

Estimation of Maternal Effects on Some Economic Traits of North Iranian Native Fowls Using Different Models

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ABSTRACT

This study was conducted to investigate direct and maternal effects on some economic traits in north Iranian native fowls. Traits considered were body weight at 1 day of age (BW1), body weight at 8 weeks of age (BW8), body weight at 12 weeks of age (BW12), egg number (EN) during the first 12 weeks of laying period, egg weight at 1st day of laying (EW1), mean egg weight at 28th, 30th and 32nd weeks (MEW), age at sexual maturity (ASM) and weight at sexual maturity (WSM). The data were analyzed using Restricted Maximum Likelihood procedure fitting an animal model with DFREML software package. A series of six different animal models with and without maternal effects were fitted for all traits, and the best model for each trait was chosen based on log-likelihood ratio tests (LRT). The direct heritability (h^2) estimates ranged from 0.03 (BW1) to 0.51 (MEW). Maternal effects were significant on all the traits studied. The estimates of maternal heritability (m^2) ranged from 0.01 (BW8, WSM, ASM, EW1) to 0.15 (BW1), and the estimates of maternal environmental variance as a proportion of phenotypic variance (c^2) varied from 0.02 (WSM, EW1, EN) to 0.23 (BW1). The correlations between direct and maternal additive genetic effects (r_{am}) were negative for all traits. These results indicate that genetic selection schemes for body weight and egg traits should utilize models incorporating both direct and maternal effects.

Keywords: Genetic parameters, Maternal effects, North Iranian native fowls.

INTRODUCTION

Iranian native hens are valuable genetic resources due to their adaptability to harsh conditions in rural areas. They provide good quality organic protein for rural as well as urban families. There are several indigenous poultry breeds in various regions of Iran which have adapted themselves to the corresponding local climatic and environmental conditions through long-term natural selection. A number of studies have been carried out aimed at the estimation of maternal effects in domestic animals, in particular for mammals (see Willham, 1980; Mohiuddin, 1993; Robinson, 1996), but little

is known about the role of maternal effects in poultry. Maternal effects are defined as any influence of a dam on the phenotype of her offspring in addition to her directly transmitted genes (Willham, 1980). In poultry, maternal (egg) effects on juvenile broiler body weight are apparent (Chambers, 1990); however, little attempts have been made to partition this maternal variance into its genetic and environmental components. Moreover, the sign and magnitude of direct-maternal additive genetic covariance has not been estimated. While, genetic parameters for economic important traits are available in literature (Le Bihan-Duval *et al.*, 1998; Hartmann *et al.*, 2003; Saatci *et al.*, 2006;

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Kranis *et al.*, 2006), information on maternal genetic effects for production and reproduction traits in Iranian native fowls is scarce. However, the data collected at Mazandaran native fowls breeding center (MNFC), supported by a fully pedigreed record over several generations provided an opportunity for evaluating direct and maternal influences on production and reproduction traits in north Iranian native fowl. Therefore, the present study was conducted to estimate variance and (co)variance components due to direct genetic effects, maternal genetic effects and maternal environmental effects for production and reproduction traits in Iranian native hens.

MATERIALS AND METHODS

Data Description

Mazandaran native fowls breeding center (MNFC) was established in 1986, with the objective of saving population of native fowls in rural areas from extinction. In the year of foundation, about 5000 cocks and hens were purchased from rural communities across the province and were transferred to a quarantine farm. In 1987, after quarantine procedures, about 2500 birds of both sexes were retained to produce hatching eggs, and chicks produced from these eggs were transferred to the MNFC. Subsequently, birds were individually tagged and trap nests were used to trace pedigrees of chicks. Birds were selected for body weight, egg number, average egg weight and age at sexual maturity. There were four hatches in each generation. The family structure was hierarchical, with dams nested within sires and thus maternal full-sibs and paternal half-sibs existed. On average, each sire was mated with ten dams and the average family size was approximately 6. Matings between close relatives were avoided.

In this study, data on 55468 birds from the first seventeen generations (G1 to G17),

were used to estimate the genetic parameters for production and reproduction traits. Data were screened several times and defective and outlier data (Mean \pm 3S.D) were eliminated. The evaluated traits were: body weight at 1 day of age (BW1), body weight at 8 weeks of age (BW8), body weight at 12 weeks of age (BW12), egg number (EN) during the first 12 weeks of laying period, egg weight at 1st day of laying (EW1), mean egg weight at 28th, 30th, 32nd weeks (MEW), and age (ASM), and weight at sexual maturity (WSM).

Statistical Analyses

Initially, least square analyses were conducted using the GLM procedure (SAS, 1996) to identify fixed effects to be included in the models. Generation and Hatch for BW1, BW8, BW12, ASM, WSM, EN, EW1 and MEW traits and also Sex for BW1, BW8 and BW12 traits were significant ($P < 0.01$) and, therefore, considered as the fixed effects. Animal, maternal genetic and environmental effects, covariance between direct and maternal genetic effects and residual were considered as random effects. An attempt was made to analysis the data using a multi-trait animal model incorporating direct and maternal effects. Unfortunately, this analysis failed to converge; consequently, data were analyzed with a series of six different single-trait animal models including or excluding maternal effects. The models were as follows:

$$y = Xb + Z_1a + e \quad (M1)$$

$$y = Xb + Z_1a + Wc + e \quad (M2)$$

$$y = Xb + Z_1a + Z_2m + e \quad Cov(a,m) = 0 \quad (M3)$$

$$y = Xb + Z_1a + Z_2m + e \quad Cov(a,m) \neq 0 \quad (M4)$$

$$y = Xb + Z_1a + Z_2m + Wc + e \quad Cov(a,m) = 0 \quad (M7)$$

$$y = Xb + Z_1a + Z_2m + Wc + e \quad Cov(a,m) \neq 0 \quad (M8)$$

where y is the vector of observations, b denotes the fixed effects in the models with associated matrix X , a is the vector of direct genetic effects with associated matrix Z_1 , c is the vector of maternal environmental effects with associated matrix W , m is the vector of

maternal genetic effects with associated matrix Z_2 , and e denotes the vector of residual effects. Variance-covariance components and genetic parameters were estimated using the DFREML software package (Meyer, 2000). For all models, maximization of the log-likelihood was implemented by the simplex method. The convergence criterion was set at 10^{-8} . Likelihood ratio tests (LRT) were performed to evaluate the significance of the contribution of each random term to the improvements in the model fit (or adequacy). The LRT is based on testing with χ^2 statistic twice the increase in log-Likelihood resulting from adding a random effect term (Meyer, 1992).

RESULTS

The summary statistics and summary structure of the analyzed data are presented

in Table 1. The log likelihood values from univariate analyses for each trait studied are shown in Table 2. Results in Table 2 show that for BW1, BW12, and ASM fitting maternal genetic and maternal environmental effects improved the *log L* significantly ($P < 0.05$), compared to a model fitting only direct genetic effect (Model 1). Therefore, Model 7, which included direct and maternal genetic effects as well as maternal environmental effects, was chosen to be the most suitable model for BW1, BW12, and ASM. For other traits, BW8, WSM, EW1, and MEW, the inclusion of direct-maternal genetic covariance in addition to maternal genetic and environmental effects, resulted in a significant improvement in *log L*. Hence, according to the log L values, the full model (Model 8) was chosen as the most suitable model for these traits.

Estimated variance components and

Table 1. Basic statistics of analyzed data in production and reproduction traits.

	N	Mean	SD	Minimum	Maximum
BW1 ^a (g)	32364	36.17	3.37	25.50	47.00
BW8 ^b (g)	54522	527.04	123.32	200	920
Bw12 ^c (g)	45639	935.65	209.17	320	1590
ASM ^d (d)	42242	162.42	18.95	98	219
WSM ^e (g)	42613	1657.00	253.41	900	2440
EN ^f	42784	37.52	16.49	1	88
EW1 ^g (g)	33553	40.60	6.19	20	61.90
MEW ^h (g)	41903	47.43	4.21	27.38	61.90

^a Body weight at 1 day of age; ^b Body weight at 8 weeks of age; ^c Body weight at 12 weeks of age; ^d Age at sexual maturity; ^e Weight at sexual maturity; ^f egg number during the first 12 weeks of laying period; ^g Egg weight at 1th day of laying; ^h Mean egg weight at 28th, 30th, 32nd weeks.

Table 2. The log likelihood values from Univariate analyses for each trait ^a (best model in bold).

Trait ^a	Model					
	1	2	3	4	7	8
BW1(g)	-48977.44	-46879.68	-46948.30	-46940.80	-46777.19	-46776.32
BW8(g)	-261386.87	-261247.86	-261304.60	-261300.94	-261244.68	-261239.99
Bw12(g)	-239294.14	-239208.07	-239212.40	-239212.40	-239193.04	-239192.39
ASM(d)	-242100.79	-242074.89	-242081.21	-242081.05	-242071.59	-242070.41
WSM(g)	-134200.86	-134067.15	-134118.20	-134068.99	-134062.35	-134001.41
EN	-126866.15	126849.21	-126857.08	-126841.25	-126847.73	-126829.02
EW1(g)	-80792.42	-80781.62	-80790.02	-80782.18	-80781.62	-80773.08
MEW(g)	-73444.38	-73420.98	-73428.26	-73416.52	-73419.11	-73401.98

^a See footnote of Table 1.



genetic parameters for the studied traits obtained from univariate analyses are presented in Tables 3 and 4, respectively. For all traits, estimates of direct heritability were influenced by the statistical model in a way that under the simple animal model (Model 1), h^2 values were overestimated; but when maternal effects were included (Models 1 and 2), estimates of h^2 decreased, especially for BW1. For other traits studied, although estimates of h^2 varied between the models with different maternal effects structures specified, these differences were minor in comparison. According to the most appropriate model, estimates of direct heritability were 0.04, 0.19, 0.24, 0.48, 0.27, 0.21, 0.50, and 0.16 for BW1, BW8, BW12, WSM, ASM, EW1, MEW, and EN, respectively. Both maternal genetic and environmental effects had significant influences on the traits studied; however, they were most important for birth weight. For BW1, maternal heritability (m^2) was considerably higher than h^2 , and explained 15% of the total phenotypic variation. For other traits, maternal heritability estimates were low: 0.01, 0.02, 0.01, 0.01, 0.01, 0.02, and 0.02 for BW8, BW12, WSM, ASM, EW1, MEW, and EN, respectively. The maternal environmental variance served as an important source of variation for BW1 (c^2 equal to 0.23). For BW8, BW12, WSM, ASM, EW1, MEW, and EN, estimates of c^2 were 0.05, 0.03, 0.02, 0.06, 0.02, 0.03, and 0.02, respectively. The covariance between direct and maternal genetic effects (r_{am}) was estimated to be -0.35 for BW8, -0.18 for WSM, -0.69 for EW1, and -0.79 for EN, respectively.

DISCUSSION

Maternal genetic and environmental effects were evaluated in addition to direct effects. In all cases, the models including maternal genetic and maternal environmental effects had higher log L values than the simple animal model, which shows that models for analyzing production

and reproduction traits in fowls should include both direct and maternal effects. Koerhuis *et al.* (1997) reported that using a biometrical model with direct and maternal genetic effects and covariance between them as well as environmental maternal effects provided the best fit for growth traits. Ignoring maternal effects resulted in the overestimation of direct heritability for body weight, a conclusion also reached by others (Chambers, 1990; Le Bihan-Duval *et al.*, 1998). A number of studies have estimated the magnitude of maternal effects on production and reproduction traits in poultry. Hartman *et al.* (2003) estimated direct heritability as 0.01 for chick weight, whereas maternal heritability was surprisingly high (0.50). In addition, Saatci *et al.* (2006) reported a low estimate of direct heritability (0.07) but higher estimates of m^2 (0.74) and c^2 (0.24) in Japanese quail for body weight at 1 week of age. Gonzalez *et al.* (2003) estimated h^2 , m^2 and c^2 for birth weight to be 0.15, 0.18 and 0.43, respectively. The authors pointed out that maternal effects were the most important part of the variation early in life and that those effects disappear gradually as the chicks grow older. For BW8 and BW12, maternal effects were low, however, these effects were statistically significant. Kourtis *et al.* (1997) proposed that a model including both additive genetic and environmental maternal effects is needed for analyzing broiler body weight at 6 weeks of age. Similar to our results, Koerhuis and Thompson (1997) and Norris and Ngambi (2006) in chickens and Chapuis *et al.* (1996) in turkeys showed that maternal effects account for a small but non-negligible part of the variability of body weight at higher ages (2% to 8% of the total phenotypic variation). Kranis *et al.* (2006) reported that the contribution of maternal influences to the phenotypic variation of body weight decreases with age. This could be expected because feeding plays an important role in body weight during the 5th and 6th weeks of life when the growth rate is high. Le Bihan-Duval *et al.* (1998) studied some production

Table 3. Estimates of variance components and genetic parameters for body weight traits^a.

Trait	Model	σ_a^2	σ_c^2	σ_m^2	σ_{im}^2	σ_e^2	σ_p^2	$h^2 \pm SE$	$c^2 \pm SE$	$m^2 \pm SE$	r_{am}	
Bw1	1	3.88	-	-	-	4.92	8.81	0.44±0.009	-	-	-	
	2	0.89	2.79	-	-	4.70	8.38	0.11±0.01	0.33±0.008	-	-	
	3	0.32	-	4.57	-	5.03	9.92	0.03±0.009	-	0.46±0.01	-	
	4	0.50	-	4.89	-0.48	4.95	9.86	0.05±0.009	-	0.50±0.01	-0.31	
	7	0.31	1.91	1.25	-	4.98	8.45	0.04±0.01	0.23±0.02	0.15±0.01	-	
	8	0.38	1.90	1.36	-0.13	4.94	8.45	0.05±0.01	0.22±0.02	0.16±0.01	-0.18	
	BW8	1	1457.86	-	-	-	4370.65	5828.52	0.25±0.01	-	-	-
		2	991.20	295.26	-	-	4424.64	5711.10	0.17±0.01	0.05±0.004	-	-
3		1062.64	-	284.12	-	4453.77	5800.53	0.18±0.01	-	0.05±0.005	-	
4		1170.81	-	334.27	-112.20	4402.18	5795.05	0.20±0.01	-	0.06±0.005	-0.18	
7		961.58	254.55	58.28	-	4439.71	5714.13	0.17±0.01	0.04±0.004	0.01±0.003	-	
8		1089.13	267.93	77.62	-100.67	4378.23	5712.24	0.19±0.01	0.05±0.004	0.01±0.003	-0.35	
BW12		1	4798.67	-	-	-	9866.18	14664.85	0.33±0.01	-	-	-
		2	3657.92	619.27	-	-	10068.18	14345.82	0.26±0.01	0.04±0.004	-	-
	3	3671.84	-	730.87	-	10143.18	14545.89	0.25±0.01	-	0.05±0.005	-	
	4	3676.26	-	735.52	-7.21	10140.78	14545.36	0.25±0.01	-	0.05±0.005	-0.004	
	7	3489.43	417.41	316.44	-	10144.44	14367.73	0.24±0.01	0.03±0.006	0.02±0.005	-	
	8	3626.56	435.10	339.82	-121.05	10079.10	14359.43	0.25±0.01	0.03±0.006	0.02±0.005	-0.11	
	WSM	1	19000.87	-	-	-	19836.14	38837.01	0.49±0.01	-	-	-
		2	17872.88	946.65	-	-	19766.79	38586.33	0.46±0.01	0.02±0.004	-	-
3		17922.12	-	891.89	-	19982.05	38796.06	0.46±0.01	-	0.02±0.001	-	
4		18222.56	-	940.54	-190.74	19838.49	38810.85	0.47±0.01	-	0.02±0.001	-0.05	
7		17671.50	709.49	375.64	-	19858.15	38614.77	0.46±0.01	0.02±0.004	0.01±0.001	-	
8		18555.44	768.18	424.16	-502.79	19424.58	38669.57	0.48±0.01	0.02±0.004	0.01±0.001	-0.18	

^a σ_a^2 = Direct additive genetic variance; σ_c^2 = Maternal environmental variance; σ_m^2 = Maternal additive genetic variance; σ_{im}^2 = Covariance between direct additive genetic and maternal additive genetic effects; σ_e^2 = Residual variance; σ_p^2 = Phenotypic variance; h^2 = Direct heritability; m^2 = Maternal heritability; c^2 = Proportion of maternal environmental variance to phenotypic variance, r_{am} = Correlation between direct and maternal additive genetic effects.
 BW1= Body weight at 1 day of age; BW8= Body weight at 8 weeks of age; BW12= Body weight at 12 weeks of age, WSM= Weight at sexual maturity.

**Table4.** Estimates of variance components and genetic parameters for reproduction and production traits.^a

Trait	Model	σ_a^2	σ_c^2	σ_m^2	σ_{am}^2	σ_e^2	σ_p^2	$h^2 \pm SE$	$c^2 \pm SE$	$m^2 \pm SE$	r_{am}	
ASM	1	77.87	-	-	-	141.89	219.76	0.35±0.01	-	-	-	
	2	58.10	14.16	-	-	142.85	215.12	0.27±0.01	0.07±0.005	-	-	
	3	64.61	-	12.57	-	142.92	220.11	0.29±0.01	-	0.06±0.005	-	
	4	86.90	-	21.76	-22.54	132.39	218.50	0.40±0.01	-	0.10±0.005	-0.52	
	7	57.56	12.25	2.61	-	143.11	215.52	0.27±0.01	0.06±0.005	0.01±0.005	-	
	8	82.93	13.50	9.64	-22.12	130.83	214.78	0.39±0.01	0.06±0.005	0.05±0.005	-0.78	
	EW1	1	8.47	-	-	-	36.24	44.71	0.19±0.01	-	-	-
		2	7.48	0.88	-	-	36.17	44.52	0.17±0.01	0.02±0.004	-	-
3		8.02	-	0.35	-	36.31	44.68	0.18±0.01	-	0.008±0.004	-	
4		9.73	-	0.90	-1.40	35.49	44.72	0.22±0.01	-	0.02±0.004	-0.47	
7		7.46	0.85	0.01	-	36.19	44.51	0.17±0.01	0.02±0.004	0.0003±0.003	-	
8		9.28	0.92	0.39	-1.31	35.30	44.58	0.21±0.01	0.02±0.004	0.009±0.004	-0.69	
MEW		1	6.72	-	-	-	7.84	14.56	0.46±0.01	-	-	-
		2	6.31	0.34	-	-	7.81	14.47	0.44±0.01	0.02±0.004	-	-
	3	6.38	-	0.30	-	7.88	14.56	0.44±0.01	-	0.02±0.004	-	
	4	7.42	-	0.47	-0.68	7.38	14.60	0.51±0.01	-	0.03±0.004	-0.36	
	7	6.26	0.27	0.11	-	7.84	14.48	0.43±0.01	0.02±0.004	0.008±0.004	-	
	8	7.48	0.35	0.23	-0.76	7.24	14.53	0.51±0.01	0.03±0.004	0.02±0.004	-0.59	
	EN	1	23.49	-	-	-	131.50	154.99	0.15±0.01	-	-	-
		2	18.96	3.47	-	-	131.64	154.07	0.12±0.01	0.02±0.004	-	-
3		20.78	-	1.98	-	132.10	154.76	0.13±0.01	-	0.01±0.004	-	
4		26.23	-	4.86	-6.16	129.48	154.41	0.17±0.01	-	0.03±0.004	-0.55	
7		18.52	2.84	0.88	-	131.86	154.11	0.12±0.01	0.02±0.004	0.006±0.003	-	
8		24.50	3.65	2.62	-5.72	128.84	153.88	0.16±0.01	0.02±0.004	0.02±0.003	-0.71	

^a σ_a^2 = Direct additive genetic variance; σ_c^2 = Maternal environmental variance; σ_m^2 = Maternal additive genetic variance; σ_{am}^2 = Covariance between direct additive genetic and maternal additive genetic effects; σ_e^2 = Residual variance; σ_p^2 = Phenotypic variance; h^2 = Direct heritability; c^2 = Maternal heritability; m^2 = Proportion of maternal environmental variance to phenotypic variance; r_{am} = Correlation between direct and maternal additive genetic effects.

EN= Egg number during the first 12 weeks of laying period; **EW1**= Egg weight at 1st day of laying; **MEW**= Mean egg weight at 28th, 30th, 32nd weeks; **ASM**= Age at sexual maturity. **WSM**= Weight at sexual maturity.

traits in a commercial line and reported that maternal effects accounted for a small part of the total phenotypic variance (from 3% to 8% according to the trait), but ignoring these effects led to significant overestimations of the direct heritability (by 11% to 19%). For BW8, the correlation between direct and maternal genetic effects (r_{am}) was negative. This negative r_{am} would reduce the efficiency of selection because maternal performance may decline under continuous selection for body weight. However, this decrease in maternal performance may be negligible due to small maternal additive genetic effects. Hartman *et al.* (2003) reported h^2 for EW of 0.6, using Meyer's Model 1 (1992), where their estimate is close to our result of h^2 for MEW (0.51). The lack of evidence for maternal effects on egg production in our study could be expected because this trait is recorded after sexual maturity when reports show negligible maternal effects (Le Bihan-Duval *et al.*, 1998; Kranis *et al.*, 2006). Failure to account for maternal effects in the analysis of egg production is common in poultry studies (see Szwaczkowski, 2003, for a review). However, as observed here, the influences of maternal effects on egg production traits are statistically significant, so that considering these effects in analyzing the egg production traits would provide more accurate estimates of direct heritability. According to the appropriate model, m^2 and c^2 for age at sexual maturity (ASM) were estimated to be 0.01 and 0.02 respectively, whereas the direct heritability was 0.48. Similar to ASM, for WSM, maternal genetic effects were negligible and contributed to the phenotypic variation at 0.01 (m^2). This was 0.02 for maternal environmental effects (c^2). Estimates of m^2 and c^2 for egg number during the first 12 weeks of laying period (EN) were low (0.02 and 0.02, respectively), and the direct heritability were relatively low (0.16). These results show that age and weight at sexual maturity as well as egg number are more dependent on the genotype of the individuals rather than maternal genes or environment provided by the mother.

Kranis *et al.* (2006) investigated direct and maternal components for egg number for two populations of Turkey (British and American). They estimated direct heritability for British population as of 0.22 and 0.34 for American population. In contrast, in their study, maternal effects were not significant on egg production and, therefore, these effects were omitted from the analyses. Fathi *et al.* (2005) studied direct and maternal effects on production and reproduction traits in a commercial broiler line. They estimated direct and maternal heritability for egg number to be 0.24 and 0.05, respectively, and 0.15 and 0.06, respectively, for age at sexual maturity.

CONCLUSIONS

The results demonstrate that all the production and reproduction traits are influenced by a combination of direct and maternal genetic and environmental effects. Overlooking maternal effects introduced by using the simple direct additive genetic animal model may result in overestimation of direct heritability. Therefore, maternal effects need to be considered to avoid overestimation of the heritability and in turn of the predicted response to selection. Estimates of direct heritability were moderate to high, indicating that selection would result in moderate to high genetic improvements in the traits studied.

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برآورد اثر عوامل مادری بر بعضی از صفات اقتصادی در مرغ های شمال ایران با استفاده از مدل های مختلف

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چکیده

در این تحقیق، اثر عوامل ژنتیکی افزایشی مستقیم و مادری بر صفات وزن بدن در سن یک روزگی (BW1)، هشت هفتگی (BW8)، دوازده هفتگی (BW12)، تعداد تخم مرغ در سه ماه اول تولید (EN)، وزن اولین تخم مرغ (EW1)، میانگین وزن تخم مرغ در هفته ۲۸،۳۰ و ۳۲ (MEW)، سن بلوغ جنسی (ASM) و وزن بلوغ جنسی (WSM) (حاصل از اطلاعات مرغ های بومی شمال ایران مورد بررسی قرار گرفت. داده ها با استفاده از روش حداکثر درستنمایی محدود شده (REML) و مدل حیوان با نرم افزار DFREML تجزیه و تحلیل شدند. با و بدون در نظر گرفتن اثر عوامل مادری ۶ مدل حیوانی مختلف برآزش شده و مناسبترین مدل با توجه به مقدار لگاریتم درستنمایی انتخاب شد. وراثت پذیری مستقیم (h^2) دامنه ای از ۰/۰۳ (برای صفت وزن بدن در سن یک روزگی) تا ۰/۵۱ (برای صفت میانگین وزن تخم مرغ در هفته ۲۸،۳۰ و ۳۲) داشت. اثرات مادری بر روی تمام صفات مورد بررسی معنی دار بودند. وراثت پذیری مادری (m^2) از ۰/۰۱ (برای صفات وزن بدن در هشت هفتگی، وزن بلوغ جنسی، سن بلوغ جنسی و وزن اولین تخم مرغ) تا ۰/۱۵ (برای وزن بدن در سن یک روزگی) و نسبت واریانس محیطی مادری به واریانس فنوتیپی (c^2) از ۰/۰۲ (برای تعداد تخم مرغ، وزن اولین تخم مرغ و وزن بلوغ جنسی) تا ۰/۲۳ (برای وزن بدن در سن یک روزگی) در تغییر بود. همبستگی بین اثر ژنتیکی افزایشی مستقیم و مادری (r_{am}) برای همه صفات منفی بود. نتایج به دست آمده نشان داد که برنامه های انتخاب برای صفات وزن بدن و تخم مرغ باید با در نظر گرفتن هر دو اثر مادری و مستقیم انجام شود.