Estimation of Genetic Parameters and Inbreeding effects of Economic Traits in native chicken under Short Term Selection

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Summary: Iranian native hens are a valuable genetic resource, due to their adaptability to harsh conditions of husbandry and environment in rural area. The genetic parameters for various traits of economic importance were studied in an Iranian Native chicken population under short term selection for egg production and body weight for over 2 years. The parameters studied were body weight at day old (BW1), 8 weeks (BW8) and 12 weeks (BW12), the weight of first egg (EGGW1) and egg weight at 30 weeks of age (EGGW30), the average number of stock eggs per day (EGG/DAY). They showed mostly moderate to high heritability estimates. Higher heritability estimates were obtained for body weight traits. Therefore, selection for body weight traits before mature age will result in gain in egg weight traits and it will be useful for breeding plans. The average inbreeding coefficients for all birds were and ranged from zero to 0.15. In this population, 34.5% of birds were inbred, with a mean inbreeding coefficient of 0.28. Inbreeding as variable has no significant effect on EGGW1; however, age of sex maturity as variable has significant effect ($p<0.001$) on EGGW1.

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Introduction

Increased rates of inbreeding in selection programmes may have an important effect on medium and long-term response to selection and reproductive performance through reduction in genetic variability, inbreeding depression and reduced probability of fixing favorable genes. Artificial selection generally results in larger variances of family size and reduced effective population sizes. This can be particularly important in small highly selected nucleus populations and when selection is based on estimated breeding values from index or best linear unbiased predictions (BLUP) with the animal model (Caballero*et al*., 1996).

Crossbreeding and selection are two based alternative approaches in genetic improvement of livestock and poultry. Crossbreeding leads to the creation of more heterozygotes and in consequence to greater genetic variation of population. By contrast, selection determines both genetic gain and inbreeding rate. The inbreeding effects include increased homozygosity, a higher risk for the incidence of lethal or deleterious recessive alleles, and decrease in performance and fitness traits (Szwaczkowski *et al*., 2003).

Native chickens are important in some rural areas. They usually produce meat and eggs without extra feed, only picking food. Improving their economical traits, such production efficiency would save these genetic resources. Since chickens under rural production systems are kept both for meat and egg production selection for genetic improvement of local chickens should seek to improve the two traits simultaneously (Nasr *et al.,*2012).

Identification of genes determining the expression of economically important traits of plants and animals is a main research focus in agricultural genomics. Most of these traits are characterized by a wide variability of the expression of genes at certain loci called quantitative trait loci (QTL). Characterization of the chromosomal regions carrying QTL can be applied in marker-assisted Selection (MAS) to improve breeding efficiency (Alexei *et al.*, 2010).

The usefulness of molecular genetics tools as; microsatellites in estimating genetic relatedness and diversity in chickens have been demonstrated in a number of native breeds, inbred strains and in commercial lines. Shahbazi *et al* (2007) represents the first results from the selection and evaluation of five polymorphic microsatellite markers for the genetic assessment of five native chicken populations (*Gallus domesticus*) in Iran. The lowest heterozygosity is found in the Isfahan population (62%) and the greatest in the populations from West Azerbaijan and Mazandaran (79%). The results showed that the genetic diversity of Isfahan native chicken population was richer than the other populations. Thus, molecular linkage maps in combination with powerful statistical methods facilitate the genetic dissection of complex traits, and the chicken is ideally suited for this task due to the relatively short life cycle and large number of progeny.

Age at sexual maturity, number of eggs, egg weight and body weight at 8th week of age are among most important traits for improving economical efficiency of Iranian native fowl (Kianimanesh & Nejati, 2009). Although natural selection is the great evolutionary force that fuels genetic change in all living beings, selection at the long term has important effects such as increased inbreeding and decreased genetic variation. However, changes in average of production traits and population response in breeding programmers' after a few generations of selections depended on accuracy and intensity of selection, effective population size and the rate of inbreeding (Bahmanimehr, 2012).

Kamali et al. (1995; 2007) has been used, different methods of selection index for selection of economic traits in Iranian indigenous hens. On the other hand, most of the estimates have been obtained through traditional estimation methods, but only very few of these were based on restricted Maximum Likelihood (REML) methodology and animal models. Best Linear Unbiased Prediction(BLUP) in animal model has been used more and more for selection in most species of farm animals. For this purpose estimates of genetic parameters in the base population are required.

The aim of this study is to estimation of inbreeding effects by using genetic parameters as; genetic, phenotypic and environment correlations variation, heritability, and correlation among several important economic traits and inbreeding effects on selection of these traits under short term selection in the native chickens of the Fars province of Iran.

Materials and Methods

In this project, data on 14,250 Iranian native chicken, belonging to The Breeding Center of Fars Native Chicken, from 7th to 11th generation were used to estimate the genetic parameters of six economic traits. All laying native birds were from a small population selected for individual phenotypic value of body weight at 12 weeks of age (BW12) and egg numbers (EN) during the first 12 weeks of laying period. In the first generation, eggs were randomly collected from rural areas and hatched to constitute the base population. Parents were selected on the basis of BW12 and EN. Cocks were selected on the basis of BW12 and the production of their sisters.

Selection procedures were continued for the next generations based on estimated breeding value and calculated genetic and environmental parameters using best linear unbiased prediction (BLUP) in an animal model. A pedigree file of 14,250 birds were used to calculate genetic and environmental parameters on some economically traits as; body weight at day old (BW1), body weight at 8 weeks (BW8), body weight at 12 weeks (BW12), the weight of first egg (EGGW1) and egg weight at 30 weeks of age (EGGW30) as well as the average number of stock eggs per day (EGG/DAY). The birds were maintained under uniform management conditions as far as possible.

A pedigree file collected on birds was used to calculate the inbreeding coefficient and their influence on these traits. The number of inbred individuals and mean inbreeding coefficients over generations are presented in Table 3. A null inbreeding level in the 7th generation was influenced by available pedigree information (birds from generation 7 were treated as base). Generally, in the next generations, the inbreeding rates increased, as the number of inbred individuals increased. Estimated genetic parameters on this population of a previous study of ours (Bahmanimehr, 2012) has used mixed model least squares, animal model and maximum likelihood whereby the variance components were partitioned into those of the traits and generations to design the fitted models of the inbreeding effects. The genetic and phenotypic correlations between six traits were re-estimated from variance and covariance component analysis. Also according to regression coefficient of inbreeding on generation in different traits Statistical models for inbreeding effects on body weight traits and egg production traits were designed:

$$Y_1 = A + b_1(F) + b_2(In)$$

$$Y_2 = A + b_1(F) + b_2(In) + b_3(Age)$$

Where Y_1 – vector of observed values of the weight traits, Y_2 – vector of observed values of the egg traits, A – fixed effects on traits, b_1 ، b_2 and b_3 – regression coefficient of generation, inbreeding and age of sexual maturity respectively.

Results

The heritability for economic traits in the animal model studied was reported in a previous study (Bahmanimehr, 2012) are presented in Table 3. The regression coefficient (b_2) of age at maturity on first egg weight was 0.164; meaning that each day increase in age of sex maturity corresponded to 0.164 g gain on the first egg weight. In addition, the regression coefficient of age of sex maturity on egg weight at 30 weeks of age was 0.051, i. e. each day increase in age of sexual maturity corresponded to 0.051 g increase on the egg weight at 30 weeks of age.

The genetic, phenotypic and environmental correlation between economic traits of this population studied on previous paper (Bahmanimehr, 2012) is presented in Table 2. There was a positive genetic correlation between weight traits and egg weight traits was also reported (Bahmanimehr, 2012). Higher estimates were obtained for BW1 and EGGW30 (0.64). However, the genetic correlation between body weight traits and number of eggs was negative. Also the moderate to high positive correlation estimates obtained between BW8 and BW12 agreed with the general observation that body weight at all ages is highly heritable and are positively correlated (Ghorbani *et al*., 2007).

The positive correlation observed between BW1 and EGGW30 and negative genetic and phenotypic correlations obtained between EGGW30 and EGG/DAY, indicated that chickens that attain higher body weight at the first day would lay bigger eggs. However, the negative genetic and phenotypic correlation obtained between number of eggs per day and all body weight traits suggest that the relationship could become more antagonistic during the process of selection. From the total 14520 birds in this population, 9510 birds were not inbred. Among them 2731 birds with zero inbreeding belonged to 7th generation due to uncertain parents and common ancestors as base population.

The number of inbred birds of this population was 5010. The inbreeding coefficients in inbred birds was between 0.0019 and 0.15 that average inbreeding coefficients in total population 0.0096 and in inbreed birds 0.028 estimated.

Inbreeding coefficients from 7th to 11th generations is presented in the Table 4. In the 7th generation inbreeding was estimated to be zero due to selected as base population. Despite the increased inbreeding coefficient from 7th to 11th generations, the inbreeding was low because only 34.5% percent of the population was inbred (inbreeding between 0 and 0.15). It led to worry of planners from increasing the inbreeding that forced them to avoid the mating of relatives.

The average inbreeding coefficient of first six generations of this population of the breeding programme was 0.048, estimated and reported by Ghorbani et al (2007). They also demonstrated 1% increasing in inbreeding in the population, causing 0.50 and 0.51 g decrease respectively in BW12 and egg production also increase 0.3 in age of sex maturity and 0.03 in egg weight of and for each bird.

Regression coefficients of inbreeding and BW1, BW8, BW12 were estimated to be –0.09, 0.6 and 1.018 respectively. This regression coefficient was estimated -0.03 and -0.12 respectively for egg weight traits as EGW1 and EGGW30 while in contrast regression coefficient of inbreeding and EGG/DAY was estimated 0.00016 that despite of positive is so low.

These results demonstrate 0.09 and 0.12 g decrease respectively in BW1 and BW8 per one percent increasing in inbreeding. Generally this increasing and decreasing is eextremely low due to very small change of inbreeding in each generation also small numbers of inbreed birds in the population. Present of production records of large numbers of non inbreed birds (65.5 percent of total population was non inbreed due to uncertain parents and common ancestors) probably caused estimation of low regression coefficient of inbreeding and production traits.

Conclusion

In designing a breeding programme, the number of individuals producing the next generation could affect stock performance. In addition, in evaluating of breeding programme some one should calculate the effect of inbreeding rate on performance traits in order to avoid misjudgments on the amount of progress in economical traits.

For improving the economic traits, the selection protocol is the main and first point of attention. Positive genetic correlation between body weight traits and egg weight traits (table 3) is an evidence of genetic potential of broilers to weight gain. Also negative correlation between body weight traits and egg number likewise is evidence to genetic potential of layers to produce more egg per year.

Inbreeding could use for determining the undesirable genes by low frequency in the mixed flocks. These undesirable genes almost always are recessive and their effects have covered by dominant alleles. Except of sex influenced traits, recessive alleles had not phenotypic expression while they are heterozygous thus, for their expression should appear homozygous genotype and it could removed from the population by increasing the inbreeding.

Inbreed mating has been used in most domestic species as a way to increasing the uniformity in the breeds particularly for a traits that has simple inheritance as feather color in the birds. Genetically relative individuals have equal breeding value due to common genes and further homogeny among them comparing the non relatives. Regression coefficient estimated for breeding value (BV) under fix effect of generation for economical traits in this population showed that, significant genetic improvement was obtained under selection for these traits.

In conclusion, this study showed, selection for body weight traits before mature ages will cause gain in egg weight traits and it will be useful in breeding plans.

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Table 1. Estimated heritability and different Variances in the economic traits (Bahmanimehr, 2012)

Traits	* $\delta^2 a$	** $\delta^2 e$	*** $\delta^2\ p$	**** h^2	Log L
BW1	4.482	3.498	7.98	0.56 ± 0.012	-16460.6
BW8	2090.82	5254.23	4736.05	0.44 ± 0.02	-64634.6
BW12	5536.86	5254.83	5254.83	0.51 ± 0.02	-71395.5
EGGW1	3.36	13.61	16.97	0.2 ± 0.2	-20882.8
EGGW30	5.57	4.36	9.93	0.56 ± 0.022	-16413.5
EGG/DAY	0.19	0.11	0.12	0.15 ± 0.025	10893.8

*Genetic (Additive) Variance; **Environmental Variance; ***Phenotypic Variance; ****Heritability

Table 2. Genetic, phenotypic and environmental correlations between the economic traits

Traits	**BW1**			**BW8**			**BW12**			**EGGW1**		
Correlation	r_a	r_e	r_p	r_a	r_e	r_p	r_a	r_e	r_p	r_a	r_e	r_p
BW1	1	1	1									
BW8	0.34	0.09	0.22	1	1	1						
BW12	0.32	0.03	0.18	0.94	0.56	0.74	1	1	1			
EGW1	0.51	-0.13	0.094	0.4	0.05	0.16	0.34	0.07	0.19	1	1	1
EG/DAY	-0.07	-0.014	-0.031	0.02	-0.07	-0.04	-0.05	-0.07	-0.06	-0.11	0.02	-0.05

r_a : Genetic Correlation; r_e : Environmental Correlation; r_p : Phenotypic Correlation;

Table 3. Inbreeding coefficient in different generations of chickens

Generation	No. of records	Average	Min	Max	Standard deviation (Sd)
G7	2731	0	0	0	0
G8	2817	0.062	0	12.5	0.88
G9	2997	0.285	0	12.5	1.408
G10	2985	1.76	0	7.03	1.55
G11	2981	2.6	0	15.04	1.58

Table 4. Average of Traits in different Generations of chickens, paralelly to increased level of inbreeding

Generation	BW1	BW8	BW12	EGGW1	EGGW30	EGGDAY	Inbreeding(F)
G7	.	585.22	919.67	35.43	44.04	.	0
G8	31.806	596.175	996.43	34.64	43.46	.	0.0621
G9	34.673	609.94	955.52	33.43	43.5	0.7765	0.285
G10	33.07	582.172	952.653	34.93	43.42	0.8007	1.756
G11	32.273	646	1070.1	35.55	45.82	0.8086	2.598

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