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Responses in Partial, Residual and Annual Egg Production Expected from Selection on Part Record in Synthetic White Leghorn flock

産卵鷄의 合成種系統에 있어서 部分檢定에 의한 選拔効果 推定에 관한 研究

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摘 要

本 研究는 産業鷄의 産卵能力을 改良하는 데 있어서 部分檢定의 効率性을 究明하기 위하여 White Leghorn 合成種系統 選抜 1世代의 478首에서 測定된 産卵記録을 分析資料로 利用하였다.

調査된 形質은 初産日齢, 40週齢까지의 産卵数(P) 및 産卵率(P′), 41週齢에서 64週齢까지의 産卵数(R) 및 産卵率(R′), 그리고 全体産卵数(A) 및 産卵率(A′) 이었으며, 初産日齢부터 40週齢까지의 短期檢定成績을 다시 細分하여 初産日齢에서 22週, 24週, ……, 40週까지 2週씩 더해 나간 기간동안의 産卵数(E_i) 및 産卵率(E_i'), 그 반대로 40週齢까지의 成績을 최초의 初産日齢 19週齢 부터, 2週씩 제외시키고 얻은 나머지 期間의 産卵数(S_i) 및 産卵率(S_i')을 각각 구하여 相對的 效率을 比較하였다.

여기서 얻어진 結果를 要約하면 다음과 같다.

1. 産卵性 形質(P, P′, R, R′, A, A′)의 遺傳力은 0.29~0.35였고 初産日齢의 遺傳力은 0.48이었다.
2. 短期産卵数(P)는 短期産卵率(P′) 및 全体産卵数(A)와 높은 相關(0.67과 0.51)을 나타냈고 初産日齢과는 높은 負의 相關(−0.64)을 나타냈으며 기타 形質과는 0.15~0.36의 相關關係를 나타냈다. 한편 短期産卵率(P′)은 全体産卵数(A) 및 産卵率(A′)과 0.51, 0.72의 相關을 나타냈고 初産日齢, 后期産卵数(R) 및 産卵率(R′)과 0.34~0.36의 正의 相關을 보였다. 以上과 같은 結果로 보아 短期産卵数에 根據한 選抜은 初産日齢을 短縮시키며 年間産卵数를 改良하는 데 效率的일 것이고 短期産卵率에 의한 選抜은 初産日齢이 다소 지연되면서 年間産卵率 改良에 效率的일 것으로 생각된다.

3. 初産日齡부터 40週齡까지는 檢定期間이 길어질수록 短期檢定의 效率性이 높아진 反面에 初期成績을 2주일씩 제외시키며 얻은 나머지 期間의 産卵数(S_i) 및 産卵率(S_i')은 部分檢定(P와 P')과 같은 效率性을 나타낸 結果로 보아 産卵初期 한달간의 産卵記録은 部分檢定에서 제외시켜도 短期檢定에 의한 選抜의 正確度는 減少되지 않을 것으로 推定되었다.
4. 部分檢定(P 또는 P')에 의해 選抜時 他 形質의 遺傳的 変化量을 推定한 結果 年間産卵数를 개량하는 데는 P에 의한 選抜이 P'에 의한 選抜보다 25% 더 效率的일 것이고 年間産卵率을 改良하는 데는 P에 의한 選抜 보다 P'에 의한 選抜이 94% 더 效率的이며 初産日齡을 短縮시키기 위해서는 P에 의한 選抜이 P'에 의한 選抜보다 98% 더 높은 改良效果를 期待할 수 있는 것으로 推定되었다.

INTRODUCTION

It has been discussed by Dickerson and Hazel (1944) that the amount of genetic progress depends on three factors: the intensity of selection, the accuracy of selection and the length of the generation interval. Dempster and Lerner (1947) concluded that the use of earlier partial record as selection criterion for high annual egg production should lead to increase more rapid genetic progress due to the reduced generation interval than selection on complete records. The possibility of more efficient selection on early partial record than on full record to improve annual egg production was reported by Lerner and Cruden (1948), Morris (1956), Oliver *et al.* (1957), and Waring *et al.* (1962) based on various estimates in different populations.

Bohren *et al.* (1970) concluded that selection on partial production, whether the criterion is percent production or egg numbers to a fixed age, should reveal response in partial, residual and annual egg production. From a theoretical comparison of criteria they showed that selection on early record, either egg numbers or percentage, should give about the same increase in annual egg numbers. Furthermore, they emphasized that selection on early percent production would result in a greater increase in annual as well as in either residual egg numbers or residual percent production.

Prior to Bohren *et al.* (1970), Oliver *et al.* (1957) suggested that selection on early percent production to a fixed age would be more efficient for improvement in annual egg production than selection on egg numbers to the same age.

To evaluate the efficiency of variously segmented early production records Lowe and Garwood (1980) theoretically compared the efficiency of selection on the segment with selection on the early percent production. From such a comparison they concluded that the use of a shorter record disregarding the beginning of the early record should cut down the expenses of collecting data against a relatively small loss of information.

There are few reports that made more precise comparison of segments of the early production as egg numbers and percent production with residual as well as annual egg production at a time in the same flock. Therefore, the main purposes of this study were to estimate the heritabilities of and gentic correlations between diversely segmented early records and other traits such as age at sexual maturity, residual and annual records, to compare theoretically the genetic gain from selection on segment with that from selection on partial production, and to evaluate synthetically the relative effectiveness of two criteria by calculating the ratio of standardized response in correlated traits from selection on partial production to another standardized response.

Material and Method

The present data pertain to the first generation of a Synthetic White Leghorn flock maintained at the Poultry Breeding Farm, College of Agriculture, Seoul National University. The details of the base population have previously been reported by Yeo and Ohh (1978).

Selection of pullets in the base population for breed replacements was based on the family average of the hen-day egg production to 40 weeks of age. The cockerels used were the full brothers of the selected pullets. Selected breeders were mated at random with the restriction that no full-or half-sib matings were praticed.

Records were obtained individually from all pullets surviving until 64 weeks of age. The available breed flock consisted of 478 fully pedigreed pullets from 15 sires and 101 dams.

The measured traits and the symbols are defined as follows.

SM (age at sexual maturity)—the number of days from hatching to first egg.

P (partial egg number)—the number of eggs produced from first egg to 40 weeks of age.

P′ (partial percent production)—the ratio of P to the number of days from first egg to 40 weeks of age.

R (residual egg number)—the number of eggs produced from 41 to 64 weeks of age.

R′ (residual percent production)—the ratio of R to the number of days from 41 to 64 weeks of age (168 days).

A (annual egg number)—the number of eggs produced from first egg to 64 weeks of age.

A′ (annual percent production)—the ratio of A to the number of days from first egg to 64 weeks of age.

The *prime(′) denotes the transformation of egg number to percent production.*

The data were analyzed on the computer using the programs which designed for the estimation of genetic variance and covariance for determining heritability and genetic correlation. The programs used were accorded to the hierarchal analysis of variance described by King and Henderson (1954) for estimation of heritability and the procedure described by Hazel *et al.* (1943) for genetic correlation, using the combined sire and dam components in any case.

Results and Discussion

The estimated heritabilities of the gentic correlations between six measures of egg production and age at sexual maturity are presented in Table 1.

Table 1. Heritabilities and genetic correlations

	Egg number			Percent production			
	P	R	A	P′	R′	A′	SM
Partial egg number (P)	.311						
Residual egg number (R)	.153	.353					
Annual egg number (A)	.668	.838	.302				
Partial percent production (P′)	.506	.364	.554	.292			
Residual percent production (R′)	.153	1.000	.838	.364	.353		
Annual percent production (A′)	.361	.907	.882	.722	.907	.316	
Age at sexual maturity (SM)	−.642	.126	−.260	.336	.126	.225	.482

Diagonal figures represent heritability

The heritabilites for egg production are estimated to be slightly low values, ranging from .29 to .35, while the estimate of heritability for age at sexual maturity is intermediate. Similar estimates were obtained by Jerome *et al.* (1956) and Poggenpoel and Erasmus (1978).

The estimates of genetic correlations between partial and annual production, either in egg number or percent production are considerably high value, .688 and .722 respectively. These large positive estimates imply that selection on partial production should result in an increase of annual production. But selection on partial egg number will shorten largly age at sexual maturity due to large negative correlation between them (−.642), while selection on partial percent production will retard age at sexual maturity.

Genetic correlations between partial and residual production in either egg number or percent production are estimated to be positive value, .153 and .364 respectively. These estimates are smaller than those obtained by Bohren *et al.* (1970) who reported correlation of .38 between partial and residual egg numbers and .58 between partial and residual percent production.

When the early record was calculated by gradually extending a laying period by two weeks, mean, standard deviation (SD), coefficient of variation (CV), heritability (h^2) and genetic correlation for the egg numbers and percent production are presented in Table 2 and Table 3, respectively. Let $\Delta G_{A.P}$ be the stadardized response in annual egg number (A) from selection on partial egg number (P), and $\Delta G_{A.E_i}$ be the standardized response in A from selection on the extending segment (E_i), as described by Bohren *et al.*(1970). Then the relative efficiency of two criteria for improving annual egg number (A) is the ratio of $\Delta G_{A.E_i}$ to $\Delta G_{A.P.}$.

According as a laying period of segment becomes longer, in Table 1 the estimate of heritability for and a negatively large genetic correlation between segment (E_i) and age at segual maturity (SM) has a declining tendency, while in Table 2 heritability for segment (E_i) is estimated to be similarly low and genetic correlation between E_i and SM shows a relatively uniform intermediate estimate except the first three E_i's. However according as a laying period of segment becomes longer, the relative efficiency in either case

($\Delta G_{A.Ei}/\Delta G_{A.P}$ or $\Delta G_{A'.E'i}/\Delta G_{A'.P'}$) increases in proportion to extended laying period.

When the early record to 40 weeks of age was shorten by gradually excluding earlier record by two weeks, genetic parameters associated with the segments are presented in Table 4 and Table 5.

Table. 2. Genetic parameters related to the number of the eggs which obtained by gradually extending a laying period to a fixed age

Extending segment	Period (wk)	Egg numbers				Genetic correlations						Relative efficiency ($\Delta G_{A.Ei}/\Delta G_{A.P}$)
		Mean	SD	C V (%)	h^2	P	P'	R(or R')	A	A'	SM	
E_1	SM-22	7.3	6.1	83.3	.51	.80	−.04	−.14	.34	−.10	−.89	.68
E_2	SM-24	16.4	8.7	53.2	.44	.83	.02	−.22	.29	−.14	−.88	.50
E_3	SM-26	27.9	10.0	36.0	.39	.86	.11	−.18	.34	−.06	−.83	.55
E_4	SM-28	40.0	10.7	26.8	.33	.89	.16	−.14	.38	−.01	−.82	.58
E_5	SM-30	52.2	11.2	21.5	.31	.91	.20	−.10	.43	.04	−.81	.63
E_6	SM-32	64.2	11.8	18.4	.28	.93	.24	−.06	.47	.09	−.79	.66
E_7	SM-34	76.3	12.3	16.1	.27	97	.32	.00	.54	.16	−.77	.74
E_8	SM-36	88.2	12.9	14.6	.26	.99	.37	.03	.57	.21	−.74	.76
E_9	SM-38	99.9	13.4	13.4	.29	1.00	.45	.09	.62	.29	−.69	.87
E_{10}	SM-40	111.3	13.9	12.5	.31	1.00	.51	.15	.67	.36	−.64	1.00

Table 3. Genetic parameters related to percent production of the early records which obtained by extending a laying period to a fixed age.

Extending segment	Period (wk)	Egg numbers				Genetic correlations						Relative efficiency ($\Delta G_{A'.E'i}/\Delta G_{A'.P'}$)
		Mean	SD	CV(%)	h^2	P	P'	R(or R')	A	A'	SM	
E'_1	SM-22	46.4	29.3	63.2	.16	.61	−.01	−.20	.19	−.12	−.62	.13
E'_2	SM-24	61.6	23.5	38.1	.09	.39	.45	−.45	−.13	−.14	.00	.10
E'_3	SM-26	70.2	17.2	24.6	.16	.34	.69	−.12	.09	.22	.27	.23
E'_4	SM-28	74.8	13.7	18.4	.21	.29	.79	.03	.18	.37	.40	.44
E'_5	SM-30	77.3	11.7	11.7	.23	.31	.84	.11	.26	.46	.42	.56
E'_6	SM-32	78.7	10.9	15.2	.20	.34	.89	.16	.31	.52	.44	.59
E'_7	SM-34	79.8	10.0	13.8	.21	.37	.96	.24	.39	.61	.46	.72
E'_8	SM-36	80.5	9.3	12.5	.21	.41	.99	.27	.43	.64	.44	.74
E'_9	SM-38	80.8	8.8	11.6	.25	.47	1.00	.31	.50	.68	.38	.87
E'_{10}	SM-40	80.9	8.4	10.9	.29	.51	1.00	.36	.55	.72	.34	1.00

Table 4. Genetic parameters related to the number of eggs which obtained by gradually excluding earlier records.

Shortening segments	Period (wk)	Egg numbers				Genetic correlations						Relative efficiency
		Mean	SD	CV(%)	h^2	P	P'	R(or R')	A	A'	SM	($\Delta G_{A.Si}$ / $\Delta G_{A.P}$)
S_1	SM-40	111.3	13.9	12.5	.31	1.00	.51	.15	.67	.36	−.64	1.00
S_2	21-40	109.6	12.9	11.3	.27	.98	.64	.23	.72	.48	−.51	.97
S_3	23-40	104.1	10.9	10.5	.21	.86	.81	.36	.74	.64	−.22	.89
S_4	25-40	94.9	9.1	10.2	.23	.67	.87	56	.80	.82	.02	1.00
S_5	27-40	83.4	8.0	9.9	.25	.60	.81	.58	.77	.81	.06	1.03
S_6	29-40	71.3	7.1	9.5	.26	.62	.80	.57	.77	.79	.02	1.03
S_7	31-40	59.2	6.0	9.6	.31	.62	.79	.55	.74	.76	.02	1.08
S_8	33-40	47.2	5.0	10.5	.36	.63	.80	.52	.74	.76	.01	1.16
S_9	35-40	35.1	3.9	11.7	.34	.70	.83	.51	.78	.77	−.04	1.18
S_{10}	37-40	23.2	2.9	12.5	.33	.76	.88	.58	.86	.84	−.05	1.29

Table 5. Genetic parameters related to the percent production which obtained by gradually excluding earlier records.

Shortening segment	Period (wk)	Percent production				Genetic correlations						Relative efficiency
		Mean	SD	CV(%)	h^2	P	P'	R(or R')	A	A'	SM	($\Delta G_{A'.S'i}$ / $\Delta G_{A'.P'}$)
S'_1	SM-40	80.9	8.4	10.4	.29	.51	1.00	.36	.55	.72	.34	1.00
S'_2	21-40	81.3	9.2	11.3	.27	.98	.64	.23	.72	.48	−.51	.64
S'_3	23-40	82.6	8.6	10.5	.21	.86	.81	.36	.74	.64	−.22	.74
S'_4	25-40	84.7	8.2	9.6	.23	.67	.87	.56	.80	.82	.02	1.00
S'_5	27-40	85.1	8.1	9.5	.25	.60	.81	.58	.77	.81	.06	1.05
S'_6	29-40	84.9	8.4	9.9	.26	.62	.80	.57	.77	.79	.02	1.03
S'_7	31-40	84.6	8.6	10.2	.31	.62	.79	.53	.74	.76	.02	1.10
S'_8	33-40	84.3	8.9	10.5	.36	.63	.80	.52	.74	.76	.01	1.18
S'_9	35-40	83.5	9.4	11.3	.34	.70	.83	.51	.78	.77	−.04	1.15
S'_{10}	37-40	82.7	10.3	12.5	.33	.76	.88	.58	.86	.84	−.05	1.23

Though earlier record was gradually excluded by two weeks, the estimates of heritability for segments (S_i or S'_i)are not influenced particularly. However considerably large positive or negative correlations between age at sexual maturity and segments containing almost greater parts of earlier records (S_1 to S_3 or S'_1 to S'_3) imply that egg records layed from first egg to 3 or 4 weeks would influence significantly association of age at sexual maturity with early records. Thus the use of segments disregarding earlier record from first egg to 3 or 4 weeks as a criterion of selection might be more effective for improving annual production than the use of the whole early record, as showed by relative efficiency in Table 4 or Table 5. However, there has been no evidence by practical experiments that could support such a hypothesis, while theoretical comparisons could be found in the report by Lowe and Garwood (1980).

To compare direct response from selection on either partial egg number or partial percent production with the theoretically calculated response in correlated measurements, the relative efficiencies are presented in Table 6 by the ratio of one standardized reponse (Δ_j) to another (Δ_i).

Table 6. The relative efficiency ratios of the standadized response in correlated trait from selection on partial record to another standardized response

numerator Δ_j / denominator (Δ_i)	$\Delta G_{A.P}$	$\Delta G_{A'.P}$	$\Delta G_{A.P'}$	$\Delta G_{A'.P'}$	$\Delta G_{R.P}$	$\Delta G_{R'.P}$	$\Delta G_{R.P'}$	$\Delta G_{R'.P'}$	$\Delta G_{SM.P}$	$\Delta G_{SM.P'}$
$\Delta G_{A.P.}$	1.00	.54	.80	1.05	.23	.23	.53	.53	.96	.49
$\Delta G_{A'.P}$	1.86	1.00	1.49	1.94	.42	.42	.98	.98	1.78	.90
$\Delta G_{A.P'}$	1.25	.67	1.00	1.30	.28	.28	.66	.66	1.20	.61
$\Delta G_{A'.P'}$	.96	.52	.77	1.00	.22	.22	.51	.51	.92	.46
$\Delta G_{R.P}$	4.39	2.36	3.52	4.59	1.00	1.00	2.32	2.32	4.21	2.13
$\Delta G_{R'.P}$	4.39	2.36	3.52	4.59	1.00	1.00	2.32	2.32	4.21	2.13
$\Delta G_{R.P'}$	1.89	1.02	1.52	1.98	.43	.43	1.00	1.00	1.82	.92
$\Delta G_{R'.P'}$	1.89	1.02	1.52	1.98	.43	.43	1.00	1.00	1.82	.92
$\Delta G_{SM.P}$	1.04	.56	.84	1.09	.24	.24	.55	.55	1.00	.51
$\Delta G_{SM.P'}$	2.06	1.11	1.65	2.15	.47	.47	1.09	1.09	1.98	1.00

Therefore,the ratio of Δ_i to Δ_j is equal to the inverted value of the ratio of Δ_j to Δ_i.

The relative ratio of $\Delta G_{A.P}$ to $\Delta G_{A.P'}$, 1.25 means that for improving annual egg number(A) selection on partial egg number (P) is 25 percent more efficient than selection on partial percent production(P). Additional support for this hypothesis was presented by Bohren *et al.* (1970) who reported the ratio of 1.13. For improving annual percent production (A') selection on partial percent production (P') is nearly two times (1.94) as efficient as selection on partial egg number (P), while in the relative efficiency for shortening age at sexual maturity (SM) selection on partial egg number is almost two times (1.98) as efficient as selection on partial percent production.

SUMMARY

Data pertaining to the first generation of a Synthetic White Leghorn flock were used to estimate the heritabilities of and genetic correlation between partial egg production (egg number or percentage) or diversely segmented part records and other

traits such as age at sexual maturity, residual and annual egg production, and to compare the expected genetic gain from selection on partial egg number or partial percent production with correlated response in other traits.

The estimated heritabilites for six measures of egg production were ranged from .29 to .35, while heritability for age at sexual maturity (SM) was intermediate (.48). Genetic correlations between partial egg number (P) and annual egg number (A), and partial percent production (P') and annual percent production (A') were .51 and .72, respectively. Genetic correlation between P and SM was estimated largely negative (—.64), while correlation between P' and SM was positively intermediate (.34).

In comparing direct response from selection on partial production (P or P') with another response in correlated trait, selection on P would be 25% more efficient than selection of P' for improving A, while selection of P' would be 94% more efficient than selection P for improving A'. For shortening SM selection of P would be 98% more efficient than selection on P'.

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