Selection For Improved Manure Consistency In Layers

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Introduction

In the last decade, animal welfare and environmentally friendly production have gained more importance in commercial poultry breeding. Environmental pollution can be reduced by performance-adjusted nutrient supply and technical modification in husbandry systems. In commercial cages, a common used ventilation of the manure band, highly reduces the problem of ammonia emission. The ventilation immediate dries the manure and the NH_3 emission is thereby decreased. However, in alternative housing systems, this ventilation is not always common in cases of high costs, or rather not possible as it is for free-range systems. Therefore, feed specialists such as Roberts et al. (2007) or Pottgüter (2008) investigated the influence of feeding fibre enhanced digestions on the dry matter content of laying hen manure and found a lowered daily ammonia emission.

However, improvements due to selection are more sustainable and do not need further input for commercial utilisation. But if new traits have to be included in the selection process, reliable tools for phenotypic recording have to be available. Scoring the manure consistency in layers can be used as an additional trait to reduce nitrogen emission. Droppings with higher dry matter content show lower ammonia emission and the risk of getting soiled eggs is also reduced.

Before selection, reliable and efficient recordings systems have to be established to estimate genetic merits for each selection candidate. Beside heritability estimates for the new trait, genetic correlation with other traits of commercial interest have to be estimated.

Material and methods

The manure of 9194 White Leghorn hens, housed in two identically constructed houses, were in terms of their dry matter content (DM), analysed in this study. A subjective score which ranges from 1 (wet, < 40 % DM) to 5 (dry, > 60 % DM) was used to assess the manure of each hen in three consecutive weeks. Single bird cages guaranteed an exact assignment from hen to manure and made it possible to record all data of one house on one day by the same person. The full pedigree of all hens is well known and further performance data such as egg number, daily feed intake, egg weight, shell breaking strength and body weight were captured additionally. During the observation period, the hens' age varied in a range from 41 to 46 weeks for the five strains analysed (A, B, C, D, E) that belong to the Lohmann Selected Leghorn breeding scheme. To analyse the significance of the different fixed factors, i.e. house, tier and recording day on the single manure score, and to estimate the repeatability of the manure score, a variance analysis was done for each strain with the procedure MIXED by the statistic program SAS (2004).

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Model 1:

$Y_{ijklm} = \mu + HS_i + TR_j + RD_k + a_l + e_{ijklm}$

Y_{ijklm} = individual observation for the corresponding trait per recording day_k and $animal_l$

μ = overall mean

HS_i = fixed effect $house_i$

TR_j = fixed effect $tier_j$

RD_k = fixed effect recording day_k

a_l = random effect $animal_l$

e_{ijklm} = random error

To estimate genetic parameters as heritabilities and genetic correlations with the software package VCE 4 (Groeneveld, 1998), model 2 was used. Distinguished by strain, for each performance trait, the heritability as well as their genetic correlation to the manure score were estimated.

Model 2:

$Y_{ijklm} = \mu + HS_i + TR_j + a_k + e_{ijkl}$

Y_{ijkl} = individual observation for the corresponding trait per $animal_k$

μ = overall mean

HS_i = fixed effect $house_i$

TR_j = fixed effect $tier_j$

a_k = additive genetic effect $animal_k$

e_{ijkl} = random error

In a final approach performance traits have been classified in four different classes each and are included in the model to replace the additive genetic animal effect.

Results and Discussion

The distribution of the recorded number of scores was concentrated on a dry matter content between 40 % to 60 %, that means score-values of 2, mainly 3 and 4. Extremely wet or dry manure with a dry matter content of less than 40 % or respectively more than 60 %, were less than 5 % of the total observed. In the past, Preisinger (2000) measured much lower and more widely spread dry matter contents for laying hens' manure. In his study, the lowest dry matter content was on an average of 15 %, the highest with 65 % almost similar the results of Steffens et al. (2010). They published the results of the analysing laboratory, LUFA Nordwest from 2008, where the dry matter content of laying hens' manure varied between 38 % to 66 %.

The repeatability for the three manure scores recorded per hen were estimated with model 1 and are summarised in table 1. With exception of strain A, the house, tier and record number had a highly significant effect on the manures' texture. Within these three fixed effects, the highest F-value and therefore, the most important effect came up to the recording day in three of the five tested strains, followed by the house effect. Only 766 hens belong to strain A, which were all housed in the same tier and therefore no effect was treasurable. Further on, the repeatabilities were with $w^2 = 0.21$ to 0.29 for all strains, nearly the same.

Table 1: Repeatabilities as well as the significance of the fixed effects on the main trait manure consistency

strain	number of hens	ω²	fixed effect	F-value	level of significance
			house	74.9	***
A	766	0.21	tier	-	-
			recording day	1.5	n.s.
			house	150.1	***
B	2318	0.25	tier	92.0	***
			recording day	252.6	***
			house	131.5	***
C	1444	0.27	tier	80.5	***
			recording day	219.7	***
			house	126.4	***
D	2306	0.29	tier	47.0	***
			recording day	467.7	***
			house	221.7	***
E	2282	0.24	tier	4.6	**
			recording day	202.6	***

Further on, the performance traits feed intake, body weight, egg number at peak production and egg weight, have a highly significant effect on the average manure score per hen ($p<0.001$). In the same model, the egg number at the beginning of lay was also significant ($p<0.01$). No significant effect on the manure score could be estimated for breaking strength. The manure of all hens were irrespective of strain, more wet in house 2 than in house 1. In contrast to expectation, hens in the highest tier showed a significant lower dry matter content. Differences between strains were in this study as well as in a publication of Leenstra and Pit (1990) found. The driest manure was calculated for strain A and the wettest manure was observed in strain E.

The classified feed intake, body weight, egg number and egg weight also showed differences in the Least-Square-Means for the average consistency of manure per hen. Hens with a moderate daily feed intake of between 95g to 120g had the most dry manure. A comparison of different body weight classes showed a negative relation to the average manure score. The higher the body weight, the lower the dry matter content. A clear linear relation was also found between egg number and manure consistency. Hens with dryer manure laid more eggs. However, hens which laid bigger eggs tend to have more wet manure.

With slight exceptions, these described relations were confirmed by the estimated phenotypic and genetic correlations. Table 2 shows the genetic correlations between the performance traits and the manure score for each strain. Although the genetic correlation to the breaking strength highly varied from $r_g = +0.25$ to $r_g = -0.26$ between the analysed strains, with the exception of strain C, the correlation to the traits feed intake, body weight, egg number at peak production and egg weight always tend in the same direction. Therefore, the estimated genetic correlations not only confirm the results of the previous variance analysis, but also the conclusions of a study of Leenstra et al. (1992). Hens with a dryer manure eat less feed, have a lower body weight, lay more eggs, especially at peak production and their eggs can be smaller. Together with heritabilities that are in accordance to table 2 on a medium level for the manure score ($h^2 = 0.14$ to $h^2 = 0.36$), it is possible to consider the consistency of manure in a selection program for layers.

Table 2: Heritabilities for the different traits as well as their genetic correlation to the manure score, separated by strain

strain / trait	A		B		C		D		E	
	h^2	r_g	h^2	r_g	h^2	r_g	h^2	r_g	h^2	r_g
manure score	0.14		0.36		0.25		0.24		0.22	
feed intake	0.30	-0.44	0.43	-0.50	0.21	+0.11	0.22	-0.21	0.19	-0.23
body weight	0.72	-0.10	0.71	-0.50	0.68	+0.01	0.60	-0.20	0.66	-0.23
egg number at begin of lay	0.24	+0.74	0.41	+0.24	0.36	+0.003	0.47	-0.22	0.47	-0.10
egg number at peak production	0.18	+0.72	0.03	+0.04	0.10	-0.11	0.04	+0.13	0.02	+0.23
egg weight	0.68	-0.07	0.63	-0.33	0.53	+0.08	0.73	-0.14	0.66	-0.12
breaking strength	0.37	+0.002	0.29	-0.26	0.21	-0.06	0.30	+0.25	0.31	-0.02

Conclusion

Scoring the consistency of weekly droppings from birds housed in single bird cages can be used as an indicator trait for water content in the manure for each single bird. Measuring the actual dry matter content for the dropping of each hen is not technically feasible in commercial breeding programs.

Estimated heritabilities in the range of 14 to 36 % for this indicator trait have confirmed enough genetic variation within lines for good selection response. Costs for recording are low and repeated measurements contribute to higher selection power. Correlation with feed efficiency and egg output are favourable.

With the addition of subjective scored manure-consistency in the selection index, a significant sustainable contribution to a more environmental friendly egg production can be achieved.

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