Statistical And Genetic Analysis Of Reproductive Traits In Laying Hens

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Introduction

In commercial egg production industries the most important key traits are laying performance, feed efficiency and egg shell quality. However, fertility and hatchability are important traits in a breeding program which has a great economical impact on franchise hatcheries (Cavero and Schmutz, 2009). Furthermore, high reproductive ability results in higher genetic progress of desirable traits in the nucleus tie and speeds up the transfer of genetic improvement from nucleus into the production tie (Bennewitz *et al.* 2007). The aim of this study was to analyze the components of genetic variation for true fertility, embryonic mortality at different stage of development and hatchability of fertile eggs.

Material and methods

Data and traits. A total number of 13’652 hatching eggs from 2087 white laying hens (Lohmann) of a full-pedigreed pure line kept in 2 different poultry houses were used. For the analysis of fertility and hatchability, eggs were taken from the 47th to 49th week of life. The eggs were collected daily and incubated after a storage time of 8-14 days. For analysis of reproductive traits, eggs that did not show livable embryos at candling on the 7th and 18th day of incubation as well as eggs that had not hatched were opened and examined macroscopically in order to assess the true fertility and to estimate the time of embryonic death by using the method according to Hamburger und Hamilton (1951). Early embryonic mortality (EEM) occurs during the first week of incubation, middle embryonic mortality (MEM) occurs after the 1st week of incubation and before transfer of the eggs into hatcher, and late embryonic mortality (LEM) occurs between the 18th day of incubation to hatching (Beaumont *et al*., 1997).

Statistical analyses. Statistical analysis of recorded fertility, embryonic mortality and hatchability data was carried out by the application of a linear logistic model. The data were analyzed for each poultry house separately including the effects of tier and age of hens with the GLIMMIX macro SAS. Estimation of variance components was done using univariate repeatability animal models with a logistic link functions including tier and age as fixed effects by applying the package ASREML (Gilmour *et al*., 1998). Heritabilities and

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repeatabilities were calculated using the variance of the logit link function. This implies a correction of the residual variance by factor $\pi^2/3$ (Southey *et al.,* 2003).

Results and discussion

Table 1 summarizes LS means and the significance of explanatory variables on reproductive traits. A significant effect of poultry houses was observed for fertility, EEM, LEM and consequently in the complex trait hatchability indicating the negative effect of environmental conditions of hens and or the environmental condition on poultry eggs directly.

The estimated fertility was in a range between 94% and 97 % and is slightly higher then reported by Förster *et al*. (1994). The distribution of embryonic mortality is illustrated in figure 1 A, showing that the 3rd day of incubation is the most critical time for embryonic survival. A number of factors affecting embryonic liveability in early stage of embryonic development such as genetics, age of hens, time of oviposition, egg weight and quality and length of storage are described and summarized by Christensen (2001). Some of these factors are associated with stage of embryonic development at oviposition, which may lead to a suboptimal precondition for embryonic survival during storage and incubation. Dehydration and albumen degradation occur during storage resulting in high embryonic mortality (Elibol *et al*., 2002). Compared to the result of research work of Förster *et al*. (1994) carried out on laying hens of the same genetic background, in this study the magnitude of early embryonic mortality is distinctively high. This is partly associated with longer storage of hatchings eggs which should be considered as challenge situation (figure 1 B).

Table 1: The effect of poultry house and tier on fertility, early, medium or late mortality in laying hens.

		Reproductive traits				
Poultry house	Tier	Fertility[1]	EEM[2]	MEM[2]	LEM[2]	Hatchability[2]
1		96.0±0.2[a]	11.4±0.3[a]	3.4±0.2[a]	8.3±0.3[a]	77.0±0.5[a]
2		95.1±0.3[b]	9.1±0.4[b]	1.6±0.2[a]	4.5±0.5[b]	84.8±0.5[b]
1	1	94.8±0.7[a]	10.8±0.9[a]	2.4±0.1[a]	8.4±0.8[a]	78.3±1.1[a]
1	2	95.9±0.4[a]	10.2±0.6[a]	3.1±0.3[a]	8.5±0.6[a]	78.1±0.8[a]
1	3	97.0±1.9[b]	13.8±1.1[b]	3.8±0.3[a]	8.1±0.8[a]	74.5±1.2[b]
2	1	94.2±0.4[a]	9.6±.05[a]	1.5±0.4[a]	5.5±0.4[a]	83.7±0.7[a]
2	2	95.4±0,5[a]	8.0±0.7[a]	1.6±0.3[a]	3.8±0.5[a]	86.6±0.8[b]

[1]Of all eggs set, [2] Of fertile eggs.

Due to management reasons, longer storage of hatching eggs is desirable and consequently a genetic improvement of hatching success of eggs stored for long periods is preferable. Another critical period for embryonic survival is the late phase of embryonic development with the peak of embryonic mortality at about day 19-20 of incubation (Jassim *et al*. 1996). Late embryonic mortality coincides with the period in which the demand for oxygen increases significantly and with a series of physiological events such as initiation of pulmonary ventilation, external pipping and hatch from the shell. LEM is mostly associated with conditions of incubation and genetic origin. Estimated genetic parameters for fertility and embryonic mortality are presented in table 2. The estimated heritability for fertility and hatchability in this study was on a low level in general, but in the usual range for fitness traits. The estimated heritability of fertility is distinctly higher than estimated heritability for embryonic mortality at different incubation stage and hatchability.

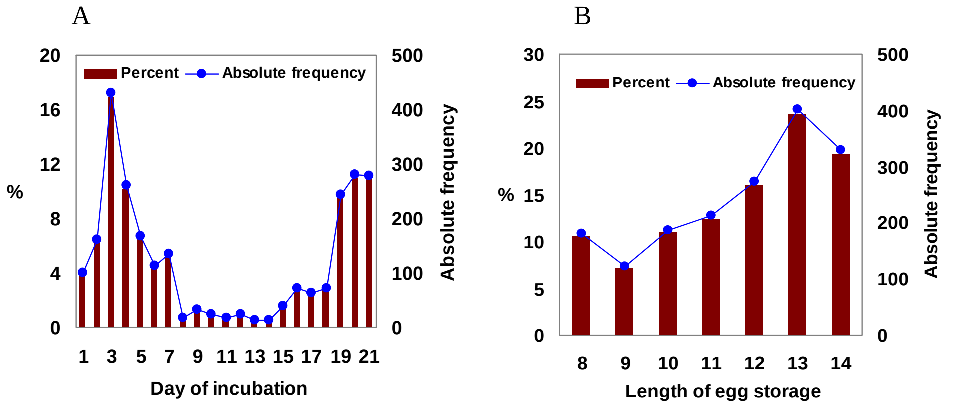

Figure 1: Proportion of embryonic death for different incubation days (A) and length of egg storage (B).

Heritability of fertility of eggs set as reported in the literature applying by different statistical methods range from 0.02 and 0.3 (Gowe *et. al*., 1993; Beaumunt *et al*. 1997, Bennewitz *et al*. 2007). The estimate heritability for embryonic mortality at different stage of incubation is quite low. In contrast to this study Beaumont *et al*. (2007) found heritabilities using a multivariate sire model for different stage of embryonic mortality of 0.09, 0.07 and 0.05 respectively. However, a comparison of genetic parameters with other studies is difficult due to different models applied und differences in the genetics of chicken lines.

Table 2: Estimation of genetic parameters for fertility, early, medium or late mortality in laying hens.

	Var (a)	Var (pe)	Heritability	Repeatability
Fertility[1]	0.567±0.198	0.705±0.183	0.124±0.042	0.279±0.021
EMM[2]	0.116±0.061	0.150±0.072	0.033±0.017	0.076±0.015
MEM[3]	0.00±0.0	0.402±0.182	0.00±0.00	0.109±0.045
LEM[4]	0.032±0.064	0.376±0.100	0.009±0.0174	0.110±0.020
Hatchability[2]	0.164±0.058	0.178±0.056	0.045±0.015	0.094±0.011

[1]Of all eggs set, [2] Of fertile eggs, [3]that survive early EMM, [4]that survive MEM.

Means and the range of estimated breeding value are presented in table 3. The reported breeding value is calculated by adding the overall mean to the estimating BLUP values on the logit scale and a subsequent inverse transformation. The reported values for fertility vary between 0.961 and 0.834 and those for hatchability vary between 0.807 and 0.681 which is almost a 15 percent difference in the probability of fertilization of eggs set and a 20 percent difference in hatchability. Taking into consideration the very high reproductive ability and very short generation interval in chicken, it is feasible to select animals successfully for high fertility.

Table 3: Mean, SD, and minimum and maximum breeding value for fertility and hatchability.

	Mean	SD	Minimum	Maximum
Fertility	0.961	0.0136	0.834	0.987
Hatchability	0.807	0.0251	0.681	0.879

Conclusion

The results of this study show that estimated heritability applying a univariate animal model for fertility was low but in the usual range for fitness traits. The estimated heritabilities for EEM and hatchability were very low and for MEM and LEM were quite low, resulting in lower selection response for the studied traits. However, considering high reproductive performance and low generation interval in chicken and the wide range in magnitude of estimated breeding values for fertility and hatchability it is feasible to select animals successfully for higher fertility.

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