Genetic Parameters for Body Weight and Laying Traits in Mazandaran Native Breeder Hens

Research Article

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ABSTRACT

Heritability, environmental and genetic correlations between body weight at hatch (BW0), eight (BW8) and twelve (BW12) weeks of age, body weight at sexual maturity (BWM), age at sexual maturity (AFE), the weight of the first egg laid by the hen (EWM), the mean egg weight from 28 to 32 wks (EW28-32) and egg numbers (ENs) were estimated by the restricted maximum likelihood method under an animal model. Data were from six generations (generation ten to fifteen) of hens kept at the Mazandaran Breeding Center of Iran. Heritability estimates for BW0, BW8, BW12, BWM, AFE, EWM, EW28-32 and ENs were 0.134, 0.235, 0.296, 0.247, 0.344, 0.125, 0.240 and 0.156, respectively. Genetic correlations between pairs of body weight measures were moderate with a range from 0.17 to 0.43. Generally, correlations of body weight traits with AFE were weak. Genetic correlation between BW8 and AFE was low, but favorable (-0.17). Egg numbers has unfavorable genetic correlation with BWM (-0.47). However, egg weight traits had favorable genetic correlation with body weight traits, except BW0, which was almost equal to zero. Age at first egg had negative genetic correlation with egg numbers, but positive correlations with egg weight traits. The absolute value of environmental correlations between traits varied from 0.00 to 0.39. The strongest environmental correlation was found between AFE and EWM. There was moderate and positive environmental correlation between BW8 and BW12 as well as between BW12 and BWM. The results showed that there are considerable genetic variations in important traits of Mazandaran native hens, and that selection on BW8, ENs and EWM, which are the most economically important traits in this breed, could be effective.

INTRODUCTION

The genetic characterization of indigenous breeds is of paramount importance, not only for conservation purposes but also for the definition of breeding objectives and the development of breeding programs. Lack of information on genetic variance components and genetic parameters limits genetic improvement because knowledge of these is crucial for accurate estimation of breeding values, optimum combination of traits in a selection program, optimization of breeding schemes and enhanced prediction of response to selection (Prado-Gonzalez *et al.* 2003; Adeogun and Adeoye. 2004; Norris *et al.* 2004). Current trends indicate that by the end of the century, 80% of the world's population will be living in the under-developed and a significant number of will have large food deficits. An increased production of animal would make an important towards filling this deficit (FAO, 2012). There are clear evidences of the positive attributes of indigenous (native) chickens and hens. Studies on biodiversity of indigenous chickens and hens revealed the presence of high genetic variability within ecotype populations (Muchadeyi *et al.* 2007; Mwacharo *et al.*

2007; Halima *et al.* 2009; Vali, 2008) indicating the potential for genetic improvement of these birds through selective breeding.

In Iran commercial poultry farms emerged in early 1950's, in order to meet the increasing demand for animal protein particularly poultry egg and meat. In the last few decades, Iranian poultry production has made great progress in the industry. During the recent years, poultry meat and egg production in Iran has been about 1.06×10^6 and 677 thousand tons per year, respectively. This was resulted mostly from wide utilization of commercial lines of poultry breeds.

There are several indigenous poultry breeds in various regions of Iran and they are adapted to the corresponding local climatic and environmental conditions through long-term natural selection. The most important native fowls of Iran, at least in respect to population size, are the Mazandaran, the Fars, the Esfahan and the Azarbaijan (Kianimanesh *et al.* 2001b). Native fowls are considered as a worthwhile genetic stock in Iran, but they are under risk of extinction therefore should be protected. The population of native fowls in Iran decreased from 30 millions in 1960's to about 12 millions in 1980's and they participate less than 10% of total poultry meat and egg productions of the country. One of the best ways to protect the native fowls from extinction is to support them through an elaborated genetic improvement program. For this purpose, in 1986 some stations were established in various provinces of Iran, including Mazandaran, Fars, Esfahan and west-Azearbaijan (Kianimanesh *et al.* 2001b), in order to make genetic improvement of the native fowls and to proliferate their population.

Mazandaran is an important pole of agriculture and animal husbandry of Iran and approximately have 4000000 native chickens (Beigi *et al.* 2007).

The location is typically hot and semi-arid with yearly minimum and maximum temperature ranges between 4 and 34 ˚C, respectively (Abbasi *et al.* 2011).

The Mazandaran hen is one of the native breeds of Iranian fowls being subject of several studies. Kianimanesh *et al.* (2001a) studied the economic values for some important traits of Mazandaran fowls, and concluded that egg number, EWM and BW8 had the greatest impact on the profit of production system, while AFE had a negative economic value. In other study, Kianimanesh *et al.* (2001c) examined genetic trend for the above mentioned traits during 11 successive generations, and did not observe any consistent genetic progress during the first 8 generations. One of the major responsible factors for this situation was declared as the lack of proper estimates of genetic parameters. Such parameters may be obtained from multiple trait analysis of data on both male and female birds from several generations, considering full pedigree relationship between individuals. The use of multiple trait animal model analysis for prediction of breeding values in both sexes of the Mazandaran fowls commenced since the ninth generation. Kianimanesh *et al.* (2001b) estimated genetic parameters for some important traits of the Mazandaran fowls using four-traits animal model. Selection objective for this breed was changed for several times and currently the selection emphasis focuses on increasing egg number and body weight but decreasing the age at sexual maturity (Kianimanesh *et al.* 2001b). Currently sufficient amount of data is available, thus re-estimation of genetic parameters is necessary. On the other hand further extension of current selection criteria to involve the other traits seems to be essential to improve overall economic efficiency of the selection program. The objective of this study was to renew those estimates, using broader information, and also to estimate genetic parameters for some additional traits.

MATERIALS AND METHODS

Animals and Data

Mazandaran Native Fowl Center (MNFC; Mazandaran province, Iran), was established in 1986. The station has two main activities, namely extension and genetic improvement. In 1986, about 5000 cocks and hens were collected from rural communities across the province and transferred to a quarantine farm. In 1987 and after practicing quarantine procedures, about 2500 birds of both sexes were remained to produce hatching eggs, and chicks produced from these eggs were transferred to the MNFC in 1988. Genetic improvement is done by selecting the best 100 cocks and 800 hens as parents of the next generations.

Parents of each generation are selected among 7000 pedigreed and performance recorded birds produced by each generation. The extension part is continuously producing and distributing 8 weeks old chicks among rural communities with the aim of increasing the population of native fowls in Northern provinces of Iran. Rearing chicks for a period of 30 to 60 days and distributing them in rural areas to enhance meat and egg production were quantitative goals of Mazandaran native fowl breeding station (Abbasi *et al.* 2011). Data used with this study, records from 9600 females and 2400 males, were obtained from six generations (generations ten to fifteen) of birds hatched between 1999 and 2006. Pedigree file (38218 females and 7643 males) originated from 15 generations. A selection index for laying traits based on individual and full-sib records was applied to hens, while cocks were selected on full sib data. Index was consist on body weight at eight weeks of age, age at sexual maturity, egg weight and egg number. The average inbreeding coefficients for all birds were 0.045 and ranged from zero to 25%.

There were four hatches in each generation. During the rearing period to 18 wk of age, the dietary crude protein (CP) and metabolizable energy (ME) were as follows:

1- 21-22% CP and 2900 kcal ME/kg of diet until 3 weeks of age.

2- 18.5-20% CP and 2800 kcal ME/kg of diet from 3 to 6 weeks of age.

3- 14% CP and 2800 kcal ME/kg of diet from 6 to 14 weeks of age.

4- 17% CP and 2800 kcal ME/kg of diet from 14 to 18 weeks of age.

During the lying period, hens were fed ad libitum using a diet containing 15.5 to 17% crude protein. At hatch birds received 23 h of light/d, which was reduced progressively by 30 min / wk up to week 18, and then increased 30 min/wk until week 23 (17 h of light/d at the beginning of egg production.

Statistical Analysis

Analysis was performed on records (Table 1) for body weight at hatch (BW0), eight (BW8) and twelve (BW12) weeks of age, body weight at sexual maturity (BWM), age at sexual maturity (AFE), the weight of the first egg laid by the hen (EWM), (egg number) EN and the mean egg weight from 28 to 32 wks (EW28-32). The descriptive statistics were calculated by PROC MEANS of SAS software (SAS Institute, 1999) and are presented in Table 1.

Using the variance components from the methods, heritabilities were calculated as follows:

$$h^2_s = 4 \times (\sigma^2_s/(\sigma^2_s+\sigma^2_e))$$
$$h^2_d = 4 \times (\sigma^2_d/(\sigma^2_d+\sigma^2_e))$$
$$h^2_{s+d} = 2 \times ((\sigma^2_s/+\sigma^2_e)/(\sigma^2_s+\sigma^2_d+\sigma^2_e))$$

Where σ^2_s, σ^2_d and h^2_{s+d} are heritabilities based on sire (σ^2_s), dam (σ^2_d) and sire + dam components of variance, respectively; σ_s^2 is the error variance component for each trait.

Genetic correlations were computed from the variance and covariance component estimates as follows:

$$R_{gxy} = (\sigma_{sxy}/(\sigma^2_{sx}) \times (\sigma^2_{sy}))$$

where r_{gxy} is the genetic correlation between traits x and y, σ_{sxy} is the sire component of covariance between these traits, and σ^2_{sx} and σ^2_{sy} are the sire variance components for traits x and y. Environmental correlations were computed similarly with the residual variance and covariance components instead of the sire variance components.

Multiple-trait animal model used to estimate genetic parameters is as follows:

$$y = Xb + Za + e$$

Where y is the vector of observations; b is the vector of fixed effects of the contemporary group, generation, sex (except for EWM, EN and EW28-32) and hatch; a is the vector of random effect of additive genetic values; e is the vector of random residual effects; and X and Z are known incidence matrices relating records to b and a, respectively.

The variances of the vectors of additive genetic values and residual effects are A ⊗ G and R, respectively, which are assumed to be mutually uncorrelated. In these expressions, A is the full additive genetic relationship matrix; G is the unknown genetic (co) variance matrix between considered traits; and ⊗ indicates the Kronecker product.

(Co) variance estimates were obtained with restricted maximum likelihood method using the DFREML software (Meyer, 1991). A value of 10^{-8} for the variance of the likelihood function values was used as iteration stopping criterion. The significance of fixed effects was estimated by proc GLM of SAS software (SAS institute, 1999), which were significant (P<0.001) for all traits studied.

RESULTS AND DISCUSSION

Heritability estimates for body weights of Mazandaran native breeder hens (Table 2) ranged from 0.134 to 0.296, with lower value for BW0 (0.134) which indicates that detection of genetic variability for body weight at 1 day of age is more difficult than 8 and 12 weeks of age or at sexual maturity.

The heritability estimate for BW8 was similar to the value reported by Kianimanesh et al. (2001b) and also was close to 0.27 reported by Ghazikhani et al. (2007) for Mazandaran fowls.

Nigussie et al. (2011) reported the heritability for BW8 and BW12 for Horro chickens of Ethiopia to be 0.16. Kamali et al. (2007) and Ghazikhani et al. (2007) estimated the heritability for BW12 for Farsi native fowls to be 0.68 and 0.54, respectively, which were much higher than our estimate for Mazandaran native fowls.

Heritability estimate for BWM was lower than the reported value (0.43) by Akbas et al. (2002). The heritability of AFE was considerably higher than 0.15 reported by Kianimanesh et al. (2001b), but was similar to the results of Koerhuis and Mckay (1996) for the same traits in broiler chickens and Mazandaran native fowl (Ghazikhani et al. 2007).

The magnitude of estimated heritability indicates that selection can result in lower AFE and consequently in higher profit of production system because of the negative economic value of AFE (Kianimanesh et al. 2001a).

Table 1 Number of observations (n), observed mean (OM), standard deviation (SD), coefficient of variation (CV), and minimum (MIN) and maximum (MAX) values of the traits*

Traits	n	OM	SD	CV (%)	MIN	MAX
BW0 (g)	12021	37.09	3.30	8.92	26.90	47.60
BW8 (g)	11929	491.74	103.25	20.10	190.00	800.00
BW12 (g)	11931	885.81	166.28	19.77	440.00	1390.00
BWM (g)	11209	1714.79	207.25	12.08	980.00	2600.00
AFE	11159	148.49	25.10	17.50	76.00	225.00
EWM (g)	8593	40.17	6.54	16.29	18.60	62.90
EW28-32 (g)	10710	47.50	4.02	8.47	34.40	60.60
ENs	11248	40.08	19.16	47.81	10.00	98.00

* BW0: body weights at one day of age; BW8: body weight at eight weeks of age; BW12: body weight at twelve weeks of age; BWM: body weight at sexual maturity; AFE: age at first egg; EWM: the weight of the first egg laid by the hen; EW28-32: average egg weights produced from 28 to 32 weeks and ENs: egg numbers.

Table 2 Heritability ±SE (diagonal), Residual ±SE (above diagonal) and genetic ±SE (below diagonal) correlations for the traits*

Traits	BW0	BW8	BW12	BWM	AFE	EWM	EW28-32	ENs
BW0	$\mathbf{0.13\pm4\times10^{-3}}$	$0.046\pm7\times10^{-3}$	$0.04\pm1\times10^{-2}$	$0.13\pm3\times10^{-3}$	$0.02\pm1\times10^{-2}$	$0.03\pm7\times10^{-3}$	$0.04\pm3\times10^{-3}$	$-0.04\pm1\times10^{-3}$
BW8	$0.24\pm7\times10^{-3}$	$\mathbf{0.23\pm1\times10^{-2}}$	$0.36\pm2\times10^{-2}$	$0.36\pm1\times10^{-2}$	$-0.10\pm1\times10^{-2}$	$0.00\pm2\times10^{-3}$	$0.14\pm5\times10^{-3}$	$0.08\pm2\times10^{-3}$
BW12	$0.18\pm1\times10^{-2}$	$0.17\pm2\times10^{-2}$	$\mathbf{0.29\pm5\times10^{-2}}$	$0.38\pm2\times10^{-2}$	$-0.12\pm2\times10^{-2}$	$0.03\pm6\times10^{-3}$	$0.15\pm8\times10^{-3}$	$0.05\pm3\times10^{-3}$
BWM	$0.25\pm1\times10^{-2}$	$0.30\pm1\times10^{-2}$	$0.43\pm2\times10^{-2}$	$\mathbf{0.24\pm4\times10^{-2}}$	$0.11\pm2\times10^{-2}$	$0.21\pm5\times10^{-3}$	$0.30\pm7\times10^{-3}$	$-0.14\pm3\times10^{-3}$
AFE	$0.04\pm7\times10^{-3}$	$-0.17\pm1\times10^{-2}$	$-0.02\pm2\times10^{-2}$	$0.00\pm2\times10^{-2}$	$\mathbf{0.34\pm2\times10^{-2}}$	$0.39\pm3\times10^{-3}$	$0.05\pm4\times10^{-3}$	$-0.19\pm2\times10^{-3}$
EWM	$0.00\pm2\times10^{-3}$	$0.26\pm3\times10^{-3}$	$0.29\pm5\times10^{-3}$	$0.54\pm4\times10^{-3}$	$0.17\pm3\times10^{-3}$	$\mathbf{0.12\pm3\times10^{-3}}$	$0.25\pm2\times10^{-3}$	$-0.12\pm1\times10^{-3}$
EW28-32	$0.15\pm3\times10^{-3}$	$0.34\pm4\times10^{-3}$	$0.31\pm7\times10^{-3}$	$0.42\pm6\times10^{-3}$	$0.15\pm6\times10^{-3}$	$0.66\pm1\times10^{-3}$	$\mathbf{0.24\pm3\times10^{-3}}$	$-0.09\pm9\times10^{-3}$
ENs	$0.03\pm5\times10^{-4}$	$-0.03\pm2\times10^{-3}$	$-0.07\pm3\times10^{-3}$	$-0.47\pm2\times10^{-3}$	$-0.21\pm2\times10^{-3}$	$-0.66\pm7\times10^{-4}$	$-0.41\pm8\times10^{-4}$	$\mathbf{0.15\pm1\times10^{-3}}$

* BW0: body weights at one day of age; BW8: body weight at eight weeks of age; BW12: body weight at twelve weeks of age; BWM: body weight at sexual maturity; AFE: age at first egg; EWM: the weight of the first egg laid by the hen; EW28-32: average egg weights produced from 28 to 32 weeks and ENs: egg numbers.

The heritability of EWM and EW28-32 were 0.13 and 0.24, respectively. Kianimanesh *et al*. (2001b) and Ghazikhani *et al*. (2007) obtained a higher estimate for the heritability for egg weight (0.36 and 0.45, respectively) in the same population. Kamali *et al*. (2007) obtained heritability estimate of 0.64 for average egg weight (EW) at 28, 30 and 32 weeks for Farsi native fowls. The heritability estimates for EW in three breeds of Catalan poultry were 0.59, 0.48 and 0.5 (Francesch *et al*. 1997).

The heritability estimate for egg numbers (ENs) was higher than the value (0.14) obtained by Kianimanesh *et al*. (2001b) but was lower than those obtained for three Catalan poultry breeds (0.20, 0.31 and 0.33, Francesch *et al*. 1997), for layer females (0.29, Hagger, 1994; 0.22, Tufveesson *et al*. 1998; 0.39, Akbas *et al*. 2002 and for Farsi native fowls (0.40, Kamalie *et al*. 2007).

Using random regression model, Luo *et al*. (2007) estimated the heritability of ENs from week 1 to 40 ranging from 0.16 to 0.54 and concluded that early selection based on cumulative ENs in the first 19 weeks of production could improve annual egg production in broiler dam lines.

Genetic correlations between pairs of body weight measures were moderate and ranged from 0.18 to 0.25. Selection for higher BW0 will result in higher body weight at 8 and 12 weeks of age and also at sexual maturity. Generally, correlations of body weight traits with AFE were weak.

Genetic correlation between BW8 and AFE was low, but favorable (-0.17) similar to the reported value (-0.18) by Ghazikhani *et al*. (2007). Similarly, Kamali *et al*. (2007) estimated the genetic correlation between BW12 and AFE in Farsi native fowls to be -0.12. Kianimanesh *et al*. (2001b) obtained positive genetic correlation between BWM and AFE. Positive genetic correlation between AFE and Juvenile body weight was reported by Sabri *et al*. (1999). Egg numbers have unfavorable genetic correlation with BWM (-0.47). However, EW traits had favorable genetic correlation with body weight traits, except BW0, which was almost equal to zero. This evidence suggests that genetic improvement in body weight would result in the reduction of EW in favor of increased ENs. This argument could be supported by the negative genetic correlations obtained in this study for EW traits and ENs.

Age at first egg had negative genetic correlation with ENs, but positive correlations with EW. Early maturity would result in early egg production and hence producing more eggs. On the other hand, increasing the number of egg would decrease the average EW which is in agreement with the founding of Lubritz *et al*. (1996) and Kamali *et al*. (2007). The absolute value of environmental correlations between traits varied from 0.00 to 0.39. The strongest environmental correlation was found between AFE and EWM, indicating that environmental factors, such as lightening regime and nutrition that are effective in reducing AFE, tend to reduce the EW, too. There were moderate and positive environmental correlations between BW8 and BW12, and between BW12 and BWM. The standard errors of all estimates between growth and egg production traits were quite low reflecting the large sample size.

CONCLUSION

Estimated heritability for traits studied here were in the range of values reported in the previous studies. The results showed that there are considerable genetic variations in important traits of Mazandaran native fowls, and that selection on BW8, EN and EWM, which are the most economically important traits in this breed, could be effective. Results on genetic correlations between traits revealed that increasing ENs would decrease AFE, which is favorable, but at the same time would result in lower unfavorable EWM. This suggests that it is necessary to include both ENs and EWM in a selection index in order to overcome their antagonistic genetic relationship.

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