speed of egg number improvements but also to work on new traits or more difficult ones like health traits, pecking and mortality for example.

Conclusion

Commercial layer flocks have shown significant improvements over recent years in terms of egg production and egg quality.

An estimation of future flock improvement is also promising due to extended cycles and new technologies, such as genomic selection.

The key points are:

- Good breeding goal definition.
- Large population size.
- High selection pressure.
- High accuracy (right phenotype, in the right environment and use of genomic in house SNP array).
- Shorter generation interval. ■