ESTIMATION OF GENETIC PARAMETERS BASED ON THE MATERNAL GENETIC COMPONENTS FOR ECONOMIC TRAITS IN LAYER

Estimaction de parametros geneticos pasada en los componemtes maternal-geneticos para los rasgos economicos en ponedor

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INTRODUCTION

Without more precise approach to analyze genetic parameters, improving egg production showing the plateau during several decades will be very difficult (Nordskog et al., 1974; Emsley et al., 1978) and Sheldon(1980) pointed out the importance of molecular genetics for breaking the plateau in egg production.

At first Willham(1966) reported that partition of genetic components such as additive variance due to the individual's own genotype and maternal genetic variance due to the dam's genotype was important in analyzing the genetic parameter and determining the response to selection. Through analysis of genetic parameters following the Willham's model, Alschwede and Robinson(1971), Vaccaro and Van Vleck(1972), and Hanrahan and Eisen(1973,1974) proposed for pig, poultry and mouse, respectively that the amount of genetic improvement seemed to be dependent upon interaction between additive and maternal genetic effects. Vaccaro and Van Vleck(1972) found that maternal genetic effects were important in determining the variation of all traits in chicks and also that the correlations of the additive and maternal genetic effects for most of the traits were calculated as negative. Silva et al.(1976) studied negative correlations between additive and maternal genetic effects could be considered as an aspect applicable to egg production in poultry.

Therefore it was suggested that heritability estimates might be biased, either upward or downward due to the correlations between additive and maternal genetic effects (Alschwede and Robinson, 1971; Hanrahan and Eisen, 1973). As a more practical application, Deese and Koger(1967), Hohenboken and Brinks(1972), and Hanrahan and Eisen(1974) calculated the adjusted heritability including additive variance, maternal genetic variance, and covariance between additive and maternal genetic effects for cattle, pig and mouse, showing the importance of correlations with additive and maternal genetic effects.

As the precise estimates of genetic parameters involving maternal genetic variance was rare for chicks, this study intended to analyze precisely genetic parameter with additive variance, maternal genetic variance and covariance between additive and maternal genetic effects, and reveal to the reasons for

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plateau of productivity in selected line and synthesized line in egg type chick.

MATERIALS AND METHODS

Two Leghorn lines used for this study were 1131 birds of line "A" and 1587 birds of line "D". Line "A" was produced from imported flocks in 1977 at College of Agriculture, Seoul National University, as synthetic population and line "D" has been closed flock at Livestock Experimental Station in O.R.D. since import from Japan in 1972. Records were terminated when birds were 64 weeks of age in line A and 43 weeks of age in line D. For each trait variance components and heritabilities were estimated using the $Y_{ijkl}=\mu+Y_i+S_{ij}+D_{ijk}+e_{ijkl}$ where, Y_{ijkl} is the observation of the 1^{th} progeny from the k^{th} sire in the i^{th} year, μ is population mean and e_{ijkl} is random error. It was assumed that the Y_i, S_{ij}, D_{ijk} and e_{ijkl} were assumed to be distributed with zero mean and variances $6y^2$, $6s^2$, $6D^2$ and $6e^2$, respectively. The sire and dam components of variance were used to estimate the heritability of each trait.

In order to be able to estimate the additive and maternal genetic effects, there were computed covariances between records of pairs of relatives chosen for this study. The kinds of relatives used as the expected coefficients for arbitrary components of additive and maternal genetic variance and covariances including the different covariances computed are given in Table 1. These coefficients were calcuated according to the procedure indicated by Willham(1963).

Table 1. Expectations of the components of variance and covariance for covariances between various relatives.

Covariances of relatives (Cov P_x,P_y)	6^2_{Ao}	6^2_{Am}	6^2_{AoAm}	6^2_{Ec}	6^2_{Ew}
Paternal half sibs	¼	0	0	0	0
Full sibs	½	1	1	1	0
Within full sibs	½	0	0	0	1
Dam-offspring	½	½	5/4	0	0
Maternal aunt-niece	¼	½	3/4	0	0

The total phenotypic variance for economic trait was defined by the casual components of variance; $6^2_p=6^2_{Ao}+6^2_{Am}+6_{AoAm}+6^2_{Ec}+6^2_{Ew}$, where $6p^2$ is phenotypic variance, 6^2_{Ao}; and 6^2_{Am} are direct and maternal genetic variances, 6_{AoAm} is covariance between direct and maternal genetic effects, 6^2_{Ec} is common environmental variance and 6^2_{Ew} is random environmental variance.

Heritabilities from additive variance component(h^2o), maternal genetic variance components(h^2m), additive and maternal genetic variances and covariance between additive and maternal genetic effects (h^2t), and correlation between additive and maternal genetic effects (r_{AoAm}) were calculated as follows;

$$h^2_o = \frac{\sigma^2_{Ao}}{\sigma^2_p}, \quad h^2_m = \frac{\sigma^2_{Am}}{\sigma^2_p}, \quad h^2_t = \frac{\sigma^2_{Ao} + \frac{1}{2}\sigma^2_{Am} + 3/2\sigma_{AoAm}}{\sigma^2_p}, \text{ and } r_{AoAm} = \frac{\sigma_{AoAm}}{\sigma_{Ao}\sigma_{Am}}.$$

RESULTS AND DISCUSSIONS

Heritability estimates from sire, dam and their combined components through sib analysis of line A and D are shown in Table 2. Heritabilities of egg number and egg weight of line D which were smaller than those of line A seemed to be caused by small genetic variance due to selection importance. Heritabilities from sire component in line A for body weights, egg numbers, egg weight, and first egg day, except egg numbers from 44 weeks to 64 weeks of age and initial egg weight, were larger than those from dam variance components. Also those of line D were the same as line A in all traits except egg number and initial egg weight. In these results larger heritabilities from sire components than those from dam components were suggested as the influence of sex linked effect, on the other hand smaller estimates from sire components compared with those from dam components were interpreted as a maternal effect (Han and Ohh, 1975; McClung, 1976).

Table 2. Heritabilities from sire, dam and combined variance components in lines "A" and "D"

Trait \ Heritability \ Line	A			D		
	h^2_s	h^2_d	h^2_{s+d}	h^2_s	h^2_d	h^2_{s+d}
8 wk B.W.	0.629	0.355	0.492	0.631	0.634	0.633
Initial B.W.	0.508	0.197	0.353	0.382	0.252	0.317
43wk B.W.	0.591	0.276	0.434	0.439	0.288	0.364
64wk B.W	0.508	0.293	0.401	-	-	-
1st egg day	0.555	0.392	0.473	0.420	0.149	0.285
43wk E.N	0.506	0.160	0.333	0.090	0.300	0.195
64wk E.N	0.230	0.271	0.251	-	-	-
Total E.N	0.415	0.314	0.365	-	-	-
Initial E.W	0.300	0.367	0.334	0.194	0.066	0.130
43wk E.W	0.646	0.519	0.582	0.318	0.427	0.372
64wk E.W	0.544	0.314	0.429	-	-	-

And heritabilities (h^2o and h^2m), adjusted heritabilities(h^2t), and the correlation (σ_{AoAm}) were shown in Table 3 and 4. Heritabilities of additive effects(h^2o) were same as those from sire component through sib-analysis. Heritabilities for maternal genetic effects of line A were 0.36-0.48 for body weight at different ages, 0.31 for the first egg day, 0.09-0.68 for egg numbers, 0-0.59 for egg weights, while line D showed smaller values, 0-0.20, than those of A line in all traits. In this study it was found that maternal genetic effects were important in determining the variation for all economic traits except egg weights before 43 weeks of age, and were more important in synthetic line A than closed line D. Especially heritability for maternal genetic effect in egg number of line D which were two times as large as that for additive effect was suggested as an important factor in solving the plateau.

Table 3. Estimates of heritability from direct(h^2_o) and maternal (h^2_m) genetic variances, adjusted heritability (h^2_t) and correlation (r_{AoAm}) between direct and maternal genetic effects in line "A"

Trait \ Estimate	h^2_o	h^2_m	h^2_t	r_{AoAm}
8 wk B.W	0.629	0.478	0.311	-0.676
Initial B.W	0.508	0.358	0.219	-0.731
43 wk B.W	0.591	0.383	0.424	-0.502
64 wk B.W	0.508	0.451	0.383	-0.489
1st egg day	0.555	0.312	0.136	-0.921
43 wk E.N	0.506	0.677	0.177	-0.761
64 wk E.N	0.230	0.091	0.103	-0.798
Total E.N	0.415	0.285	-0.034	-0.989
Initial E.W	0.300	0	0.208	-
43 wk E.W	0.646	0	0.968	-
64 wk E.W	0.544	0.586	0.357	-0.567

Table 4. Estimates of heritability from direct (h^2_o) and maternal (h^2_m) genetic variances, adjusted heritability (h^2_t), and correlation (r_{AoAm}) between direct and maternal genetic effects in line "D"

Trait \ Estimate	h^2_o	h^2_m	h^2_t	r_{AoAm}
8 wk B.W	0.631	0	0.753	-
Initial B.W	0.343	0.088	0.212	-0.670
43 wk B.W	0.444	0.160	0.248	-0.691
1st egg day	0.420	0.172	0.116	-0.954
43 wk E.N	0.090	0.196	0.039	-0.748
Initial E.W	0.194	0	0.096	-
43 wk E.W	0.318	0	0.842	-

Adjusted heritabilities (h^2_t) in line A were 0.22-0.42 for body weights, o.14 for the first egg day, 0-0.18 for egg numbers and 0.21-0.97 for egg weight and in line D, 0.21-0.75 for body weights, 0.12 for the first egg day, 0.04 for egg weights. Egg numbers, first egg day, and initial egg weights in both lines showed generally low estimates, on the contrary the estimates for body weights and egg weights after 43 weeks of age in both lines were medium or high. Considering the importance of maternal genetic effects, heritability estimation including additive variance, maternal genetic variance and covariance between additive and maternal genetic effects seemed to be more reasonable in utilizing poultry breeding than that from sire or dam component through sib analysis.

Correlations between additive and maternal genetic effects for all traits of line A and D, if existent, were estimated highly negative, from -0.50 to -0.99 appearing particularly -0.92 and -0.95 for the first egg day in line A and D and -0.99 for the egg number from 22 weeks to 64 weeks of age in line A. These results seemed to show that difference between heritability estimates from sire and dam variance components through sib analysis could be derived, if dominant effects were absent, from negative correlations between additive and maternal genetic effects. Therefore the same estimates from sire and dam variance components in body weight at 8 weeks of age in line D could be considered as a cause of zero in correlation between additive and maternal genetic effects. Initial egg weights in both lines and egg weight from the first egg day to 43 weeks of age in line D, which did not show correlation between additive and maternal genetic effects and showed difference between estimates from sire and dam components were considered to be derived from high common environmental variance (6^2_{Ew}) or dominant effects.

SUMMARY

Data from the 2,718 birds of two Leghorn populations for three generations were analyzed to determine the different components of genetic variance of economic traits. It was found that maternal genetic variance, comparing with additive variance determining the variation, was also important for most of the traits with except egg weights before 43 weeks of age in both lines. Correlations with the additive-maternal genetic variances, when present, were highly negative in all traits which seemed to influence to derive difference between heritabilities from sire and dam variance components through sib analysis in the absence of the dominance effect. Adjusted heritabilities included additive variance, maternal genetic variance and covariance between additive-maternal genetic effects were high in body weights and low in egg numbers and initial egg weights of both lines.

RESUMEN

Datos desde las 2,718 aves de dos poblaciones de Leghorn durante tres generaciones fueron analizados para determinar los diferentes componentes de la variante genetica de los rasgos económicos. Fue descubierta que la variante maternal-genética, comparada con adición variante determinando la variación, también fue importante para la mayoría de los rasgos con excepción de los pesos de huevo antes de 43 semanas de edad en ambas lineas. Correlaciones con las variantes de adición maternal-genética, cuando aparecen, fueron muy negativas en todos rasgos que parecen dar influencia entre las herencias de los componentes de variante de macho y hembra a través del análisis sexual falto del efecto dominante. Las herencias ajustadas, incluyendo adición variante, variante maternal-genética y covariante entre los efectos de adición maternal-genética fueron altas en los pesos de cuerpo y bajas en los números de huevo y los pesos de los huevos iniciales de ambos líneas.

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