# THE POPULATION OF LAYING HENS LOSES IMPORTANT GENES: A CASE HISTORY

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**Summary**

The switch from keeping laying hens in a floor or free range system into a cage system led to a considerable change in the way that breeding and selection took place. In the past 40-50 years up to the present date, the increase in genetic improvement of the egg laying trait was substantial. However, age-adapted populations of laying hens seem to have lost some of their abilities to an adequate performance when returned to the old floor/free range systems. The strong concentration of all parts of the poultry production has meant that less than 10 international breeding companies supply most hens for laying purposes in the world and they have very little interest in developing genetic material for the West-European region where there are harked consumer preferences for eggs produced in non-cage systems. A particular Danish line, of White Leghorn origin named "The Skalborg hen" seems to have survived during an era of cage production system and they seems to have a production potential at farm level.

Key words: Genetic stock, Floor system, Cages, Skalborg line

## *Introduction*

The introduction of the hen as a farm animal can be traced back to 2000 B.C., but systematic breeding did not take place until the beginning of the nineteenth century, at least in Europe and America. Thus for about 200 years hen breeding and selection has taken place in Europe and America with the purpose of developing specific breed characteristics and eventually to breed for an improved egg laying capacity.

Up to the middle of the twentieth century selection and breeding was mainly based on progeny testing of males, in which the progeny groups were

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tested in pens. Around the 1950s an event of vital importance for housing layer hens occurred: the system of cages was introduced. The major impact of the change from the floor systems to the cage systems was that the "flock size" decreased dramatically, the "nesting behaviour" became non-interesting for the farmers and the hens were lifted out of the "manure environment". In this paper, some of the effects on the genotype as a result of such changes in the environment will be mentioned, as well as what happens when attempts are made to go back to the previous floor/free range system after a certain time. The results of a search for genetic material which still has some of the ability to perform appropriately in floor/free range systems are reported.

*The Effect of Switching from Floor Systems to Cages*

The switch from keeping laying hens in a floor or free range system into a cage system also led to a change in the way that breeding and selection took place. Previously the breeders had kept their hens in floor systems in family groups of hens in small pens or in large pens with a trap nesting system to record the egg production of the individual hen. Breeders developed the new cage system very quickly in the form of single bird cages as it was then possible to identify the exact egg production of individual hens. The best illustration to document the rational of this came from a Californian research work (Lowry and Abplanalp, 1970) in which a considerably larger genetic improvement in egg yield was demonstrated, when selection and breeding were based on information from hens in individual cages compared to selection for high numbers of eggs laid by free range hens in a trapnest system. A considerable genotype-environmental interaction was recognised, as the difference in egg yield between the two breeding methods was three times as large when both experimental lines were tested in cage systems compared to a test of the two lines in a floor system. The authors concluded that a specific genetic adaptation had occurred to the system in which they were bred.

After 40 to 50 generations of selection for an efficient hen under the cage system, the laying hen has been genetically developed to produce more than 300 eggs during the first 12 months of their laying career, and using less than 2.2 kg feed per kg eggs. Part of this efficiency is due to a reduced body weight. This substantial genetic improvement has taken place contemporary with a strong concentration and specialisation of the poultry production. On a world-wide basis less than 10 international breeding companies are presently supplying the majority of the breeding material which is behind the egg production in the developed world and they have a growing part of the market in the developing countries.

*Correlated changes*

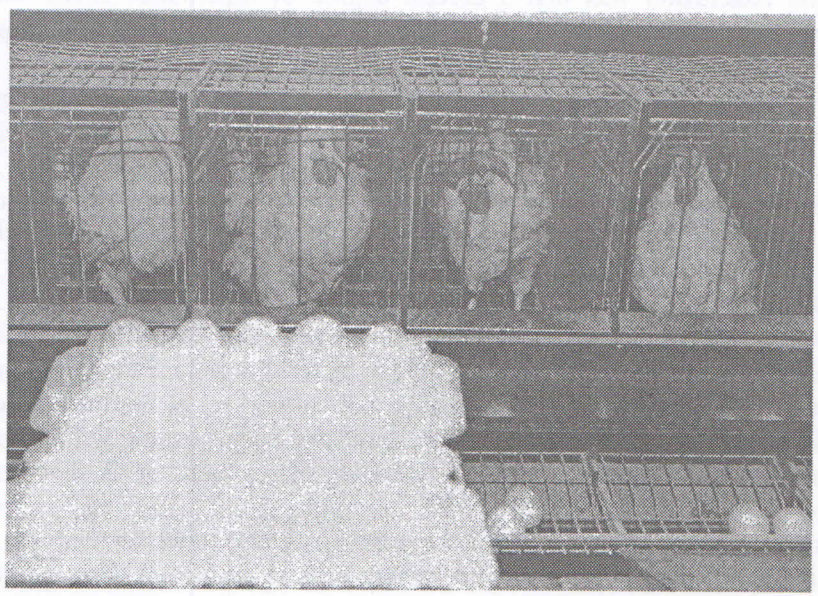
When trying to assess the performance of a production system which allows hens to move around in larger flocks, observations and investigations on these cage-adapted hens have, during recent years, shown, that these genetically cage adapted hens:

1) have lost some of their ability to go to a nest before oviposition;
2) feather peck against each other;
3) tend to peck aggressively, sometimes ending in cannibalism.

These are all behaviour characteristics to which the hen is not exposed in an individual cage and therefore will not influence her egg laying record, but these three issues will always be of importance for a hen in a floor/free range system with many hens influencing her egg laying record and the chance to be selected as a parent.

Regarding nesting behaviour, some results and experiences were obtained from a selection experiment with laying hens. The base population was created in 1969 by crossing 7 international commercially bred laying stocks. After four generations of systematic crossing the base population was divided into 5 experimental lines which for the following 6 generation were selected as:

Figure 1. - FREQUENCY OF FLOOR EGGS OF THE SELECTED LINES IN PROPORTION TO THE FREQUENCY OF THOSE IN THE CONTROL LINE.



- C-line. Control with complete random mating
- N-line. Selected for high egg number to 42 weeks of age
- E-line. Selected for high egg weight at the age of 38-40 weeks
- $I_1$-line. Selected for and index of high egg number and high egg weight
- $I_2$-line. Selected as line I1

In each line, 400-500 hens were tested for egg laying traits. The hens were kept in floor pens with 30 to 200 hens and the eggs from the individual hens were recorded on the basis of those laid on the trap nest. (Sørensen et al. 1982; Sørensen, 1992). Figure 1 illustrates the change in eggs laid on floor for the various selected lines in relation to the control line. The decrease in the curves for lines N, $I_1$ and $I_2$ is substantial and could be interpreted that these lines have got a better ability or willingness to go to the nest when laying their egg, and this effect is genetic in origin, as these lines have been selected for a high number of eggs laid in the nest, while the selection in the E-line was based on egg weight. It was not possible to estimate the heritability but it is not negligible as the selected lines have reduced the frequency of floor eggs by 9% per generation compared to the control line. It has to be added that the 7 international laying stocks, who were the base for the control line, are supposed to have been selected for high laying capacity in a cage system through several generations. The frequency of floor eggs in the control line fluctuated between 10 and 2 per cent during the experiment.

The conclusion was that a certain degree of inheritance exists for the nesting behaviour and breeding in a cage system. However, this does not necessarily imply that genes lie behind a good nesting behaviour.

Regarding feather pecking and cannibalism, there have been no reports demonstrating that selection for laying performance in individual cages has any correlated effect on feather pecking or cannibalism. On the other hand among flocks of hens in floor/free range systems there have been so many observations of defeathered flocks of hens and so many reports on flocks of hens in which cannibalism has been serious, that it is beyond just rare occasions.

During the last few years, there has been a growing interest in trying to test if there is any genetic variability which can be used to reduce these bad habits. Among those studies, the work by Craig and co-workers at Purdue University should be mentioned. For several years they have been working with problems related to the concept of aggressive pecking among hens or as they term it 'beak-inflicted injuries" (BI). Over several years, they ran selection experiments based on seven generations, (Muir, 1996) in which the birds were kept in group cages with up to nine halfsib hens in each cage. The criteria for

selection was a family based index which included survival rate. After 7 generations of selection, the mortality due to cannibalism was reduced to a third of what it was in the non-selected control line, 17% versus 48%, when tested in 12 bird cages and without beak trimming the hens (Craig and Muir, 1996). Thus there is obviously a considerable genetic potential in reducing the hens' disposition for cannibalistic behaviour, though it has not yet been tested if this change in genetic predisposition also would happen if the hens were tested under floor/free range conditions.

In Western Europe there has been much concern about the gentle feather pecking which leads to defeathered hens, but not necessarily to cannibalism. At Hohenheim University in Germany, developed equipments which can be used on a large scale to measure the birds' tendency to feather peck and he has recently presented a useful tool (Bessei et al. 1997). At Research Centre Foulum in Denmark, intensive studies have shown that the degree of inheritance is low ($h^2$=0.15), but there are prospects for genetic improvement through breeding and selection (Kjaer and Sørensen, 1997).

### *From Cages to Floor/Free Range - the Consumer Appeal*

Although the cage system from many rational points of view offers more advantages than any other systems of egg production, it must be admitted that the welfare of hens is generally better in floor/free range systems (Figure 2). These arguments have been used by the general public and in particular some special animal protection groups to request a ban on the cage system in several countries in Western Europe. After 15-20 years of public debate on the subject, the situation is that a real ban on the cage system does not exist except in one country (Switzerland), but in many countries there is a certain market for eggs from non-caged hens. The market share of eggs from non-caged hens in Denmark was 30% in 1996 and has shown a rapid increase over the last 3 years; similar changes had occurred in the other Western European countries where such public pressure exists.

### *Genetic Stock to Be Used for the Floor/Free Range System*

None of the few international breeding companies dealing with layer stock has shown real interest in developing a special hen for this floor/free range system as they argue that it is a small market for them, needs an expensive

breeding programme and nobody knows if the existing genetic material is suitable to use. They also claim that future consumer preferences are unpredictable, but above all they state that it does not fit into the large scale philosophy of the egg production.

Most of breeds developed by hobby breeders are poor layers because the main concern has been the exterior and not so much the laying efficiency. In spite of this there may be some original landraces which had formerly been bred to produce eggs.

Also there may also be some small scale breeders left in various countries who have had a particular interest in breeding for laying traits in special lines. These hens may not be as efficient as the ones from the international breeding companies but they have perhaps seen a particular possibilities to exist in a market of small holders or back yard hen farmers who obviously exist also in the developed world. The way these hens have been kept may differ substantially, but there may be some who have had their hens in floor systems for various reasons.

### *The particular situation in Denmark*

For reasons which had nothing to do with animal welfare there was a ban against cage systems for laying hens right from the beginning of the cage era in the 1950s. The ban was abolished in 1979. Denmark had, as all other countries, large numbers of poultry breeders, a number which decreased down to 4 in 1970. During the next 10 years these 4 breeders worked hard to compete with the large international breeding companies which were in the Danish market during most of the time. As the ban on cages existed, the egg producers kept the hens in large flocks either in floor systems with litter or in wire netting systems, termed the "Pennsylvanian system".

### *The Skalborg hen*

Among the four breeders, C. Christiansen, Skalborg has to be mentioned in particular. He had a long career as a poultry breeder and had already individual control over 3000 hens in the middle of the 1960s under the floor system. They based the measuring of the laying of the individual hen on the trap nest 7 days a week in a 12 month period. The myth says that he always brought a small axe with him and hens he found with an egg outside the nest was immediately

killed. Thus he had performed a most effective recording and a strong selection for hens which were well-behaved as to laying behaviour and relation to other hens in the house through 30-40 generations. He and his successor continued in the same way up to 1980. The Skalborg hens which actually was a cross of two lines became well known to be high yielding, calm and well feathered hens weighing slightly more than average and laying large eggs. The Skalborg hen had to compete with others from two Danish poultry breeders as well as the large international breeding companies. Two others of the 4 breeders obtained special permission to keep hens in individual cages and they imported genetic material from some of the foreign breeders which meant that their special ability to the floor system was soon abandoned.

The Skalborg hen met her fate the day the ban on cages for laying hens was abolished, which is easily seen in table 1.

Table 1. - COMPARISON OF THE DANISH SKALBORG HEN WITH VARIOUS INTERNATIONAL BREEDS, CARRIED OUT IN A FLOOR SYSTEM (NEERGARD, 1978) AND IN A CAGE SYSTEM (NEERGARD, 1983).

| Breeds | Country | Eggs in 365 days per placed hen* | Eggs in 365 days, hen day* | Eggs in 365 days per placed hen** | Eggs in 365 days, hen day** |
|---|---|---|---|---|---|
| Shaver | CanadA | 265 | 274 | 278 | 298 |
| Babcock | USA | 259 | 264 | | |
| Hisex | Netherlands | 264 | 267 | | |
| Lohmann | Germany | 259 | 268 | 276 | 285 |
| Dekalb | USA | | | 264 | 292 |
| Skalborg | Denmark | 262 | 267 | 240 | 266 |

*Test in floor system in 1978; **Test in cage system in 1982

Denmark as most other countries ran a Random Sample Test station for laying hens, in which the genetic material available on the market was tested. Up to 1980 this test took place in a pen-based floor system with 30 hens per pen and 4 pens per breed. From 1981 the system was changed to a 4-bird cage system and 128 birds per entrance.

From table 1 it is seen that the Skalborg hen competed reasonably well with other international breeds when the test was carried out in a floor system, but later when changed to the cage system Skalborg was the loser, partly because the other produced better in cages and partly due to a higher mortality observed in the Skalborg hen. The latter had been observed in other comparisons already and is most probably caused by the fact that the Skalborg hen was not adapted to the cage system.

Figure 2. - HENS IN FLOOR/FREE RANGE SYSTEM

*The Hellevad hatchery and the Skalborg line*

Among the four breeding centres mentioned above, the Hellevad hatchery had a particular position as they had the policy to be a supplier for the small holder and back yards. They had since 1956 bred a line of New Hampshire derived from a breeding company in USA. The Hellevad hatchery has long been known to produce a cross of White Leghorn x New Hampshire which has proven to be particularly value in small-scale egg production under semi optimal conditions. The breeding programme is rather simple and as no multiplying units was in play they have run a low cost operation and been able to survive due to the interest from the small scale market. The important aspect to mention is that they use and have used all the time egg yield laid in a trap nest, good feather condition and persistency in egg production as the base for selection. Also it should be mentioned that they had never used vaccine for the breeding bird, nor had they used beak trimming.

Our particular interest for the Hellevad hatchery is that the White Leghorn line they use and have used for many years is the female line of the Skalborg hen or line 01. In former times the Hellevad hatchery each year bought day-old male chickens from this line at Skalborg. At the time of uncertainty for the Skalborg breeding centre, the Hellevad hatchery agreed with the Skalborgs to

receive material from line 1 of the Skalborg hen so that they could continue the breeding with this line and have continued for 18 years.

*Conclusion*

The enormous concentration in the commercial poultry world has created a considerable degree of risk for monotypic populations as pointed out by Crawford (1990). The fact that these world-wide populations seem to have lost some of their ability to behave in a fully appropriate way in production systems which are still in use and preferred by consumers of the product should not be neglected. By discussing of the matter in Denmark it became clear that at least one line exists, the Skalborg line, which has not been through the process of a genetic alteration and adaptation to a system in which some behaviour traits could be harmful under other systems. It is important to identify these types of genetic material which may have a broader genetic variation and still have a production capacity at the farm level.

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## POPULACIJA KOKOŠI NESILICA GUBI VAŽNE GENE: POVIJEST BOLESTI

**Sažetak**

Prijelaz od držanja kokoši nesilica u slobodnom sustavu na zatvoreni sustav doveo je do znatne promjene u načinu uzgoja i selekcije. U zadnjih 40 - 50 godina došlo je do znatnog genetskog poboljšanja u značajci ležnja jaja. Međutim, izgleda da su populacije nesilica prilagođene zatvorenom držanju izgubile neke svoje sposobnosti adekvatne performanse kada su vraćene na stari sustav slobodnog držanja. Jaka koncentracija svih dijelova peradarske proizvodnje znači da manje od 10 međunarodnih poduzeća uzgajača isporučuje većinu kokoši nesilica u svijetu i njih vrlo malo zanima razvijanje genetskog materijala za Zapadno-europsku regiju gdje postoji izrazita potražnja potrošača za jajima iz slobodnog sustava. Određena danska linija podrijetla Bijeli leghorn po imenu "Kokoš Skalborg" izgleda da je preživjela u razdoblju proizvodnje u zatvorenom sustavu te izgleda da ima proizvodni potencijal na razini farme.

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