

Simulated Direct Selection for Feed Conversion Ratio in Laying Hens and its Effect on Relative Traits

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Abstract: The aim of this study was to simulate direct selection for feed conversion ratio in laying hens and to compare the prediction response of feed conversion ratio and correlated responses on related traits with family selection and within-family selection methods. We randomly selected 10 dwarf brown laying hens from each of 60 dam families for a total of 600 hens. Egg weight and feed consumption were recorded daily during the experiment (27-33 weeks of age) and the feed conversion ratio was calculated. The heritability estimated of the feed conversion ratio was 0.15 which indicates that direct selection for this trait was effective.

Key words: Heritability, simulated selection, dwarf chicken, egg weight, feed conversion, China

INTRODUCTION

The Feed Conversion Ratio (FCR) is defined as the feed consumed per unit egg weight in laying hens. The FCR of laying hens is a complex trait that is influenced by the interaction of many different component traits such as dietary energy level, environmental temperature, egg mass, Average Egg Weight (AEW), age of the chicken, Daily Feed Intake (DFI) and overall health of the hen. The available feeding space also may influence the hens' feed intake (Cunningham, 1982) and the FCR (Anderson *et al.* 1995).

Flock and Tiller (1999) indirectly selected for FCR in brown-egg hens, the results showed a decrease in feed consumption from 132.4 g day⁻¹ in 1968-124.9 g day⁻¹ in 1997. Preisinger and Flock (2000) used indirect selection methods to improve the FCR of laying hens from 2.46-2.10 between 1980 and 1997. The FCR can be selected indirectly through Egg Number (EN), feed intake and AEW. But it had been genetically selected so many years on laying hens and their egg production had physiological limit (Emsley, 1997) and market demands require that AEW is neither too big nor too small.

Therefore, it's a big difficult to select FCR with indirectly methods on laying hens. Otherwise, the FCR in broilers was improved through direct selection (Guill and Washburn, 1974; Pym and Nicholls, 1979). Genetic selection was used to create a highly efficient

broiler that can attain a body weight of 2.0 kg at 40-42 days of age with an overall FCR of <2 (Siegel and Dunnington, 1987; Hartmann, 1989).

The aim of the current study was to estimate the genetic parameters for this flock of dwarf laying hens. We then directly selected for FCR with family selection and within family selection methods and the correlated responses on related traits were calculated both for the methods. We want to know what the relative traits change with directly selecting FCR.

MATERIALS AND METHODS

Experimental animals: About 600, 27 weeks old dwarf hens (CAU 3 brown-egg dwarf chickens) were obtained from Beijing Agricultural University Poultry Breeding Company Limited (Beijing, China) and it consist of the basic population. The hens were drawn from 60 dam families with 10 hens randomly selected from each of the families.

Each hen hatched on the same day and all hens were reared under identical conditions. During the experimental period when hens were 27-33 weeks of age, the animals were maintained in 3 tier individual cages in a closed-type housing system with automated lighting and temperature control. Each cage contained water and one plastic-type feeder which would accurate calculation of the feed intake, respectively. The hens were fed a complete balanced diet based on the standard nutrient requirements

for laying hens. The feed for laying period based containing 16.50% protein, ME 2700 kcal kg⁻¹, 3.75% Ca, available P 0.25%, Arg 0.7%, Lys 0.69%, Met 0.40%, Met+Cys 0.65%.

Data collection: The FCR was calculated from 27-33 weeks. The Body Weight (BW27) of the flock was weighed at beginning on week 27. Feed (100-120 g) was added to each feeder each morning and the remaining feed for each hen was weighed weekly. EW and EN were recorded daily in the afternoon. The Age of First Egg (AFE) was recorded and the Total Egg Weight (TEW20-43) and Egg Number (EN20-43) were recorded from week 20-43 which were used to calculate the correlation selection.

Statistical analyses

Analysis Models: The genetic parameters of Daily Feed Intake (27-33 weeks) (DFI27-33), Average Egg Weight (27-33 weeks) (AEW27-33), Total Egg Weight (27-33 weeks) (TEW27-33), Egg Number (27-33 weeks) (EN27-33) and Feed Conversion Ratio (27-33 weeks) (FCR27-33) were estimated by DMU (DJF MULTivariate) software (Jensen and Madsen, 2008) which is based on Restricted Maximum Likelihood (REML) (Henderson, 1985) Methods. The following model was used:

$$y_{ij} = a + d_i + e_{ij}$$

Where:

- y_{ij} = The performance of chicken i
- a = The general mean
- d_i = The random additive genetic effect of chicken i
- e_{ij} = The random error

$$E(y_{ij}) = a + d_i$$

$$\text{Var}(y_{ij}) = \text{Var}(e_{ij}) = \sigma^2_j$$

Simulated selection: We directly selected FCR based on phenotypic value with family selection and within-family selection methods and the correlated responses on related traits were calculated that are DFI27-33, AEW27-33, EN27-33, TEW27-33, AFE and BW27. About 40% of the top FCR in the flock were selected (selected population) and compared those traits' correlated responses between selected population and basic population.

Family selection: The mean phenotypic values of FCR for each family were calculated and families with the top 24 (40%) mean FCR values were selected. The performance of the selected families was compared with that of the basic population. The expected response for each family (R_f) was calculated as follows:

$$R_f = sh^2 \frac{1 + (n^* - 1)r}{n^*[1 + (n^* - 1)t]}$$

$$n^* = \frac{(N - \sum n_i^2 / N)}{(a - 1)}$$

$$t = \frac{\sigma_B^2}{\sigma_T^2}$$

Where:

- S = The selection differential
- h^2 = Heritability with half-sib families, $r = 1/4$
- t = The correlation of phenotypic values for members of the family
- N = The number of individuals
- n_i = The number of individuals in family i
- a = The number of families
- σ_B^2 = The between group variance
- σ_T^2 = The total variance

The VARCOMP procedure and the METHOD = REML function in the SAS software package were used to calculate σ_B^2 and σ_T^2 (SAS Institute Inc., 1996).

Within-family selection: The individual phenotypic values of FCR were ranked in each family and hens with the top 40% FCR values within each family were selected. The performance of the selected individuals was compared with that of the basic population. The expected response within-family (R_w) was calculated as follows:

$$R_w = sh^2(1 - r) \sqrt{\frac{n^* - 1}{n^*(1 - t)}}$$

Those symbols used in the above equation are the same as the previous equation (Falconer and Mackay 1996).

RESULTS AND DISCUSSION

Heritability and correlation: Estimates of the heritability and genetic correlations for the different phenotypic traits and the FCR are shown in Table 1. DFI27-33 and AEW27-

Table 1: The genetic parameters of DFI27-33, AEW27-33, TEW20-43, EN20-43 and FCR27-33 for the dwarf laying hens

Traits	DFI27-33	AEW27-33	TEW20-43	EN20-43	FCR27-33
DFI27-33	0.59±0.11	0.49±0.15	0.49±0.29	0.65±0.25	0.68±0.19
AEW27-33	0.39±0.11	0.44±0.10	0.44±0.32	0.08±0.30	-0.23±0.25
TEW20-43	0.15±0.10	0.12±0.09	0.10±0.07	0.85±0.17	0.17±0.44
EN20-43	0.17±0.10	0.08±0.08	0.80±0.03	0.12±0.07	0.62±0.42
FCR27-33	0.18±0.11	-0.35±0.07	-0.16±0.07	-0.17±0.07	0.15±0.07

Heritabilities are on the diagonal ($h^2 \pm SE$), genetic correlations (Correlation coefficient $\pm SE$) are above the diagonal and phenotypic correlations (Correlation coefficient $\pm SE$) are below the diagonal. DFI27-33 = Daily Feed Intake (27-33 weeks), AEW27-33 = Average Egg Weight (27-33 weeks), TEW27-43 = Total Egg Weight (20-43 weeks), EN20-43 = Egg Number (20-43 weeks), FCR27-33 = Feed Conversion Ratio (27-33 weeks)

Table 2: The prediction response of FCR27-33 and the correlated responses of DFI27-33, AEW27-33, TEW20-43 and EN20-43 with Family Selection Method

Family selection method	FCR27-33	DFI27-33 (g)	AEW 27-33 (g)	EN20-43	TEW20-43 (kg)	AFE (day)	BW27 (kg)
Basical (Average±SD)	2.07±0.49	87.40±6.8	49.40±3.3	88.30±12.0	4.88±0.71	135.6±3.3	1.47±0.19
Selected (Average±SD)	2.01±0.15	84.50±3.0**	49.90±2.0	86.70±5.0	4.78±0.33	136.0±1.4	1.44±0.08
S	-0.06	-2.90	0.50	-1.60	-0.10	0.4	-0.03
h ²	0.15	0.59	0.44	0.12	0.10	-	-
R _f	-0.01	-1.44	0.20	-0.17	-0.01	-	-

DFI27-33 = Daily Feed Intake (27-33 weeks), AEW27-33 = Average Egg Weight (27-33 weeks), TEW27-43 = Total Egg Weight (20-43 weeks), EN20-43 = Egg Number (20-43 weeks), FCR27-33 = Feed Conversion Ratio (27-33 weeks), AFE = Age at First Egg, BW = Body Weight at 27 week, Basical = Basical population; Selected = Selected population; S = Selection differential; h² = heritability; R_f = the response of family selection; **p<0.01

Table 3: The prediction response of FCR27-33 and the correlated responses of DFI27-33, AEW27-33, TEW20-43 and EN20-43 with Within-Family Selection Method

Family selection method	FCR27-33	DFI27-33 (g)	AEW 27-33 (g)	EN20-43	TEW20-43 (kg)	AFE (day)	BW27 (kg)
Basical (Average±SD)	2.07±0.49	87.40±6.8	49.40±3.3	88.30±12.0	4.88±0.71	135.6±3.3	1.47±0.19
Selected (Average±SD)	1.97±0.45**	83.90±6.1**	49.90±3.4	85.50±11.7**	4.77±0.73	135.7±3.3	1.43±0.19*
S	-0.10	-3.50	0.50	-2.80	-0.11	0.1	-0.04
h ²	0.15	0.59	0.44	0.12	0.10	-	-
R _w	-0.01	-1.48	0.16	-0.23	-0.01	-	-

DFI27-33 = Daily Feed Intake (27-33 weeks), AEW27-33 = Average Egg Weight (27-33 weeks), TEW27-43 = Total Egg Weight (20-43 weeks), EN20-43 = Egg Number (20-43 weeks), FCR27-33 = Feed Conversion Ratio (27-33 weeks), AFE = Age at First Egg, BW = Body Weight at 27 week, Basical = Basical population; Selected = Selected population; S = Selection differential; h² = heritability; R_w = the response of within-family selection; *p<0.05; **p<0.01

33 showed high heritability whereas TEW27-33, EN27-33 and FCR27-33 showed low heritability. In terms of genetic correlations, DFI27-33 and EN27-33 were positively correlated with FCR27-33. TEW27-33 was weakly correlated with FCR27-33 and AEW27-33 was negatively correlated with FCR27-33. DFI27-33 was highly correlated with AEW27-33, TEW27-33 and EN27-33. EN27-33 and TEW27-33 were highly correlated whereas AEW27-33 was nearly independent of EN27-33.

With respect to phenotypic correlations, AEW27-33 was only weakly correlated with TEW27-33 and EN27-33. FCR27-33 was negatively correlated with TEW27-33, EN27-33 and AEW27-33 but it was positively correlated with DFI27-33 although, the correlation was weak. EN27-33 was highly correlated with TEW27-33.

Family selection: Table 2 shows the results of the family selection. The FCR27-33 of difference between the initial population and selected populations was not significantly. The difference of selected and basic populations was not significantly in AEW27-33, EN20-43, TEW20-43, AFE or BW27. There was a significant (p<0.01) difference in DFI27-33 between the basic and selected populations.

Within-family selection: Table 3 shows the results of the within-family selection. The FCR27-33 for the selected population was significantly lower than that of basic population (p<0.01) and the prediction response was 0.01. DFI27-33 and EN20-43 were decreased significantly in the selected population (p<0.01). The basic and selected

populations did not differ in TEW20-43, AEW27-33 or AFE but the BW27 was significant (p<0.01) different with basic population.

The estimated heritability of FID27-33 and AEW27-33 was moderate. The estimated heritability of AEW27-33 in this study was consistent with those found in the literature (Grunder *et al.*, 1989; Besbes *et al.*, 1992; Ledur *et al.*, 2002).

The estimated heritability of EN27-33 was 0.12 which is consistent with the heritability of EN of 0.09-0.27 as reported by Besbes *et al.* (1992) for two pure genetic lines.

The heritability estimate for FCR27-33 was 0.15, (Zhang *et al.*, 2003) reported that the heritability of FCR was 0.07 in a random mating control population of chickens which indicated that direct selection for this trait was possible. Throughout the results of the two selection methods for the FCR27-33 had positive genetic correlations with EN20-43, TEW20-43 and DFI27-33, it suggesting that direct selection for FCR27-33 would be decreased EN20-43, DFI27-33 and TEW20-43 simultaneously.

CONCLUSION

Of the two selection methods that were used, it conclude that selection for feed conversion ratio might also reduce egg number, daily feed intake and total egg weight. In terms of genetic correlations, the feed conversion ratio was correlated with egg number, total egg weight and daily feed intake.

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