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Estimates of genetic parameters for monthly egg production in a commercial female broiler line using random regression models

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ABSTRACT

In the present study, genetic parameters for monthly egg production, collected from weeks 24–55 on 16,200 hens during 9 generations from a pedigreed commercial female broiler line, were estimated using random regression models. With and without age at sexual maturity (ASM) as a covariate, two analyses were fitted to the data for the different models. To identify the best orders of Legendre polynomials, nine different models were compared. On the basis of Bayesian information and Akaike information criteria, a random regression model with second order Legendre polynomial for fixed effect and third order for additive genetic and permanent environmental effects, was chosen as optimal model. Without considering ASM as a covariate, the heritability estimates of monthly egg productions ranged from 0.099 to 0.229. By including ASM in the model, heritabilities for the first and second monthly records decreased by 38.86% (from 0.229 to 0.140) and 51.33% (from 0.150 to 0.073), respectively. Genetic and phenotypic correlations among monthly egg records were high between adjacent periods and decreased as the time interval increased. Genetic correlations between the first monthly records and other periods changed from positive to negative (varying from −0.095 to −0.619) with considering ASM in the model. The effect of age at sexual maturity on the estimates of heritability and genetic correlations for the first month records suggests it is necessary to include ASM in the analysis of egg production to avoid biased estimates. The heritability of the fourth month egg production and its relatively high genetic correlations with all other later ages show that it could be the most appropriate period for selection.

1. Introduction

Egg number is a longitudinal trait that depends on months of production, increasing to a peak and then decreasing over time. The description of this trait is various in different studies. To analyze the egg number, monthly (Anang et al., 2001, 2002; Farzin et al., 2011; Nurgiartiningsih et al., 2004; Wolc et al., 2007a, 2007b; Wolc and Szwaczkowski, 2009) or cumulative (Farzin et al., 2010; Luo et al., 2007; Nurgiartiningsih et al., 2004) egg records can be used. Selection for improving egg production was usually done based on early part records, generally up to 40 week of age (Luo et al., 2007). So, to design a suitable selection program, we need to estimate the heritabilities and genetic correlations among different part records. The pattern of genetic and phenotypic variances of egg production have been analyzed in literature using single or multiple trait (Anang et al., 2000; Farzin et al., 2011; Nurgiartiningsih et al., 2004),

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repeated records (Farzin et al., 2011; Kranis et al., 2007; Wolc et al., 2007a), fixed regression (Anang et al., 2001; Wolc et al., 2007b) and random regression models (Anang et al., 2002; Luo et al., 2007; Wolc and Szwaczkowski, 2009).

Using of random regression models has been increased to describe longitudinal traits (Schaeffer and Dekkers, 1994), because of their flexibility and capability to account for time-dependent effects (Swalve, 2000). Anang et al. (2002) suggested that the random regression was the feasible model to estimate genetic parameters of egg numbers on laying chickens, when compared against the multiple-trait model. Also, similar results were indicated in turkeys by Kranis et al. (2007).

In spite of several reports on laying hens, few estimates of genetic parameters have been reported for egg production in broiler lines. Moreover, the estimates of heritability for egg numbers varied strongly in various studies and depended on population, time, trait description and models used, ranging from 0.01 to 0.61, in laying hens (Anang et al., 2001; 2002; Nurgiartiningsih et al., 2002, 2004; Szwaczkowski, 2003; Unver et al., 2004; Wolc et al., 2007a) and 0.06 to 0.43, in broiler dam lines (Farzin et al., 2011; Luo et al., 2007). Also, some studies reported a high estimate of heritability for the first month of laying period (Anang et al., 2000, 2002; Kranis et al., 2007; Nurgiartiningsih et al., 2004; Wolc et al., 2007a), which may be resulted from the variation in age at sexual maturity (Anang et al., 2000). Farzin et al. (2011) estimated the genetic parameters of monthly egg production using single-trait, multiple-trait and repeated records animal models and reported that the exclusion of age at sexual maturity from the analysis of monthly egg production, especially for the first records of laying period, resulted to overestimation of (co)variance components and their corresponding parameters. Therefore, the objective of the present study was to estimate genetic parameters for monthly egg production in a female broiler line, using random regression model, and investigate the effects of including the age at sexual maturity in the model.

2. Materials and methods

The data were collected from a commercial female broiler line, selected during nine generations (between 2000 and 2008), moderately for body weight and residual feed intake at seven weeks of age and mainly for the total number of chicks produced during 28 to 39 weeks of age, average egg weight at weeks 31 and 33 and age at sexual maturity (ASM) at 20 weeks of age. Body weight was recorded individually for each bird, whereas the residual feed intake was measured from the performance records of their half sibs and full sibs. Also, selection of the birds at 20 weeks of age was carried out based on information of their relatives collected from all previous generations. Chicks were raised on full feed for the first six weeks and then fed restricted amounts daily until 20 weeks. At 20 weeks of age, all selected birds (approximately 134 roosters and 1206–1474 hens per generation) were randomly assigned to floor pens, 9 to 11 hens with 1 rooster per pen. The progeny of each generation were produced from up to four different hatches (weeks 43–50 for the first six generations and weeks 45–48 for the last three generations) through collecting hatching eggs over two consecutive weeks.

For this line, weekly egg productions of 16,200 hens from 1198 sires and 7564 dams were recorded individually in trap-nests. The period of data collection was from 24 to 55 weeks of age (32 weeks). Monthly egg records were generated by summing each 4 continuous weekly eggs (e.g., M1 = sum of the eggs produced from 24 to 27 weeks of age to M8 = sum of the eggs produced from 52 to 55 weeks of age). For each weekly record, it was assumed that all missing values were known and equal to zero.

Monthly records were described based on the following random regression model using Legendre polynomials as covariates:

$$y_{ikl} = GH_i + \sum_{m=0}^{q_1} b_m z_{klm} + \sum_{m=0}^{q_2} a_{km} z_{klm} + \sum_{m=0}^{q3} p_{km} z_{klm} + e_{ikl}$$

where y_{ikl} is the monthly egg record of kth hen in lth month, GH_i is the fixed effect of ith generation-hatch, b_m is the mth fixed regression coefficient, a_{km} is the mth random regression coefficient for additive genetic effect, p_{km} is the mth random regression coefficient for permanent environmental effect, z_{klm} is the covariate of the Legendre polynomial, e_{ikl} is the random residual effect, and q_1, q_2, and q_3 are the orders of the Legendre polynomials for the fixed, additive genetic, and permanent environmental effects, respectively.

In the repeated measurements, the residual variance can be assumed homogeneous or heterogeneous over time. To improve the accuracy of estimations in the present study, the residual variances were assumed heterogeneous throughout the laying period and divided into eight classes. Although, it was reported that inclusion of heterogeneous residual variances had little influence on the values of genetic parameter estimates (Wolc and Szwaczkowski, 2009).

To investigate the effect of ASM on (co)variance components and genetic parameters, the data were reanalyzed by fitting this effect as a covariate in the model. Estimates of variance and covariance components and their respective parameters were carried out by the restricted maximum likelihood method (REML) using WOMBAT program (Meyer, 2007).

Based on the phenotypic means pattern of egg productions over months, the Legendre polynomial of order 2 was used for modeling the fixed effect of month on egg production. Various orders of Legendre polynomial were characterized for additive genetic and permanent environmental effects. These orders are often chosen to be the same for simplicity of computing (Schaeffer, 2004), but in the present study, to determine the adequate model, both equal and unequal orders were tested. Nine different random regression models were compared to identify the best orders of fit for additive genetic and permanent environmental effects. Orders higher than 3 were not used, because no change in the patters of genetic variances with increasing polynomial orders was observed.

Bayesian information criterion, BIC (Schwarz, 1978) and Akaike information criterion, AIC (Akaike, 1974) were used to