Genetic parameters for egg production and nesting behaviour in a non-cage environment

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To enable maximum use of data recording for breeding value estimation, layers are kept in single bird cages today. Daily egg recording, and quality tests on egg samples are the major input for genetic improvement in layers. After introducing single bird units, individual feed intake recording and egg quality assessment are the key traits for genetic improvement. With an increasing demand for eggs from non-cage systems, breeders have to adjust testing environment and breeding objectives to the changing production environment.
A novel nest was designed in which birds are identified by transponder technology in floor housing. Layer's behaviour and egg production can be automatically recorded without any obstruction to bird behaviour patterns.
The egg production and the daily pattern of nest visits have been recorded over a period of ten month in a flock of 337 Lohmann Silver hens which were housed in an aviary system with access to a covered outside run (winter garden). About 90% of the eggs were laid during the time between 6.00 to 11.00 a.m.. The hens spend about 10 minutes on a visit without laying an egg and if the hens do lay eggs, the visit takes 30 minutes, on average. The repeatability for this duration of stay in a nest box without laying an egg, varies from r=0.14-0.30. The repeatability estimates for the duration of stay are higher, if the hen lays an egg (r=0.43-0.51). In addition to the nest behaviour of laying hens, egg production parameters were recorded. In different periods, the heritability for rate of lay ranges from h^2=0.08-0.36. Genetic parameters for egg weight were estimated from eggs which were weighed on ten different days. The phenotypic correlation between the individual egg weights are very high (up to r_p=+0.85) and the heritability estimates for egg weight in floor housing are between (h^2=0.08 – 0.52), with variation from day to day. The performance testing in floor management with the funnel nest in combination with transponder identification supplies a major input for a breeding program in selecting hens dedicated to alternative housing.

Keywords: laying hens; floor housing; nest behaviour; egg production; genetic parameters

Introduction

Increasing demand of the consumers in eggs obtained from alternative housing systems, requires that breeding companies offer layers on the market which are capable of high egg production in non cage systems. Important selection traits for these hens are: high number of saleable eggs per hen housed in a non-cage environment and an adjusted behaviour like nest acceptance and plumage quality. In reality, it is hard to record these traits for a high number of hens for breeding population with reasonable labour cost and high accuracy. For this target, we developed a special transponder technology, with which it is possible to allocate each laid egg to the respective hen. An antenna in the floor of the funnel nest box, identifies the hen automatically, by reading a transponder which is fixed to the hens leg. In addition, the attached computer system records when the hen goes into the nest, when she lays the egg and when she leaves. With this data system, we have the possibility to measure egg production and egg quality parameter as well as the behaviour patterns of the hen in a floor housing system.

The aim of the study was to investigate the nesting behaviour of the hen and to design a nest system which makes it possible to record field data from performance tests in order to estimate genetic parameters which are important for a successful breeding programme for layers dedicated to non-cage environments.

Materials and methods

337 Lohmann Silver hens were housed in a floor system with access to a covered outside run (winter garden). Over a period of ten months' data of their nesting behaviour and egg production were automatically recorded with a technical system composed of leg transponders and nest-floor antennas. The 48 funnel nest boxes (which results a hen-nest ratio of 1:7), were opened from 3.00 a.m. to 3.00 p.m.. During this time all eggs are stored in an egg collecting tube in sequence of laying. Before collection, the eggs were marked with a printed label according to the sequence of laying, provided from the computer recording system. With these labels it is possible to allocate the egg to the respective hen. The data describing the nesting behaviour patterns, were automatically recorded when the hen moved in or out of the nest. 99,298 nest visits were analysed with the statistical program package "SAS", whereas about 30,000 nest visits of the first three 28-day-laying-periods were deleted. During this time the nesting behaviour would be influenced by 24 hour opened nest period as well as the disease of Mannheimia haemolytica (Pasteurella) and this would induce wrong conclusions. The heritabilities for the egg weight based on 10 different days were estimated with an animal model, using the programme VCE (GROENEVELD, E., 1998).

Results and discussion

The recorded data showed good nest acceptance of the Lohmann Silver hens. If only 2% of the laid eggs were collected as floor eggs, it is a sign for well designed nest boxes (APPLEBY, C. et al., 2004). Before onset of lay, 90% of the hens are exploring the nest boxes, and during this time the hens visited on an average of 9 times a nest box. After the hens laid the first egg, they moved on a daily average of 1.2 times into a nest box. About 70% of these nest visits per hen were successful nest visits, that means nest visits, where hens do lay eggs. The duration of stay in a nest box took around 30 minutes for a successful nest visit, whereas a nest visit without laying an egg took much shorter (around 10 minutes per hen) *(Table 1)*.

Table 1 Mean ($\bar{x}$), median, standard deviation (s), minimum (min) and maximum (max) values for the duration of stay in a nest box with and without oviposition

	$\bar{x}$	median	s	min	max
with oviposition (min)	29.80	26.96	13.70	0.48	106.47
without oviposition (min)	10.39	7.99	11.66	0.26	153.98

The repeatability for this duration of stay in a nest box without laying an egg, varied from r=0.14-0.30 within the different laying periods. The repeatability estimates for the duration of stay were higher if the hen laid an egg (r=0.43-0.51). The utilisation of the 48 funnel nest boxes were very constant and high, but it seemed that the hens didn't have a favoured nest box. Every hen occupied most of the available nests. 90% of the eggs were laid between 6.00 to 11.00 a.m.. Such a short time period in which most of the eggs were laid has also been found by many other authors (e.g. LILLPERS, K., 1993; ZAKARIA, A. H. et al., 2005), but the time of the day for this period differed. While ZAKARIA, A. et al. (2005) observed in broiler breeder flocks in the morning, LILLPERS, K. (1993) noticed that the early afternoon was a main egg laying period, for layers (White Leghorn) which were housed in individual cages. This range in oviposition time during the day is mainly regulated by environmental factors such as lighting programme, but genetic variation is just as important. The estimated heritability for the oviposition time differed in analysis from LILLPERS, K. (1993) depending on the three selection lines (one for egg number, one for egg mass as well as one for egg mass and food consumption) from 0.38, 0.68 and 0.78. Our own research achieved a estimated repeatability for the oviposition time which varied from r=0.37-0.56, depending on the laying period. For the analysis of egg weight, during 10 days in period 13, all eggs were individually weighted. The phenotypic correlation between the individual egg weights of each day are high (r_p=+0.66 - +0.85) and the estimates for heritability of egg weight vary in a range of h^2=0.08 to 0.52 for the different days. The reason for the low estimates at some days has to be further analysed *(Table 2)*.

Table 2 Heritability for egg weight

date	n	$\bar{x}$	s	s^2_e	s^2_a	s^2_t	h^2
28.11.	216	64.0	5.2	20.3	7.2	27.5	0.26
01.12.	216	63.5	5.2	19.4	7.6	27.0	0.28
04.12.	205	64.1	5.1	17.8	8.4	26.2	0.32
06.12.	204	64.4	4.9	15.0	9.4	24.4	0.39
09.12.	200	63.2	5.3	24.9	2.8	27.7	0.10
10.12.	206	63.7	5.4	14.4	15.6	30.0	0.52
12.12.	200	64.0	4.6	15.8	5.4	21.2	0.25
14.12.	212	64.4	5.0	15.7	9.5	25.2	0.38
15.12.	208	63.5	5.1	21.3	4.6	25.9	0.18
19.12.	194	63.9	5.3	25.5	2.2	27.7	0.08

Further statistic analysis' showed that the heaviest eggs were laid in the first morning hours of the day *(figure 1)*. Egg weights gradually decreased during the later day. These are results which were confirmed by ARAFA, A. S. et al. (1982), CHOI, J.H. et al. (1980) and ZAKARIA, A.H. et al. (2005). CHOI et al. (1980) pointed out that the time of oviposition had no effect on egg weight. The authors reported that some of the eggs laid early in the morning were the first eggs of the clutch, and it was concluded that the heavier eggs in the early morning hours are the result on the higher proportion of the first egg of the laying sequence being laid in the morning than later during the day.

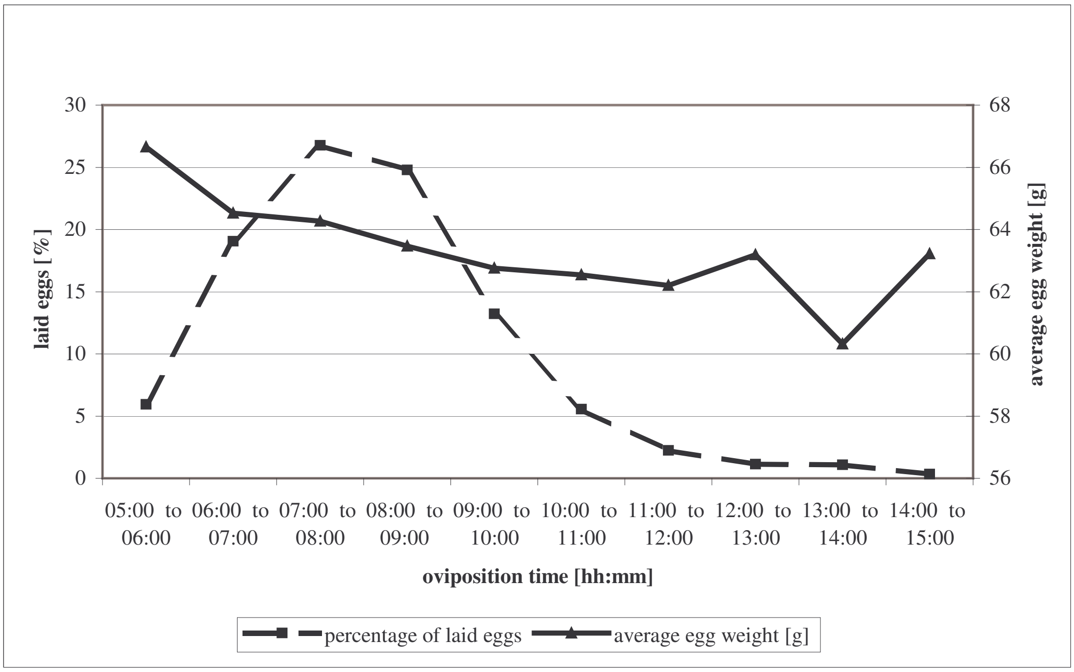

Figure 1 Distribution of oviposition time and egg size during the day

A laying sequence is determined by the time interval between two laid eggs by the same hen. The average clutch length was 13.5 ($\bar{x}$ =13.5, median=6, s=18.7) eggs, without a day off. LILLPERS, K. (1993) reported that the egg weight decreased significantly with increasing clutch length, but only for sequences with less than 18 eggs. The median of the time in oviposition interval is almost two minutes longer than 24 hours (24:01:43) which correspond to results in further analysis. After one or two days without an egg, the next egg was laid 17 minutes earlier during the day. The phenotypic correlation between the length of the laying sequence and the oviposition time were r_p= - 0.17. Accordingly, YOOH et al. (1988) reported that hens with short intervals laid their eggs earlier in the day than hens with longer intervals. Short intervals are linked with less days off and longer laying sequences, which results again in a higher rate of lay. In different periods, the heritability for rate of lay ranged from h^2=0.08-0.36 *(Table 3)*.

Table 3 Heritability estimates for egg number in different laying periods (from period 4 onwards min. 5 eggs/period)

laying period	**n**	$\bar{x}$	s^2_e	s^2_a	h^2
period 1	238	6.1	13.2	7.5	0.36
period 2	238	22.6	24.3	9.3	0.28
period 3	238	*11.1	65.2	7.7	0.11
period 4	238	24.1	19.3	5.0	0.21
period 5	238	26.2	10.1	0.8	0.08
period 6	238	26.3	7.8	1.2	0.14
period 7	238	26.0	6.3	1.4	0.18
period 1 -2	238	28.7	31.2	23.5	0.43
period 3 -7	238	113.7	191.1	14.6	0.07

*Drop in production due to infection with M. haemolytica

Estimated genetic correlations between the oviposition interval and part record egg number were r_g= - 0.45 (McCLUNG et al., 1976) and r_g= - 0.61 (YOOH et al., 1988). This supported the statement that hens with a capacity to lay one egg at roughly the same time every day, are the best layers.

Conclusion:

The funnel nest box offers the opportunity to record automatically important performance and behaviour parameter of hens, housed in non-cage systems. These data supply a major input for a successful breeding program in selecting hens dedicated to alternative housing.

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