Selection Against Mortality Due To Cannibalism In Layers, Does It Work?

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Introduction

Mortality due to cannibalism in layers is expected to increase due to prohibition of traditional battery cages in the European Union in 2012 and of the expected ban on beak trimming in a number of EU member states. Therefore, a solution is needed to reduce this problem.

One of the possibilities to reduce mortality is genetic selection. Mortality depends, however, on the behavior of group members, so-called social interactions. Traditional breeding methods, like individual selection, ignore these social interactions. Muir (1996) showed that group selection can be used to reduce mortality. Group selection, however, can only be used when selection candidates (SC) are housed in groups. In the poultry breeding industry, SC are typically housed individually to record own egg production traits. A selection method is needed that takes into account social interactions, while keeping SC individually. Ellen *et al.* (2007), therefore, proposed a selection method, where SC are housed individually and selected based on the survival of full sibs kept in family groups.

The aim of this paper is to demonstrate selection based on relatives and to compare realized response to selection with theoretical expectations.

Material and methods

Stock. A purebred White Leghorn layer line from the Institut de Sélection Animale B.V., a Hendrix Genetics company was used. The line was chosen because historic mortality records were reasonably high.

Selection method. This experiment was conducted within a commercial breeding environment. Hence, selection and mating decisions had to be taken within the operational limitations occurring in practical breeding programs. SC were housed individually, to allow individual recording of egg production traits. Full sibs of SC, with intact beaks, were housed in 4-bird family cages. Survival in the cages was recorded. SC were selected based on survival of their full sibs. For the first generation, SC were selected in two directions: high survival line, highest survival in 4-bird cages; low survival line, lowest survival in 4-bird cages. For the following generations, SC were selected in one direction: high survival line,

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highest survival in 4-bird cages. Selection decisions also took estimated breeding values (EBV) for egg production traits into account; only SC with good EBV for production traits were selected as parents. For the control, SC of the standard commercial breeding program were used. Hence, in the control line, selection was mainly for traits related to egg production. Selection took place when SC were approximately 40 weeks of age. Hence, at the time of selection, survival data was only partly known.

Offspring were hatched in more than one batch. For the high survival line, hens and roosters of the final batch were housed individually and used as parents for the next generation. Table 1 shows the number of hens per hatch and selection line for each generation.

Table 1: Number of individuals per direction of selection and per generation

	Generation 1			**Generation 2**		**Generation 3**	
Hatch	High	Control	Low	High	Control	High	Control
1	237	185	197	61	385	537	579
2	185	223	185	62			
3				100			
Total	**422**	**408**	**382**	**223**	**385**	**537**	**579**

Housing conditions. The first and second generation were housed in the same laying house, whereas the third generation was housed in a different laying house. Hens were allocated to laying cages, with 4 full sibs or half sibs of the same selection line and age in a cage. Hens were placed in the level closest to the lights.

Data and data analyses. Hens were observed daily. Dead hens were removed, and cage number and wing band number were recorded. For each hen, information was collected on survival (0 = alive; 1 = dead) and survival days. Survival rate was calculated as percentage of hens still alive at the end of the study. Survival days were defined as number of days from the start of the study till either death or the end of the study (with a maximum of 417 days). Survival rate was analyzed using logistic regression procedure and survival days were analyzed using survival analysis (SAS 1996).

Expected response to selection. Response (ΔG), *i.e.*, the genetic change of the mean trait value per generation, equals the per generation increase of the average Total Breeding Value (TBV) of the population,

$$\Delta G = \iota \rho \sigma_{TBV} \ , \tag{1}$$

(Ellen *et al.* 2007) where ι is the selection intensity, ρ is the accuracy, and σ_{TBV} the standard deviation of TBV among individuals. The σ_{TBV} is the square root of the total heritable variation in the trait, which equals (Bijma *et al.* 2007)

$$\sigma_{TBV}^2 = \sigma_{A_D}^2 + 2(n-1)\sigma_{A_{DS}} + (n-1)^2 \sigma_{A_S}^2 \tag{2}$$

where $\sigma_{A_D}^2$ is the direct genetic variance, $\sigma_{A_S}^2$ is the associative genetic variance, and $\sigma_{A_{DS}}$ is the covariance between direct breeding values and associative breeding values. The accuracy is the correlation between the selection criterion and the TBVs of individuals

$$\rho = r\eta \Big/ \sqrt{\tau + (1-\tau)/mn} \qquad (3)$$

(Ellen *et al.* 2007) where r is relatedness between the candidate and the sibs kept in family cages, $\eta = \sigma_{TBV} / \sigma_{TPV}$, $\tau = 0.5\eta^2$, and mn is the number of relatives in m groups consisting of n individuals each. TPV is the phenotypic analogy of the TBV, and equals $\sigma^2_{TPV} = \sigma^2_{P_D} + 2(n-1)\sigma_{P_{DS}} + (n-1)^2 \sigma^2_{P_S}$.

Results and discussion

Survival. Table 2 shows the average survival rates and days of the 3 generations and the different hatch weeks. In the first generation, high survival line yielded a significant higher survival rate and days than control and low survival line. In the second generation, control yielded a non-significant higher survival rate and days than high survival line. In both generations, there was a significant effect of hatch week. In the third generation, high survival line yielded the highest survival rate and days (not significant).

Table 2: Average survival rate and days per direction of selection and per generation

		Survival (%)			Survival days		
Generation	Hatch	High	Control	Low	High	Control	Low
1	1	72±3.4	62±3.5	50±3.1	375±7.4	356±7.6	329±6.7
	2	84±3.0	77±2.8	72±3.0	387±6.4	382±5.8	374±6.4
2	1	69±5.9	72±2.4		368±12.8	371±5.1	
	2	54±6.0			328±13.0		
	3	65±4.6			348±10.0		
3	1	82±1.7	80±1.6		387±3.5	383±3.3	

Response to selection. For the expected response, heritabilities were calculated using genetic parameters given in Ellen *et al.* (2008). The expected and realized response for each generation are given in Table 3. Both phenotypic standard deviation and standard deviation of TBV differ between the generations. Accuracy is highest for the first generation, because selection was based on full sibs, whereas accuracy was lowest for the third generation, because selection was based on a combination of full sibs, half sibs and cousins.

Expected responses ranged between 2.2 and 2.6 days. These are low compared to responses given in Ellen *et al.* (2007) and Wade *et al.* (Submitted), ranging between 9.6 and 19.2 days. Those responses were based on a selection intensity (ι) of 1. In the selection experiment, ι is, however, much smaller, ranging between 0.16 and 0.30, resulting in a lower ΔG . Realized responses were positive in generation 1 and 3 (11 and 4.3 days, respectively) and negative in generation 2 (-2.3 days). Realized response in generation 3 is in accordance with expected response. For future selections, it is important to increase ι. One option could be to postpone the age of selection, to increase differences in survival between different families.

In generation 2, a negative realized response was found. This negative response can not be explained by the expected responses. However, it could be due to management (Ellen 2009).

Table 3: Expected and realized response to selection

	Base generation	Generation 1	Generation 2	Generation 3
σ_P	60	71	114	79
σ_{TBV}	26	31	50	35
ρ	0.35	0.32	0.21	-
S_P [1]	14.2	11.4	34.0	-
ι [2]	0.24	0.16	0.30	-
$\Delta G_{Expected}$ [3]		**2.6**	**2.6**	**2.2**
$\Delta G_{realized}$		**11**	**-2.3**[4]	**4.3**

[1] $S_P = \overline{P}_{selected} - \overline{P}_{population}$. [2] $\iota = S_P / \sigma_P$. [3] $\Delta G_{Expected} = \iota \rho \sigma_{TBV}$, where ι and ρ refer to the parents. [4] Only hatch week 1.

Conclusion

Selection against mortality due to cannibalism is difficult and realized responses are small or negative. In the first generation, there was, however, a significant increase in survival in the high selection line. In this selection experiment, ι is quite low resulting in a small response. For future selection, it is important to increase ι, by means of increasing differences in survival between families used for the selection.

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