

Selection of laying hens for improved consistency excreta

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Introduction

Ammonia (NH₃) emission is a major concern for the poultry industry, including laying hens. KLING and QUARLES (1974), CARLILE (1984) as well as DEATON *et al.* (1984) showed that excessive levels of NH₃ may adversely affect health and production by contributing to corneal ulcers, decreased lung function, lower egg production and reduced body weight gains. As a more general problem, it is of environmental concern as an aerial pollutant in closed houses and exhaust ammonia to the environment.

In commercial cage systems, the widely used ventilation of the manure belt reduces the problematic ammonia emission effectively. The ventilation immediately dries the manure and the NH₃ emission is minimized. In floor housing systems, however, ventilated manure belts are uncommon because of relatively high cost, and not possible for free-range systems. Therefore, feed specialists as ROBERTS *et al.* (2007) and POTTGÜTER (2008) investigated the influence of feeding fibre enhanced diets on the dry matter content of laying hen excreta and ammonia emission. The more exact method to determine moisture content applied by de Verdal *et al.* (2010) is not considered as practical for large numbers of hens in a commercial breeding program.

The objective of the current study was to determine whether individual differences can be determined subjectively with sufficient accuracy to serve as basis for genetic selection as a long-term approach to minimize environmental pollution. Individual observations on the consistency of the droppings of fully pedigreed hens in individual cages were collected and analyzed together with the conventional performance traits to estimate genetic parameters.

Material and methods

The weekly individually taken droppings of 9,194 White Leghorn hens of 5 LSL strains, housed in two identical single cage houses, was scored in regard to their dry matter content. A subjective score ranging from 1 (wet, < 40 % DM) to 5 (dry, > 60 % DM) was used to assess the manure of each hen in three subsequent weeks. All data were recorded by the same person, one house per day. From all hens the full pedigree is known. Performance data include egg number, daily feed intake, egg weight, shell breaking strength and body weight. During the observation period the hens' age ranged from 41 to 46 weeks.

Fixed effects as house, tier and week of observation on the individual manure score and repeatability of the manure score were estimated for each strain with the procedure MIXED of the statistics program SAS.

Model 1:

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

Y_{ijklm} = individual observation for each trait per record number_{kl} and animal_l

μ = overall mean

HS_i = fixed effect house_i

TR_j = fixed effect tier_j

RN_{kl} = fixed effect record number_{kl}

a_l = random effect animal_l

e_{ijklm} = random error

The average manure score per hen across the three observation weeks was used to study correlations with feed intake, body weight, egg production, egg weight and shell breaking strength.

Heritabilities and genetic correlations were estimated with the software package VCE 4 (GROENEVELD, 1998), using the following model 2:

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

Results and Discussion

The distribution of the recorded scores was concentrated on a dry matter content between 40 % and 60 % (scores 2, 3 and 4). Extremely wet or dry manure, with a dry matter content of less than 40 % or more than 60 %, were observed on less than 5 % of the hens. In the past PREISINGER *et al.* (1994) measured much lower and more wide 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 to this investigation and to results of STEFFENS *et al.* (2010). They published results from laboratory LUFA Nordwest obtained in 2008, where the dry matter content of laying hens' manure varied between 38 and 66 %.

The repeatabilities for the three weekly manure scores per hen were estimated with model 1 and are shown in table 1. With the exception of strain A, the house, tier and record number had a highly significant effect on the manure score. Within these three fixed effects the highest F-value and therefore the most important effect came up to the record number in three of the five tested strains, followed by the effect house. Only 766 hens belong to strain A, which were all housed in the same tier and therefore no effect was measurable. The repeatabilities were similar for all 5 strains, ranging from $\omega^2 = 0.21$ to 0.29.

Table 1: Repeatabilities (ω^2) and significance of fixed effects for the manure score.

strain	number of hens	ω^2	fixed effect	F-value	level of significance
A	766	0.21	house	74.9	***
			tier	-	-
			recording day	1.5	n.s.
B	2318	0.25	house	150.1	***
			tier	92.0	***
			recording day	252.6	***
C	1444	0.27	house	131.5	***
			tier	80.5	***
			recording day	219.7	***
D	2306	0.29	house	126.4	***
			tier	47.0	***
			recording day	467.7	***
E	2282	0.24	house	221.7	***
			tier	4.6	**
			recording day	202.6	***

The performance traits feed intake, body weight, egg number at peak production and egg weight had a highly significant influence on the average manure score per hen. Early egg production also had a significant effect, with an error probability of $p < 0.01$. No significant influence on the manure score could be found for shell breaking strength. The average manure score was lower for all strains in house 2, i.e. the droppings appeared wetter than in house 1. A negative trend in the dry matter content was additionally recorded from hens which were housed in the lowest tiers to the top tiers. The estimated Least-Squares-Mean score for manure consistency decreased from 3.1 to 2.8, which refer to more wet droppings in the upper than in the lower level. Differences between strains were found in this study as in a publication of LEENSTRA and PIT (1990). The analysis of variance showed that strain A had the driest, strain E the wettest manure.

The classified feed intake, body weight, egg number and egg weight also showed differences in the Least-Squares-Means for the average manure score per hen. Hens with a daily feed intake between 95g to 120g had the driest 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 desirable positive correlation was found between dryness of excreta and egg production, while larger eggs appeared to be associated with wetter 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. Whereas the genetic correlation to the breaking strength highly varied from $r_g = +0.25$ to $r_g = -0.26$ between the analysed strains, the correlation to the traits feed intake, body weight, egg number at peak production and egg weight tend with exception of strain C always 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 dryer manure eat less feed, have a lower body weight, lay more eggs, especially at peak production and their eggs are 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 texture of manure in a selection program for layers.

Table 2: Heritabilities for manure score and conventional traits and their genetic correlations to manure score per strain.

trait	strain	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 early		0.24	+0.74	0.41	+0.24	0.36	+0.00	0.47	-0.22	0.47	-0.10
peak rate of lay		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

Measuring the actual individual dry matter content of the droppings of large numbers of hens is not technically feasible in commercial breeding programs. Instead, subjective scoring of the dryness of weekly droppings from birds housed in single bird cages was investigated as an indicator trait for water content in the manure for individual hens. Estimated heritabilities in the range of 14 to 36 % for this trait suggest enough genetic variation within lines to expect response from selection, which would be a contribution to more environment friendly egg production. Hens with the desired performance profile, i.e. producing more eggs from less feed, apparently tend to produce drier excreta. 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.

Zusammenfassung

Kotkonsistenz als Selektionskriterium in der Legehennenzucht

Eine subjektive Kotbeurteilung von Leghennen in Einzelkäfigen ist als Merkmal zur Bestimmung des Wassergehaltes in Exkrementen geeignet. Die exakte Berechnung des tierspezifischen Trockensubstanzgehaltes im Legehennenkot ist hingegen zu aufwendig, um die Kotkonsistenz in ein Zuchtprogramm zu etablieren.

Für die subjektive Beurteilungsnote des Kotes wurden Heritabilitäten von 14 bis 36 % geschätzt. Diese versprechen genügend genetische Varianz innerhalb der Linien, für eine erfolgreiche Selektion auf den Trockensubstanzgehalt im Hühnerkot. Wünschenswerte genetische Korrelationen zu weiteren wichtigen Selektionsmerkmalen, wie der Futteraufnahme und der Eizahl, sowie ein relativ geringer Aufwand für die Datenerfassung unterstützen die Einbeziehung dieses Merkmals in den Selektionsindex. Die subjektive Kotbeurteilung liefert einen nachhaltigen Beitrag zu einer umweltfreundlicheren Eierproduktion.

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