Breeding strategies and genetic adaptation of meat type and layers type birds used for organic production

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Summary
A number of investigations have showed that the layer type hybrids generally available have a numbers of short comings regarding behaviour in free range/organic production systems that manifest in: Too high tendency to feather pecking and cannibalism and many mislaid eggs. Experiments have shown that feather pecking, cannibalism and nesting behaviour can be improved by selection. Test among existing hybrids has not yet pointed out and ideal “organic hen”. The breeds used for table meat has to be based on slow growing bird. The breeds that have been used give problems with breast blisters and experiences has shown that work is needed to improve the carcass and the meat quality.

Introduction
Organic production of eggs and meat are subject to a numbers of rules and restriction. From the breeding point of view the free range requirement is perhaps the most serious for laying hens and the requirement of being 12 weeks before slaughter is the most serious for broilers.

When the construction we now know as cage was first introduced in North America shortly after the 2nd world war the start of a completely different life for the laying hen was initiated. It was not realised until almost 20 years later that the genetic improvement of egg production obtained in cages was not reflected to the same level when the same hens were tested under floor condition with litter (Lowry & Abplanalp, 1970, Dickerson & Mather, 1976). In other words a Genotype x System interaction was introduced, or one could speak of a genetic adaptation to life in cages.

The cage was of special interest for breeders in their selection for higher laying intensity. Before the introduction of cages genetic improvement was based on either progeny test of males based on daughter groups placed in small pens, or individual recording of laying capacity based on trap nest control in floor pen. Introduction of individual cages for hens improved the possibilities for a more precise recording of the individual hen and therefore also a better response to selection for higher egg yields. In the Scandinavian Selection and Crossbreeding Experiment carried out in the years 1970 to 1980 (Liljedahl et al. 1979), selection for high egg number to 42 weeks of age was twice as effective in cage system as when based on floor system (Sørensen, 1992). Thus the cage introduced some 50 years ago, and mentioned first time in Poultry Science in the 1956 volume, has increased in egg yield with more than 2 eggs per year over the last 30 years (Flock, 1999). The production today (2002) is 310 eggs during 360 days from 140 day of age, but using these hens in organic production system the production level is about 75% of that, further we are seeing a lot of different problems that causes cannibalism, mislaid eggs and high mortality rate.

Regarding broiler chickens the modern broilers offered from breeding companies has a growth capacity that allows reaching 2.5 to 3 kg before the age of 6 weeks. A further 6 weeks of growth results in chickens with body weights at 4-6 kg that is fare more than what is acceptable to market as chickens. On top of that a large proportion of these chickens will have leg problems to an extent, which will not allow the farmers to grow the chickens further.

This was the situation about 10 years ago when the interest for an organic production of poultry were started.
The laying hens

It is the impression from visits to breeding companies and discussions with their geneticists that the hygienic standard is very high in elite birds, mainly as a requirement from their customer. Also it is clear that the elite hen has been kept in individual cages for many generations, which implies that their laying pattern has not been disturbed by a social engagement to establish the ranking order.

The consequence in terms of genetic capacity has become a high egg-yielding hen assuming the management conditions are optimal. That means the hen should be kept in a well-equipped cage system, have free access to a balanced diet, and having a high hygienic standard supplied with a good vaccination program. If these conditions are not met we must admit a risk because the ancestors of the hen have:

- not been exposed to infection pressure for many generations and therefore no direct selection for disease resistance has taken place.
- been selected for a high numbers of eggs laid in the individual cages, and no drive exist for the hen to go to a particular nest for laying her eggs.
- not been disturbed by interplay with other hens during the period they were recorded for egg laying. Therefore the ability to perform an appropriate social handling of the other hen in the flock has not been in focus at all.
- had free access to a balanced diet; therefore the hen may get into trouble with her laying if the feed is not optimal.

Up until now it is known that:

- Native and local breeds not selected and the Red Jungle Fowl seem to have a better genetic resistance against infection, and often they also demonstrate a better defence and escape from predators. (experiences from rural area of developing countries)
- The floor laying rate of “cage adapted” breeds of laying hens was reduced to half over 5 generations of selection for laying rate in a floor system with trap-nest as will be demonstrated in a following section.
- When keeping hens of the high yielding breeds from international companies under floor condition in houses or in free-range systems there are too many cases in which the cannibalism and feather pecking get out of control.

Breeding companies try to neglect the effects of the genotype × environment (G × E) interaction, because it is inconvenient for them to have a selection environment that accounts for the traits of importance. Going through the literature on the subject there are many different findings, and the main conclusions are that the chance for a G × E interaction increases as the difference between the environments grow and the genetic distance between the breeds is large.

INDICATION OF A G × E INTERACTION

Until 1980 it was not allowed to keep hens in cages in Denmark and up to that time some Danish breeding companies used floor systems with trap-nest to record the individual laying of hens as a criterion for selection, one of these was the Skalborg Hen. Already at that time the large international breeding companies had some parent stock in Denmark and these hybrids vent into the Random Sample Test for laying stock at Favrholm in 1978 when they were still tested in floor systems. In 1980 the ban against hens in cages was lifted and at a trial at the Random Sample Test at Favrholm, Denmark, in 1982 the same breeds/hybrids were compared in a newly established cage system (Table 1).

In comparing Shaver and Lohmann with the Danish Skalborg it is obvious that in the floor system the Skalborg is equal to the international breeds. When tested in cages the international breeds have expressed their full capacity for laying which are 8% larger than on floor whereas the Skalborg produces at the same rate in both environments.
Table 1  Comparison of the Danish Skalborg hen with various international breeds carried out in a floor system (Neergård, 1978) and in a cage system (Neergård, 1983).

<table>
<thead>
<tr>
<th>Breeds</th>
<th>Country</th>
<th>Eggs in 365 days per placed hen</th>
<th>Eggs in 365 days, hen day</th>
<th>Eggs in 365 days per placed hen</th>
<th>Eggs in 365 days, hen day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shaver</td>
<td>Canada</td>
<td>265</td>
<td>274</td>
<td>278</td>
<td>298</td>
</tr>
<tr>
<td>Babcock</td>
<td>USA</td>
<td>259</td>
<td>264</td>
<td>267</td>
<td>285</td>
</tr>
<tr>
<td>Hisex</td>
<td>Netherlands</td>
<td>264</td>
<td>267</td>
<td>276</td>
<td>285</td>
</tr>
<tr>
<td>Lohmann</td>
<td>Germany</td>
<td>259</td>
<td>268</td>
<td>276</td>
<td>295</td>
</tr>
<tr>
<td>Dekalb</td>
<td>USA</td>
<td>264</td>
<td>292</td>
<td>276</td>
<td>285</td>
</tr>
<tr>
<td>Skalborg</td>
<td>Denmark</td>
<td>262</td>
<td>267</td>
<td>240</td>
<td>266</td>
</tr>
</tbody>
</table>

Looking at the relative difference between the two expressions for laying rate it was observed that Skalborg had a 5 time higher mortality in cages compared to the floor, while the international breeds had a mortality rate which was 1.5 time higher in the cages. The conclusion is that although there is no statistical significantly Hybrid × Management interaction it is obvious that the Skalborg breed is genetically adapted to the floor system whereas the international breeds are genetically adapted to cage systems.

**BEHAVIOUR TRAITS OF IMPORTANCE IN FREE RANGE/ORGANIC PRODUCTION**

When trying to perform a production system which allow hens to move around in larger flocks the following three traits seems important:

1. the ability to go to a nest before the oviposition
2. the tendency to perform feather pecking against other hens
3. the tendency to perform aggressive pecks sometimes ending with cannibalism

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

Regarding nesting behaviour we had some results and experiences from a selections experiment with laying hens. The base population was in 1969 created by a cross of 7 international commercially bred laying stock. The base population was divided into 5 experimental lines which for the following 6 generations were selected as

- **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
- **I1-line** Selected for and index of high egg number and high egg weight
- **I2-line** Selected as I1-line

The hens were kept in floor pen with 30 to 200 hens and the eggs from the individual hens were recorded on the base of those laid on the trap nest. (Sørensen et al 1980; Sørensen, 1992). Figure 1 illustrates the change in frequency of eggs laid on floor for the various selected lines in relation to the control line. The decrease in the curves for lines N, I1 and I2 are 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 has been selected for high number of eggs laid on the nest, while the selection in the E-line was based on egg weight. Thus 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 stock 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 conclusion was that a certain degree of inheritance exists for the nesting behaviour.

Regarding feather pecking there has been no reports demonstrating that selection for better laying performance in individual cages has any correlated effect on feather pecking or cannibalism. On the other hand there has among flocks of hens in floor/free range systems been so many observations of defeathered flocks of hens and also so many reports of flocks of hens in which cannibalism has been serious that it is beyond just rare occasions. In Western Europe a numbers of research groups have been concerned on this behaviour. At Research Centre Foulum in Denmark intensive studies has shown that the degree of inheritance is low (h² = 0.15), but there is prospect for a genetic improvement through breeding and selection (Kjær and Sørensen, 1997). It is later illustrated by a divergent selection experiment showing a considerable effect of selection direct for tendency to feather pecking over 3 generations (Kjær et al, 2001). See Figure 2.
Figure 2  Effect of three generations of divergent selection for tendency to feather peck (HP line for high tendency, LP line for low tendency). Bouts per birds is series of gentle pecks performed without interruption. (Kjaer et al., 2001)

Direct selection for reduce habits of cannibalistic behaviour were demonstrated by Craig and co-workers at Purdue University which through several years has been working with problems related to aggressive peck among hens or as they term it “Beak-inflicted injuries” (BI). After 7 generations of selection, the mortality due to cannibalism were reduced to a third of that in the non-selected control line or 17% versus 48%, when tested in 12 bird cages and without beak trimming of the hens. (Craig and Muir, 1996).

Thus there is obviously a considerable genetic potential in reducing the hens disposition for performing feather pecking leading to naked hens and also direct cannibalistic behaviour.

NON OPTIMAL FEEDING

In organic egg production it is often considered as a problem, that the organic rules do not allow to add amino acid to the mixture, and therefore it is often believed that the hens does not have a fully balanced diet.

At the Swedish Agricultural University at Uppsala two lines (A RIR line and a WL line) has been bred for better egg production based on a diet prepared from "home grown cereals" or a low protein level (13%) . This may be an advantage for organic production. This Swedish hen also termed SLU-1329 (RIR xWL) so far has been tested in aviary system and in free-range system in Sweden against conventional hybrids. In the Aviary system it was compared with Lohmann LSL feeding a 15% crude protein diet (Abrahamsen and Tausen, 1998) and SLU-1329 showed a significant less rate of lay (75% versus 83 %). Under floor condition the SLU-1329 was compared to Lohmann LSL and Hisex white and Hisex brown using the low protein diet (13.5 % crude protein) and had rate of lay of 75% and 78% up to 78 weeks of age in two investigations while the international hybrids had a rate of lay of the same or significant lower. In both test the SLU-1329 had a significant better feed efficiency (Wilhelmson & Carlgren, 1996; Wilhelmson et al. 1996). Thus it seems that the Swedish Hen is a good alternative when egg production takes place with a low protein diet under floor condition.
TEST OF BREEDS AND HYBRIDS
During the last 10 years there has been quiet a number of comparisons of breeds or commercial hybrids in several countries. Few of them are published and many of them are carried out on farms, which is OK from some points of views, but it is difficult to get reliable overall statements except for the egg production. Diseases, mortality and welfare issues remains to be studied more carefully before anything can be stated about a possible difference among the available breeds/hybrids to be suitable in an organic egg production.

QUALITY OF EGGS IN ORGANIC PRODUCTION
The problem of mislaid eggs is a big concern when dealing the external quality of eggs as eggs laid on floor always results in dirty shells, although much can be done with management here are obviously a genetic component that should be utilized. Regarding internal quality little is known that could be related to the genetics of the birds.

Meat type bird
Organic table bird production is a production system that has not reached a level yet that it is beyond the beginner. Due to rules that chickens should reach 12 weeks before slaughter and that they should be on free range for about 6 weeks, the experiences from the ordinary broiler production is not of much help.

Figure 3  Relationship between gait score (GS) and live weight, feeding a fully balanced diet.

At Gleadthorpe Research Centre in England were run a research programme to evaluate the suitability of different genotypes of poultry for use in extensive table bird production system, and 13 genotypes ranging from modern broilers to “traditional breed” participated in the investigation (Kestin et al 2001). On of the aspect were to investigate the degree of lameness of the various genotypes. In Figure 3 are presented the relationships between weight at 81 d and the gait score given as 0 for the perfect walk and 5 for the immobile bird.

At Research Centre Foulum a comparison between Ross208 females and a cross of a slow growing breed (Labresse) with a mediary growing Cornish breed showed that the Ross chickens on top of the lameness also had pectoral myopathy in some of the birds (Nielsen et al. 2003). In the affected birds a large proportion of the M. pectoralis minor was green and had an almost cooked appearance.

Thus the few farmers in Denmark have so far being using the ISA I657 which has been widely used in the French “Label Rouge” production system. Experiences and investigations from these farmers reports that there often are problems with breast blisters probably due to requirement that the rules prescribe use of perches.
References


