The genetic improvement of fertility and hatchability in breeders

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During the last few decades, commercial layer flocks have shown significant improvements in terms of number and quality of eggs produced. If breeding companies regularly mention that the breeding goal is to maximise the number of saleable eggs per hen housed, it is not exclusive; selection pressure is also on internal egg quality, feed efficiency and parent stock (PS) performance to produce chicks of good quality.

In the past (1960s and 1970s), selection was focused on productivity traits for the distributors but also for the egg producers, then (in the 1980s and 1990s) the egg quality traits were added to the breeding goals and since the beginning of this century breeding companies are taking into account welfare and health aspects when there is a genetic component (see Fig. 1).

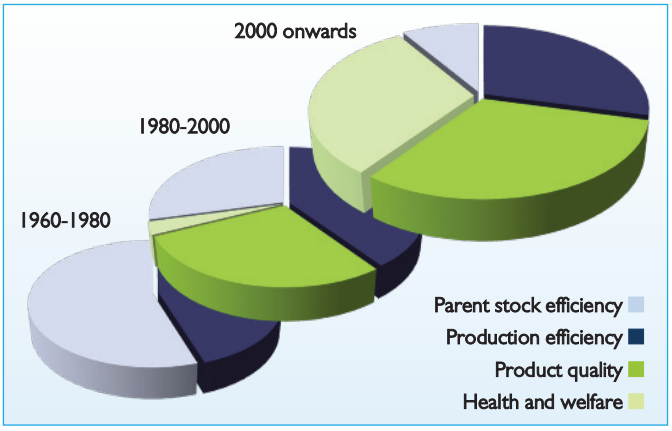
Although this trend might suggest that breeding companies hardly work on specific traits which are key for distributors, this is not the case.

The Institut de Sélection Animale (ISA) is aware that fertility and hatchability are key factors in the economic success of their distributors, next to the number of hatching eggs produced per hen housed. Of course hatchability automatically includes only chicks of good quality.

These reproduction traits depend on many environmental parameters, such as hatchery conditions (storage time, temperature and humidity in the storage room, incubators and hatchers), techniques used (short period of incubation during egg storage), the general condition of the breeder flocks and management applied. Of course when artificial insemination is used, the team carrying out artificial insemination is also a key factor. But, and this is what interests us here, genetics also explains some of the variability in observed performance.

If breeding companies focus a lot on egg producer traits, they do not forget to work on fertility and hatchability, because these are key traits for them too.

Fig. 1. Breeding goal evolution.



Fertility measurements

In the ISA breeding program, the semen of all males housed in their pure line R&D farms is tested several times during the life of the male. The semen test follows a strict procedure in order to be able to compare all males on a one-to-one basis (for example all males are trained before being tested, the time between sampling and measurement is the same for all individuals).

For such tests microscopes and spectrophotometers are used and the quality and quantity of semen is recorded (volume, motility, % alive, concentration). Only individuals with the best results and a good index will be used to improve pure lines.

The fertility results are recorded during candling when eggs are moved in the hatchers. Whenever an automatic or manual candling machine is used, true fertility is systematically measured.

A breakout session is done. All clear eggs are broken to determine whether there has been an embryonic development and, if so, when embryonic development stopped.

For each hatch, the hatchability results are registered in the database. Only chicks of good quality – perfectly hatched without phenotypic default – are taken into account. To avoid any bias, the position in the incubator and hatcher can also be recorded. All eggs are individually identified, the fertility result is recorded and related to males (sires) and hatchability results will be related to females (dams). Then data are analysed and used in the selection process.

Recording hatchability.

Each year 1,500,000 eggs are individually identified and used to produce animals that will be eventually wing-banded and on which data is collected. These eggs allow information on fertility and hatchability levels of the pure line breeding animals to be collected.

Hatchability related traits

Improving hatching results will come through improved fertility and hatchability, but not only. Indeed, other factors which can be changed through selection also have a role. Successful hatching is linked to an optimal egg weight, eggs should be neither too big nor too small, and this is one of the reasons why ISA continues to work on the shape of the egg weight curve of all lines. The optimum egg weight should be reached as soon as possible, and not increase much more thereafter. A good egg shell quality (good for gas exchange) is also a key factor. In order to get lots of DOC per females, the first point for distributors is to use PS with a good egg production level and good livability. All these traits are traits of primary importance to customers: the egg producer traits are already included in the balanced breeding program. Because ISA

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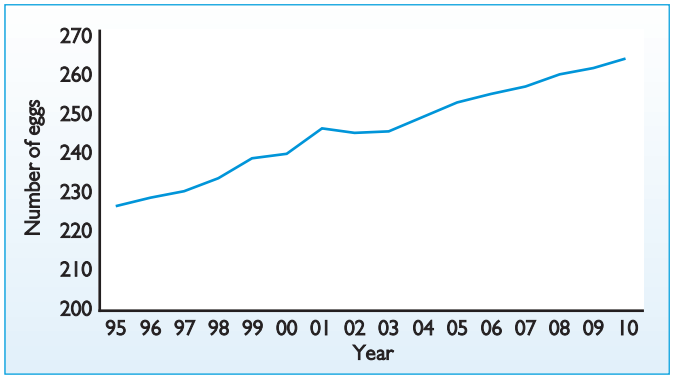

Fig. 2. Number of hatching eggs per ISA Brown parent stock female at 64 weeks.

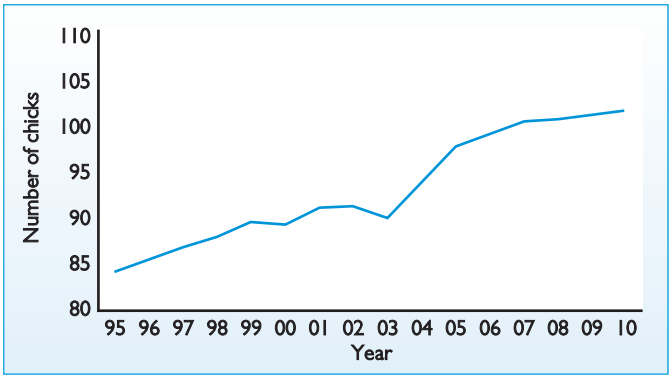

Fig. 3. Number of commercial female day old chicks per ISA Brown parent stock female.

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keeps its pure line birds up to 100 weeks of age, all traits are also recorded until that age, which helps to be more effective in the selection of the correlated traits like fertility and hatchability.

Some traits may be difficult to measure, for example sexual behaviour. Despite video recordings made during experiments, this is a complex trait to be considered. The majority of their GP flocks allow them to naturally favour correct sexual behaviour. Indeed, males with best semen quality and best sexual behaviour will produce the majority of the PS. But, new technologies like pedigree reconstruction based on DNA samples done at day one in the hatchery will allow ISA to collect a huge amount of data and avoid the difficulty of analysing thousands of hours of video recordings. Indeed the real number of DOC per male on the floor could be known.

Through high throughput genotyping, high throughput phenotyping can be done. These new techniques will become standard in the near future to improve certain traits. Other traits such as the interaction between semen of different males in the female genital tract are still under investigation.

For all traits mentioned above, genetic parameters, genetic breeding values and correlation with other measured traits in their breeding program are calculated. Heritability (which is the part of the phenotypic variability explained by genetic variability) for a trait such as hatchability is around 0.20 (from 0.11-0.31 depending on the pure lines), which makes selection a tool for improvement. Genetic improvement on one of the PS females is shown in Figs. 2 and 3.

Correlations between hatchability and other traits are not necessarily obvious. Some clients, having birds with the strongest shells, are worried about a loss of hatchability due to these strong shells.

Data collected in the breeding program shows that this does not need to be the case.

As we can see in Fig. 4, there is no correlation between hatchability and shell strength. It is the same for egg shell colour: it does not influence the hatchability results. Having darker eggs or stronger shells does not automatically mean better or worse hatchability. Characteristics like how porous the shell is or if the egg has a hairline crack is much more correlated with hatchability.

Late measurements

Fertility and hatchability are as many traits: improvement will come from better performance at the end of the life of the animals. Measures done on reproductive traits are collected during the life of the birds, up to more than 100 weeks of age for males. But waiting until there is a complete data set to obtain good accuracy of the estimated breeding value used for selection will lead to an increase of the generation interval, which will slow down the speed of the selection program. In such situations the use of genomics is important.

Indeed genomic information gives the opportunity to the geneticists to estimate breeding values for each bird at a young age with a high accuracy just with DNA analyses. Genetic improvement will speed up by reducing the generation interval, but pure line birds will still be kept and measured until 100 weeks to continuously update the link between trait performances and DNA markers which can slightly change over the years.

Impact on renewal cycle

Last but not least, ISA continues to work on reproductive traits such as fertility, hatchability, chick quality and total number of hatching eggs per PS female, where in the future the production cycles of PS flocks could be extended.

Direct customers may have in mind to extend their renewal cycle of their breeders to improve their profitability. Of course this will be possible and it will happen, but it is important that distributors are aware that whatever the breed they use, if they keep the PS longer, the frequency of their renewal will decrease.

The consequence of this will be seen at the CS level: evolution will be done in big steps, but less often than in the past. This is in opposition to a more linear competitive evolution that we can see with more frequent renewal.

Faster PS turnover makes it possible to deliver quickly the last genetic level offered by the breeding company to final customers. This is the reason why ISA does not further extend the reproductive cycle length of their GPS flocks. ■

Fig. 4. Shell strength plotted against hatchability.

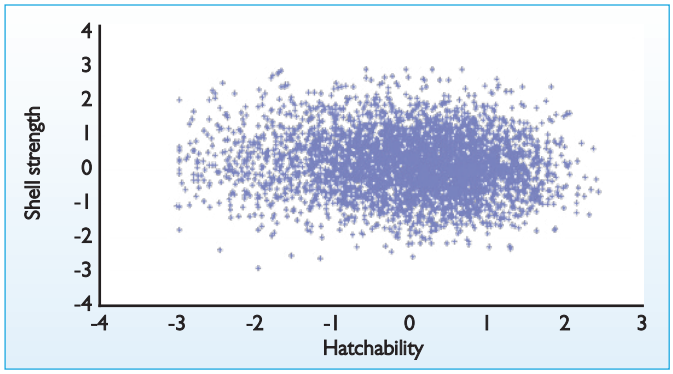

Fig. 5. Shell colour plotted against hatchability.