Estimation of Genetic Parameters for Economic Traits in Korean Native Chickens

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ABSTRACT : Heritabilities and genetic correlations of economic traits were estimated with a multiple-trait animal model on 5 different strains of Korea Native Chickens (KNC): Red Brown (RB), Yellow Brown (YB), Gray Brown (GB), Black (B) and White (W). The data used for this study were collected from the Daejeon branch of the National Livestock Research Institute and included 11,233 performance records and 12,729 individual animals. DFREML and SAS BASE/STAT packages were used to estimate genetic parameters and descriptive statistics. The estimated heritabilities for strain RB, YB, GB, B and W, respectively, for age at 1st egg were 0.24, 0.27, 0.12, 0.32 and 0.18; for body weight at first egg were 0.39, 0.43, 0.38, 0.52 and 0.57; for body weight at age of 270 days were 0.43, 0.51, 0.30, 0.52 and 0.67; for egg weight at first egg were 0.08, 0.13, 0.07, 0.06 and 0.07; for egg weight at age of 270 days were 0.37, 0.43, 0.22, 0.34 and 0.41; and for number of eggs laid by age of 270 days were 0.24, 0.25, 0.37, 0.36 and 0.30. The genetic and phenotypic correlations were also estimated. ***(Asian-Aust. J. Anim. Sci. 2006. Vol 19, No. 3 : 319-323)***

Key Words : Korean Native Chickens, Genetic Parameters, DFREML

INTRODUCTION

The first introduction of Korean Native Chicken (KNC) was not clear although it was assumed to be introduced through south and north China about 2,000 years ago. KNC are less fatty and higher protein content compared to foreign breeds. Therefore it is very popular to domestic consumers. The initial endeavor to establish the pure lines of KNC was started in 1980 by governmental research institutes by way of collecting them being spread nationwide and the phenotypic characteristics of 5 KNC strains were shown in Table 1.

Pursuing an efficient selection and genetic improvement of chickens, various authors have studied and published on estimation of genetic parameters on egg production and growth (Lush, 1948; Lerner and Cruden, 1951; King and Henderson, 1954; Kinney, 1969; McClung et al., 1976). Han et al. (1986) published on genetic parameters of economic traits in KNC named O-Gol and Jung et al. (1992) reported the estimated heritabilities and genetic correlations among economic traits on KNC. Since 1950's, numerous studies have been reported on the heritability estimates for the age at first egg, egg production, and egg weight for the layers. But there have been little studies for established pure strains of KNC. Mixed linear models with BLUP property have been of primary use for estimation genetic parameters and genetic evaluation. Recently the random regression model has been widely used for those purpose (Yang et al., 2004). A molecular approach to detect major genes affecting the economic traits for chicken has been studied by Mannen et al. (2004). In this study, heritabilities and genetic correlations on the economic traits of established KNC pure strains were estimated with multiple trait animal models.

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MATERIAL AND METHOD

Data

The data used in this study were collected from 5 different strains of KNC raised at Daejeon branch of National Livestock Research Institute, Rural Development Administration, Rep. of Korea. The five different strains are RB, YB, GB, B and W. From these strains, the performance-tested records have been collected for 7 generations from 1995 to 2001. The number of animals and records by trait and strain were shown in Table 2. The analyzed traits were age at first egg, body weight at first egg, body weight at age 270 days, egg weight at first egg, egg weight at age 270 days, and number of eggs laid by age 270 days.

Statistical model

SAS GLM procedure (SAS, 2000) was used to find out the phenotypic differences among strains with following model :

Table 1. Phenotypic characteristics of KNC

Pals of body	Strains				
	RB	YB	GB	B	W
Comb	Scarlet	Scarlet	Scarlet	Dard red	Scarlet
Head	Red brown	Yellow	Yellow	Black	White
Bead	Yellow	Yellow	Yellow	Black	Yellow
Earlobe	Scarlet	Scarlet	Scarlet	Red, white	Scarlet
Wattle	Scarlet	Scarlet	Scarlet	Dark red	Scarlet
Neck	Red brown	Yellow	Gray brown	Black	White
Back	Red brown	Yellow	Red brown	Black	White
Wing	Red brown	Yellow	Black	Black	White
Tail	Green black	Green black	Green black	Black	White
Shank	Gray black	Gray black	Gray black	Gray	Gray black
Toe	Gray black	Gray black	Gray black	Black	Gray black

Table 2. Means and their standard errors by trait and strain

Traits	Strains	No. of records	Mean[1]	Std. Err.
Age at 1st egg (days)	RB	3,598	149.88[b]	0.241
	YB	3,175	148.24[c]	0.246
	GB	889	149.42[b]	0.493
	B	2,418	152.84[a]	0.298
	W	1,136	147.36[c]	0.442
Body weight at 1st egg (g)	RB	3,253	1,552.41[c]	3.707
	YB	3,141	1,473.75[d]	3.164
	GB	754	1,398.02[b]	6.280
	B	2,182	1,583.37[a]	4.558
	W	1,023	1,545.78[c]	6.664
Body weight at age of 270 d (g)	RB	3,458	1,876.22[b]	4.836
	YB	3,093	1,738.53[d]	4.153
	GB	861	1,698.91[e]	8.330
	B	2,345	1,895.21[a]	5.765
	W	1,083	1,769.16[c]	7.462
Egg weight at 1st egg (g)	RB	3,602	33.24[a]	0.083
	YB	3,174	32.25[c]	0.087
	GB	890	32.19[c]	0.146
	B	2,417	32.95[b]	0.097
	W	1,139	30.64[d]	0.132
Egg weight at age of 270 d (g)	RB	3,183	50.76[a]	0.065
	YB	2,834	49.25[c]	0.068
	GB	786	49.09[c]	0.120
	B	1,936	50.04[b]	0.081
	W	962	47.90[d]	0.107
No. of eggs laid by age of 270 d	RB	3,574	87.59[b]	0.460
	YB	3,155	89.75[a]	0.479
	GB	882	87.88[ab]	0.989
	B	2,386	84.49[c]	0.591
	W	1,124	86.41[bc]	0.953

[1] The same letters in the same trait denote that means are not significantly different (p>0.05) and these are available for only pre-planned pair-wise comparisons.

$$y_{ij} = s_i + e_{ij}$$

where,
y_{ij} : j^{th} observation of i^{th} strain,
S_i : j^{th} strain effect, and
e_{ij} = random residuals.

Strain least squares means of each trait were compared with pair-wise manner with SAS GLM's PDIFF option (SAS, 2000).

Multiple trait individual animal model was used to estimate heritabilities and genetic correlations among the 6 traits of each strain. The linear model used for this analysis was given as:

$$y_{ijk} = \text{hatchday}_{ij} + a_{ijk} + e_{ijk}$$

where,
y_{ijk} : record of k^{th} individual measured in j^{th} hatchday for i^{th} trait,
hatchday_{ij} : fixed effect of j^{th} hatchday for i^{th} trait,
a_{ijk} : additive genetic effect of k^{th} individual in j^{th} hatchday for i^{th} trait and,
e_{ijk} = random residuals.

The DFREML version 3.1 (Meyer, 2001) package were used for the genetic parameter estimation and SAS BASE/STAT package was also used to get descriptive statistics of data. The estimates obtained from previous run of 2 traits pair-wise analysis were used as starting values for six trait genetic parameter estimation and AI-REML was used for searching algorithm. In Table 3, levels of fixed and random effect were listed by trait and strain. The levels of fixed effect for body weight at first egg trait were smaller than other traits because body weights at first egg were not taken in 1995.

RESULTS

Phenotypic differences among strains

The means, their standard errors of each traits and pair-wise comparisons among strains were computed with

Table 3. Estimated heritabilities, genetic correlations and phenotypic correlations in strain RB

Traits	Age at 1st egg	Body weight		Egg weight		No. of eggs by age 270 d
		at 1st egg	at age 270 d	at 1st egg	at age 270 d	
Age at 1st egg	0.24	0.31	0.34	0.48	0.31	-0.81
Body weight at 1st egg	-0.03	0.39	0.97	0.36	0.57	-0.48
Body weight at age 270 d	0.09	0.64	0.43	0.16	0.56	-0.47
Egg weight at 1st egg	0.29	0.11	0.52	0.08	0.73	-0.37
Egg weight at age 270 d	0.10	0.32	0.34	0.23	0.37	-0.30
No. of eggs laid by age 270 d	-0.59	-0.07	-0.16	-0.18	-0.10	0.24

Heritabilities are on the diagonal, genetic correations are above and phenotypic correlations are below the diagonal.

Table 4. Estimated heritabilities, genetic correlations and phenotypic correlations in strain YB

Traits	Age at 1st egg	Body weight		Egg weight		No. of eggs by age 270d
		at 1st egg	at age 270 d	at 1st egg	at age 270 d	
Age at 1st egg	0.27	0.14	0.14	0.66	0.24	-0.61
Body weight at 1st egg	-0.03	0.43	0.92	0.50	0.42	-0.08
Body weight at age of 270 d	0.09	0.66	0.51	0.14	0.42	-0.13
Egg weight at 1st egg	0.33	0.08	0.51	0.13	0.60	-0.37
Egg weight at age of 270 d	0.08	0.26	0.30	0.20	0.43	-0.30
No. of eggs laid by age of 270 d	-0.53	0.01	-0.11	-0.17	-0.06	0.25

Heritabilities are on the diagonal, genetic correations are above and phenotypic correlations are below the diagonal.

Table 5. Estimated heritabilities, genetic correlations and phenotypic correlations in strain GB

Traits	Age at 1st egg	Body weight		Egg weight		No. of eggs by age 270 d
		at 1st egg	at age 270 d	at 1st egg	at age 270 d	
Age at 1st egg	0.12	0.51	0.72	0.48	0.38	-0.58
Body weight at 1st egg	-0.09	0.38	0.90	0.77	0.26	-0.06
Body weight at age of 270 d	0.08	0.65	0.30	0.09	0.41	-0.21
Egg weight at 1st egg	0.35	0.04	0.69	0.07	0.56	-0.05
Egg weight at age of 270 d	0.17	0.25	0.33	0.23	0.22	-0.58
No. of eggs laid by age of 270 d	-0.57	-0.01	-0.17	-0.18	-0.12	0.37

Heritabilities are on the diagonal, genetic correations are above and phenotypic correlations are below the diagonal.

MEANS and GLM procedure with PDIFF option of SAS 8.2 package for each trait and strain (Table 2). For all six traits, the strain effect were significant at $p>0.05$ and least squares means of each trait from different strains revealed differences of strains.

Genetic parameters

The heritabilities, genetic correlations and phenotypic correlations estimated with six trait multiple animal model were shown in Table 3, 4, 5, 6 and 7 for strain RB, YB, GB, B and W, respectively.

The estimated heritabilities for Age at 1st egg were 0.24, 0.27, 0.12, 0.32 and 0.18 for strain RB, YB, GB, B and W, respectively. The results of the study conformed with the finding of Lee, et al. (1998) using of KNC with an estimated heritability for age at first egg, 0.13-0.25. Although report by Han and Ohh (1975) was slightly higher, 0.20-0.45 in their study using short Comb White Leghorn (SCWL) Korean laying stocks. The estimated heritability of strain B was in the range of previous estimates in White Leghorn breed (Emslay et al., 1977; Hagger and Abplanalp, 1988). However, the estimates from all strains studied were lower than previous estimates of 0.40 by Craig et al. (1972) and 0.47 by Singh et al. (1972) in White Leghorn breed, and much lower than 0.58 reported by Tixier-Boichard et al. (1995) in Brown Leghorn breed.

The estimated heritabilities for Body weight at first egg were 0.39, 0.43, 0.38, 0.52 and 0.57 for strain RB, YB, GB, B and W, respectively. However, lower heritability values, 0.23-0.39, were reported by Lee et al. (1998) in their study of 4 strains of KNC. These estimates were similar to those of 0.47 reported by McCling et al. (1976).

The estimated heritabilities for Body weight at age of 270 day were 0.43, 0.51, 0.30, 0.52 and 0.67 for strain RB, YB, GB, B and W, respectively. Lower heritability values (0.13-0.49) were published by Lee et al. (1998). For YB, B and W strains, the estimated heritabilities were somewhat lower than previous estimates of 0.60 by Buchel (1970), 0.58 by McClung et al. (1976), 0.59 by Tixier-Boichard et al. (1995), 0.62 by Vaccaro and Van Vleck (1972) in White Leghorn breed. However, the estimates of all strains in this study were much lower than the estimate of 0.73 reported

Table 6. Estimated heritabilities, genetic correlations and phenotypic correlations in strain B

Traits	Age at 1st egg	Body weight at 1st egg	Body weight at age 270 d	Egg weight at 1st egg	Egg weight at age 270 d	No. of eggs by age 270 d
Age at 1st egg	0.32	-0.10	-0.01	0.30	-0.07	-0.50
Body weight at 1st egg	-0.04	0.52	0.86	0.48	0.58	-0.05
Body weight at age of 270 d	0.01	0.70	0.52	0.13	0.47	-0.15
Egg weight at 1st egg	0.25	0.12	0.45	0.06	0.44	-0.12
Egg weight at age of 270 d	0.03	0.32	0.34	0.20	0.34	0.11
No. of eggs laid by age of 270 d	-0.49	-0.05	-0.14	-0.11	0.00	0.36

Heritabilities are on the diagonal, genetic correations are above and phenotypic correlations are below the diagonal.

Table 7. Estimated heritabilities, genetic correlations and phenotypic correlations in strain W

Traits	Age at 1st egg	Body weight at 1st egg	Body weight at age 270 d	Egg weight at 1st egg	Egg weight at age 270 d	No. of eggs by age 270 d
Age at 1st egg	0.18	0.44	0.43	0.54	0.07	-0.76
Body weight at 1st egg	0.02	0.57	0.94	0.78	0.58	-0.35
Body weight at age of 270 d	0.10	0.66	0.67	0.09	0.52	-0.38
Egg weight at 1st egg	0.34	0.10	0.55	0.07	0.45	-0.52
Egg weight at age of 270 d	0.01	0.26	0.27	0.15	0.41	-0.12
No. of eggs laid by age of 270 d	-0.54	-0.06	-0.16	-0.20	-0.03	0.30

Heritabilities are on the diagonal, genetic correations are above and phenotypic correlations are below the diagonal.

by Hagger (1990) in White Leghorn breed.

The estimated heritabilities for Egg weight at first egg were .08, 0.13, 0.07, 0.06 and 0.07 for strain RB, YB, GB, B and W, respectively. A heritability estimate of 0.01-0.20 were reported by Lee et al. (1998) with strains of KNC. Hagger (1994) reported an estimate of 0.75 for egg weight at first egg. Lerner and Cruden (1951) and Strong et al. (1978) also reported estimates ranging from 0.50 to 0.78.

The estimated heritabilities for Egg weight at age of 270 day were 0.37, 0.43, 0.22, 0.34 and 0.41 for strain RB, YB, GB, B and W, respectively. Similar heritability values were published by Lee et al. (1998). These estimates are also similar to those of 0.30 reported by Craig et al. (1969). However, These estimates were much lower than previous estimates of 0.50 by Abplanalp (1956), 0.55 by Wei and Vander Werf (1993), and 0.75 by Hagger and Abplanalp (1988).

The estimated heritabilities for No. of eggs laid by age of 270 day were 0.24, 0.25, 0.37, 0.36 and 0.30 for strain RB, YB, GB, B and W, respectively. These estimates were in the range of previous estimates reported by Bray et al. (1960), Hicks (1958) Boukila et al. (1987), and Vaccaro and Van Vleck (1972) ranging from 0.25 to 0.34.

The negative genetic correlations ranged from -0.50 to -0.81 between age at first egg and no. of eggs laid by age of 270 days across the strains implies that if we select shorter one in age at first egg will lead to increment of egg production. These are in agreement with literature estimates of -0.77 and -0.79 reported by Merritt (1968) and Foster (1981), respectively. According to the genetic correlation between body weight (body weight at first egg and body weight at age of 270 day) and egg production (no. of eggs laid by age of 270 days) were ranged from -0.05 to -0.48 across the strains, smaller one can produce more eggs than bigger one. These estimates are similar with literature estimates of -0.36 by Hagger (1994) and -0.17 by Emsley et al. (1997). However, strength of relationships were lower than previous estimates of -0.91 reported by Johari et al. (1981). The genetic correlation between body weight at 1st egg and body weight at age of 270 days ranged from 0.86 to 0.97 across the strain shows that the body weight at first egg changes little over the production period. However, genetic correlation between egg weight at 1st egg and egg weight at age 270 d were ranged from 0.44 to 0.73 across the strains, which implies that egg weight can be readily changed rather than body weight. Phenotypic correlations among the traits were quite similar to genetic correlations, but it shows slightly lower values than those of genetic correlations.

DISCUSSION

The Korean farmers reared KNC for the purpose of increasing body weight as well as egg production because the KNC was known as dual purpose breed with respect to consumer. The great genetic potential of these traits will be helpful for genetic improvement of the objective traits through selection for superior sires and dams. For increasing genetic potential, the estimation of genetic parameters of economic traits is essential in poultry breeding. The heritability estimates for most production traits were of significant size to effectively improve the economic traits of chicken. However, egg weight at first egg had very low heritabilities across the 5 different strains, which indicates this trait was, at large, environment dependent. For most economic traits of KNC, their heritabilities are of moderately large sizes and will enhance a great potential for genetic improvement.

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REFERENCES

Abplanalp, H. 1956. Selection procedures for poultry flocks with many hatches. Poult. Sci. 35:1285-1304.

Boukila, B., M. Desmarais, J. P. Pare and D. Bolamba. 1987. Selection for increased egg production based on annual record in three strains of White Leghorns. 1. Comparison of different partial records to improve annual egg production. Poult. Sci. 66:1077-1084.

Bray, D. F., S. C. King and V. L. Anderson. 1960. Sexual maturity and the measurement of egg production. Poult. Sci. 39:590-601.

Buchel, K. 1970. Investigations of the heritability of certain characters in fowls of medium heavy breed's with reference of the possibility of selection for the breeding of broilers. Anim. Breed. Abstr. 38:4238.

Craig, J. V., D. K. Biswas and H. K. Saadeh. 1972. Genetic Variation and correlated responses in chickens selected for part-years rate of egg production. Poult. Sci. 48:1288-1296.

Emsley, A. G., E. Dickerson and T. S. Kashyap. 1977. Genectic parameters in progeny-test selection for field performances of strain-cross layers. Poult. Sci. 56:121-146.

Foster, W. H. 1981. The estimation of rate of lay from part-record data. Br. Poul. Sci. 22:399-405.

Han, S. W. and B. K. Ohh. 1975. Studies on the Heritabilities and Genetic Correlations among Egg Weight Increase and Certain Other Traits in Egg Production Stocks of Chicken. Kor. J. Anim. Sci. 17(1):15-45.

Hagger, C. and H. Abplanalp. 1988. Selection with restriction in a poultry breeding scheme with different selection procedures in both sexes: Direct reponses. Br. Poult. Sci. 29:251-263.

Hagger, C. 1990. Response from selection for income minus food cost in laying hens, estimated via the animal model. Br. Poult. Sci. 31:701-713.

Hagger, C. 1994. Genetic correlations between body weight of cocks and production traits in laying hens, and their possible use in breeding schemes. Poult. Sci. 73:381-387.

Hicks, A. F. Jr. 1958. Heritability and correlation analysis of egg weight, egg shape and number in chickens. Poult. Sci. 37:967-975.

Johari, D. C., M. Dutt and K. Q. Husain. 1981. Genetic and phenotypic correlation for some traits of economic importance in a strain of White Leghorn. Anim. Breed. Abstr. 49:1673.

King, S. C. and C. R. Henderson. 1954. Variance component analysis in heritability studies. Poult. Sci. 33:147-154.

Kinney, T. B. 1969. A summary of reported estimates of hritabilities and of genetic and phenotypic correlations for traits of chickens. USDA. Agriculture Handbook No. 363.

Lee, I. J., S. D. Kim, B. D. Sang, H. G. Jung and I. Y. Park. 1998. Study on the Estimation of Genetic Parameters of Economic Traits in Korean Native Chicken. Animal Genetics and Breeding 2 (2):99-106.

Lerner, I. M. and D. M. Cruden. 1951. The heritability of egg weight: The advantages mass selection and of early measurements. Poult. Sci. 30:30-41.

Lush, J. L. 1948. The genetics of population Ames. Iowa. Mimeo book, Iowa stage college.

Mannen, H., Y. Dote, H. Uratsuji, K. Yoshizawa, S. Okamoto and S. Tsuji. 2004. Isolation and linkage mapping of coding sequences from chicken cosmids by exon trapping. Asian-Aust. J. Anim. Sci. 17(3):309-312.

McClung, M. R., A. B. S. Wang and W. T. Jones. 1976. Respons to selection for time interval between ovipositions in the hen. Poult. Sci. 55:160-171.

Merritt, E. S. 1968. Genetic parameter estimates for growth and productive traits in a randombred control strain of meat type fowl. Poult. Sci. 47:190-199.

Meyer, K. 2001. DFREML user’s manual, http://agbu.une.edu.ac/~kmeyer/dfreml.html

SAS soft. 2000. SAS/STAT guide for personal computers at 6.08, SAS institute inc., Cary, NC, USA.

Singh, R., V. K. Taneja and P. N. Bhat. 1972. Compartive effeciency of selection indices on a White Leghorn population. Poult. Sci. 51:294-299.

Strong, C. F. J. R., K. E. Nester and W. L. Vacan. 1978. Inheritance of egg production, egg weight, body weight and certain constituents in Cortunix. Poult. Sci. 58:1-9.

Tixier-Boichard, M., D. Boichard, E. Groeneveld and A. Bordas. 1995. Resticted maximum likelihood estimates of genetic parameters of adult male and female Rhode Island Red chickens divergently selected for residual feed consumption Poult. Sci. 74:1245-1252.

Vaccaro, R. and L. D. Van Vleck. 1972. Genetics of economic traits in the Cornell randombred control population. Poult. Sci. 51:1556-1565.

Wei, M. and J. H. J. Vander Werf. 1993. Animal model estimation of additive and dominance variances in egg production traits of poultry. J. Anim. Sci. 71:57-65.

Yang, R. Q., H. Y. Ren, S. Z. Xu and Y. C. Pan. 2004. Estimation of genetic parameters for body weight in Chinese Simmental Cattle using random regression model. Asian-Aust. J. Anim. Sci. 17(7):914-918.