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Original Article

Heritabilities and Genetic Correlations for Egg Weight Traits in Iranian Fowl by Multi Trait and Random Regression Models

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ABSTRACT

Objective: The main objective of this research was estimation of genetic parameters for five consecutive measurements of egg weights in Isfahan fowl using multi trait model and random regression models. **Methods:** The statistical models included generation-hatch as a fixed effect, weeks of age as a covariate and additive genetic and individual permanent environmental effects as random effects. The date set included records of egg weight measured from 21 weeks to 84 weeks of age that collected during 15 generations from 1986 to 2011. For acquiring of best accuracy of variance components and determining appropriate model, used heterogeneous residual variances with 5 classes and considering different orders of Legendre polynomial and accordingly eight different models were compared. Finally, the model with fourth order for additive genetic effect and third order for individual permanent environmental effect was selected as best model. **Results:** Results showed high genetic correlations of the 32 weeks of age with all other ages also its heritability indicated that it could be the optimum period for breeding.

1.INTRODUCTION

The Isfahan fowls a native bird spread out in center of Iran, According to the records of Isfahan fowl, sexual maturity or egg production begins on average at 22 weeks of age and reached to peak production at approximately 29 weeks of age then subsequently, the production gradually decreases until approximately 87 weeks of age. The egg production traits such as egg weight can be considered as a longitudinal trait and can be analyzed by using multi trait model (MTM) and recently random regression models (RRM). To improve of accurate genetic parameters, the residual variances can be considering heterogeneous in the time trajectory. Inattention of heterogeneous residual variances caused overestimated additive genetic variances estimates. However, heterogeneous residual variances increasing the number of parameters to be estimations (Jamrozik and Schaeffer, 1997; Jamrozik et al., 1997). The use of RRM in estimation of variance components of egg weight traits in Isfahan fowl has not been researched, therefore the main aim of this study was to estimate of genetic parameters by RRM and MTM using average information restricted maximum likelihood (AI-REML) method.

2. MATERIALS AND METHODS

Records of this study collected from 15 generations of Isfahan native fowl during 1986 to 2011 time period. The structure of pedigree and traits has shown in table 1. The

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following multiple-trait RRM was fitted to estimate variance components:

$$y_{ijkl} = GH_i + \sum_{m=0}^{n_1} \beta_{jm} z_m(l) + \sum_{m=0}^{n_2} \alpha_{km} z_m(l) + \sum_{m=0}^{n_3} \gamma_{km} z_m(l) + e_{ijkl}$$

Where y_{ikl}, was the weekly egg weight record of *k*th hen in *l*th week; GH_i represent the fixed effect of *i*th generation−hatch; β_{jm} is the fixed regression coefficient for the *m*th order of the polynomial of the period ;α_{km} and γ_{km} are the *m*th random regression coefficients for direct additive genetic and permanent environmental effects of *k*th animal, respectively; $z_m(l)$ was the *m*th covariate evaluated at *l*th week; and e_{ijkl} is the random residual effect. Variables *n1*, *n2* and *n3* are the numbers of covariate coefficients, which are dependent on the order of Legendre polynomial for *β*, *α* and γ effects, respectively.

For running of model firstly used heterogeneous residual variances with 5 classes, secondly the Legendre polynomial of order 3 was used for modeling the fixed effect of weeks on egg weight, thirdly various orders of Legendre polynomial were used for random effects, thereby eight different random regression models were compared to identify the best orders of fit for additive genetic and permanent environmental effects. The models were compared by the logarithm of maximum likelihood (Log(ML)), the Akaike's information criterion(AIC; Akaike, 1974) and Bayesian information criterion(BIC; Schwarz, 1978). The MTM has follow structure:

$$y = \mathbf{Xb} + \mathrm{Zu} + \mathbf{Wpe} + \mathbf{e}$$

Where y presents the phenotypic vector; b is the fixed effect vector (GH); u and pe are the vectors of random additive genetic and permanent environmental effects respectively, e is the residual random effect vector and X, Z, W are the incidence matrices that relate the data to the fix and random effects, respectively.The analyses were performed by the method of REML procedure (AI-REML) using the WOMBAT software (Meyer 2007).

Table 1: Summary information of traits

Traits	Mean (gr.)	CV (%)
EW22	46.44	9.15
EW28	48.19	8.14
EW30	49.22	8.55
EW32	50.91	8.11
EW84	47.71	9.01

3. RESULTS

The values of AIC, BIC and log (LM) for models with different orders of fit has shown in the Table 2. The 8th model, with order of Legendre polynomial fourth and third for the additive genetic and individual permanent environmental effects respectively was chosen as best model.

Table 2. Different orders of Legendre polynomial applied for different RRMs.

Models	Order of fit n2 n3	Number of Parameter	Log(ML)	AIC	BIC
1	22	11	-112832	225546.1	225691.7
2	23	14	-112459	224801.5	224911.2
3	24	18	-112229	224616.9	224519.5
4	32	14	-112189	224333.3	224519.3
5	33	17	-112177	224282.0	224417.1
6	34	20	-112156	224198.2	224385.8
7	42	18	-112101	224044.1	224114.4
*8	43	21	-111984	223783.6	224060.2

*best model, Order of fit for additive genetic (n2), permanent environmental (n3) effects.

The estimates of variance components, genetic parameters using MTM and RRM were presented in Tables 3 and 4, respectively. The heritability and increased and remained relatively stable and then increased in ew84. The heritability estimates by the RRM and MTM were very close for all the traits and increasing over time. The estimates ratio of permanent environmental variance to the phenotypic variance was high in the BW21, substantially decreased and stayed in a constant period in EW 28, 30 and 32, then increased for EW84 (Table 5). The results from the RRM and MT models showed that the genetically correlations between egg weights were positive.

Table 3. Estimated values of genetic (σ^2_a), residual (σ^2_r), and phenotypic (σ^2_p) variances and heritability (h^2) for egg weight traits using MTM (±standard errors).

	EW21	EW28	EW30	EW32	EW84
σ^2_a	3.98±0.22	4.75±0.24	5.06±0.26	5.65±0.27	5.87±0.30
σ^2_r	8.86±0.47	8.21±0.18	8.09±0.19	7.95±0.18	7.90±0.15
σ^2_p	12.84±0.21	12.91±0.16	13.15±0.17	13.60±0.14	13.77±0.21
h^2	0.31±0.02	0.37±0.02	0.38±0.02	0.42±0.03	0.43±0.03

Table 4. Estimation of variance component and derived parameters for egg weight traits using RRM.

	EW21	EW28	EW30	EW32	EW84
σ^2_a	4.11±0.12	4.93±0.20	5.51±0.18	6.24±0.33	7.28±0.53
σ^2_{pe}	2.23±0.24	2.85±0.14	3.22±0.14	3.34±0.14	4.47±0.65
σ^2_r	4.99±0.19	5.71±0.04	5.31±0.07	4.75±0.09	4.68±0.62
σ^2_p	11.33±0.19	13.49±0.14	14.04±0.14	14.23.±0.14	16.33.±0.15
h^2	0.36±0.02	0.37±0.01	0.39±0.01	0.44±0.01	0.46±0.02
pe^2	0.20±0.02	0.20±0.01	0.21±0.01	0.21±0.01	0.30±0.02

Table 5. Estimated values of genetic (upper triangle) and phenotypic (lower triangle) correlation (±standard errors) between egg weight traits using RRM.

	EW21	**EW28**	**EW30**	**EW32**	**EW84**
EW21		**0.51±0.07**	**0.51±0.07**	**0.51±0.07**	**0.54±0.11**
EW28	**0.13±0.01**		**0.98±0.01**	**0.99±0.01**	**0.96±0.01**
EW30	**0.13±0.01**	**0.57±0.01**		**0.99±0.01**	**0.98±0.01**
EW32	**0.11±0.01**	**0.52±0.01**	**0.59±0.01**		**0.99±0.01**
EW84	**0.23±0.01**	**0.54±0.01**	**0.61±0.02**	**0.68±0.01**	

Table 6. Estimated values of genetic (upper triangle) and phenotypic (lower triangle) correlation between egg weight traits using MTM (±standard errors).

	EW21	EW28	EW30	EW32	EW84
EW21		0.49±0.06	0.43±0.06	0.44±0.05	0.51±0.05
EW28	0.10±0.00		0.95±0.01	0.98±0.01	0.74±0.00
EW30	0.100.01	0.56±0.01		0.91±0.01	0.71±0.02
EW32	0.10±0.01	0.55±0.01	0.58±0.01		0.89±0.02
EW84	0.21±0.00	0.42±0.02	0.49±0.02	0.55±0.01	

The estimate of genetic parameters using RRM for the Iranian native fowl egg production traits didn't reported yet, but several researches has been reported by MTM. The estimated heritability values for our studied traits were within the range of values reported in previous studies, the estimated values were different and ranging from 0.10 to 0.65, for instance, Shadparvar et al. (2012) obtained heritability estimate of 0.12 and 0.24 for average egg weight and EW28-32, respectively, Kianimanesh et al. (2001) and Ghazikhani et al. (2007) reported a higher estimate for the heritability for egg weight (0.36 and 0.45, respectively), also Ghorbani et al. (2010) obtained heritability estimated of 0.19, 0.46 for EW1 and average egg weights traits respectively. These differences may be due to different models and structure of data set used in this analysis. The heritability estimate for EW traits in the present study relatively agrees with the findings of Vivian et al. (2010) on a Nigerian local chicken ecotype and Lwelamira et al. (2009) who worked on two Tanzanian chicken ecotypes, reported a like amount of heritability for egg weight traits (h2=0.44). The result related to heritabilities was in accordance with the result of Hani et Al. (1999), on Heritability of egg traits of White Leghorn hens, also an increase in estimated heritability of egg production traits with age reported by Luo et al. (2007). However, the authors used accumulated egg production traits, however, the observed gradual increase in heritability with age does not agree with the finding of the U-shaped pattern of heritability described in previous studies (Anang et al., 2002; Wolc et al, 2009).

The high estimate of the ratio in variance of permanent environmental effects to the phenotypic variance may be showed that this effect is an important source of phenotypic variation for EW traits. The high values estimate of h^2 and pe^2 for the EW traits has been attributed to the variation in the age at sexual maturity and effect of this age on egg weight For early ages (Anang et al., 2000), physiology of fowls on starting and ending of production life, influences of different genes through laying periods especially genes related to persistency and quality in EW84 (Wolc et al. 2009 and Nurgiartiningsih et al. 2004), thereby caused lack of uniformity of production in these periods.

The result correlated to correlation in this study also was in good accordance with results of Luo et al. (2007) who found high genetic correlations between monthly and total egg production, except for the first month similarly. Veronica (2005) reported a high genetic correlation (0.95) between monthly egg weight traits of two laying hen lines. A similar pattern of genetic correlations to the present study were also reported by Mielenz et al. (2002), Anang et al. (2000), and Kranis et al. (2007). Also, Wolc et al. (2009) based on RRM in three different laying hen's lines reported high estimated genetic correlation coefficients (0.78 to 0.91). Based on result of current study, the comparison of genetic parameter estimates showed that both models were able to description of dynamics of the genetic variance and estimated heritabilities were increasing over time.

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