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journal or publication title	Japanese Poultry Science
volume	33
number	4
page range	235-241
year	1996-07
URL	http://id.nii.ac.jp/1588/00000097/

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日本家禽学会誌　第33巻　第4号　1996年7月
235頁～241頁
Reprinted from
JAPANESE POULTRY SCIENCE
Vol. 33, No. 4, July, 1996
pp. 235～241

Comparison of the Clutch Traits and Egg Production Predicted by the Multiphasic Model Among the Laying Strains

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A study was carried out to examine the effects of lines on the clutch traits and the prediction of egg production in laying hens. Data of oviposition time were recorded at four stages from the 120th day to the 330th day of egg production for two years. The duration of observation in each stage was 30 days. The four lines were abbreviated as H, L, J and X. The H and L lines were obtained from long term divergent selection for high and low yolk-albumen ratios. The J and X lines were the commercially obtained. The clutch traits were intra clutch mean lag of oviposition time (LAG), mean delay of pause day between clutches (DELAY), the rate of internal laying (IP), the number of clutches (CN), the average length of clutches (CL) and the average size of clutches (CS).

There were significant differences between lines and stages for all clutch traits. LAG values in the J and X lines (0.28 hours and 0.22 hours, respectively) were significantly shorter than those in the H and L lines (1.04 hours and 1.32 hours, respectively). Accordingly, the values of CL and CS were significantly larger, and CN values were significantly smaller in the J and X lines. The values of DELAY in the H and L lines significantly differed from those in the J and X lines. IP values were 9.91%, 7.75%, 4.22% and 5.54%, respectively, for the H, L, J and X lines.

The clutch traits obtained from the first stage were used to predict total egg number of 270 and 360 days of laying periods (EP270 and EP360) by the multiphasic model. Correlation coefficients between actual and predicted values of the four lines were 0.72 and 0.67 for EP270 and EP360, respectively. The correlation coefficients in the J and X lines that laid more than 300 eggs in 360 days of laying period ranged from 0.75 to 0.88, being higher than those in the H and L lines (0.60～0.75) with 240 eggs in the same laying period.

(*Jpn. Poult. Sci.*, **33** : 235-241, 1996)

Key words : clutch traits, egg production prediction, multiphasic model, laying hen.

Introduction

Egg production has achieved successful progress by the application of quantitative genetics methods. This approach is unlikely to gain a further increase because of losing genetic variation of the traditional selection traits and limitation of one egg per day. Selections for short oviposition interval though conducted in different environments of light-dark cycles have shown a new trend to continued improvement of egg production (McClung *et al.*, 1976 ; Foster, 1981 ; Sheldon *et al.*, 1984 ; Naito *et al.*, 1989).

Received Nov. 10, 1995

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The rate of lay in these selection experiments was significantly increased in the selected stages.

LILLPERS (1993) attempted to characterize laying process by the "oviposition pattern" that is the time at which the eggs are laid and the interval between them. Moreover, genetic variation of oviposition pattern traits was reported to be higher than that of conventional traits. Recently, a multiphasic model has been developed to characterize egg production by the cyclic process, so called clutch (KOOPS and GROSSMAN, 1992; LUC *et al.*, 1995). In this model, egg production was treated as a function of oviposition interval, length of pause day and internal laying. It is expected that the model could be used to predict annual egg production of individual hens by using records of oviposition time in the early stage of laying. The aim of this study is to examine the effects of lines on the clutch traits and the prediction of egg production by the multiphasic model in laying hens.

Materials and Methods

Data were obtained from four lines of White Leghorn laying hens. The H and L lines have been founded by a divergent selection for high and low yolk albumen ratios since 1970, and relaxed the selection since 1983 (MITSUMOTO and MIYOSHI, 1989). In 1994, two commercial lines were introduced into our laboratory. These lines were designated as J and X.

The hens were housed in individual cages at 150 days of age with the light/dark regime about 14hr/10hr. Oviposition time of individual hens was recorded at four stages for two years in April, June, August and October 1993 and in April, May, June and October 1994. The first observation stage was started at the 120th day and the last stage was completed at the 330th day of egg production. The duration of observation in each stage was 30 days. Oviposition time was observed every one hour from 5:30 a.m. to 6:30 p.m., and recorded to the nearest half hour. The hens with no egg laid during the observation stage were excluded from the data set (LUC *et al.*, 1995). The number of hens and records of oviposition time are presented in Table 1.

Data of egg production were recorded daily for individual hens. Total egg number was calculated for 270 and 360 days of laying periods (EP270 and EP360, respectively). EP270 represents a period before entering the end of the production period, while EP360 is the whole production period.

The clutch traits were defined as intra-clutch mean lag of oviposition time (LAG),

Table 1. Number of hens and records of oviposition time

Line[1]	1993		1994	
	No. of hens	No. of records	No. of hens	No. of records
H	131	464	81	293
L	119	416	88	325
J			11	43
X			17	67

[1] H: High line; L: Low line; J and X: Commercial lines.

mean delay of pause day between clutches (DELAY). These traits were estimated by the multiphasic model of Luc *et al.* (1995). Other clutch traits that were calculated from the data of oviposition time included the rate of internal laying (IP), the number of clutches (CN), the average length of clutches (CL), and the average size of clutches (CS). IP was estimated as percentage between the number of missing eggs and the number of observed days in each stage. The missing eggs were determined based on the time of oviposition as described by Luc *et al.* (1995).

To examine the effects of lines and stages of observation on the clutch traits, univariate analysis of variance as split plot design was applied by using the GLM procedure of SAS (1985). Because there were empty cells in the data set, the type IV sums of squares were used to determine the significances of the effects (SAS Institute, 1991). Duncan's multiple range test was performed to compare means of the clutch traits.

Data of the clutch traits obtained from the first stage were used to predict EP270 and EP360 by the multiphasic model of Luc *et al.* (1995). The predictability of the model in each line was based on the correlation coefficients and regression of actual values on predicted values. Significant differences of intercepts and regression coefficients from 0 and 1, respectively, were accessed by *t*-test.

Results and Discussion

Table 2 presents mean squares of the effects obtained from the univariate analysis of variance as spit plot design for each clutch trait. There were significant effects ($p < 0.01$) of line and stage for all clutch traits. The effect of line may be explained by the difference in genetic origin. Significant effects of the stage indicate the influence of aging on these traits. This is in agreement with the reports of Bahr and Palmer (1989), and Lillpers and Wilhelmson (1993) that when the hen ages, the oviposition interval increases. Significant interactions between line and stage were estimated for most clutch traits except for LAG. In the X line, DELAY and CN increased at the stage 2 and

Table 2. Mean squares of the clutch traits from the analysis of variance for split-plot design

Source	df	Trait[1]					
		LAG	DELAY	IP	CN	CL	CS
Between birds							
Line	3	42.520*	351.038*	1237.556*	280.132*	1527561.6*	3072.209*
Error 1	443	1.428	31.823	232.522	9.559	33136.2	60.978
Within birds							
Stage	4	5.511*	113.757*	711.479*	61.448*	384580.1*	714.209*
Line×Stage	10	0.216	142.796*	243.487*	3.008*	102578.2*	178.929*
Error 2	1149	0.315	19.238	82.748	1.192	7050.3	12.614

[1] LAG : Intra clutch mean lag of oviposition time (hour) ; DELAY : Mean delay of pause day between clutches (hour) ; IP : The rate of internal laying (%) ; CN : The number of clutches ; CL : The average length of clutches (hour) ; CS : The average size of clutches (egg).

* : Significant effect at $p < 0.01$.

decreased at the stage 3, while the decreases at the stage 2 and the increases at the stage 3 were found for CL and CS. However, the H, L and J lines showed the similar trends of changing in means of DELAY, CN, CL and CS by stages. This indicated that the interactions between line and stage for these traits were caused by the changes of the X line at the stages 2 and 3, but a clear explanation for these changes could not be obtained in this study except a possibility of different genetic background of this line. IP values in the four lines did not showed a clear trend of changing over stages. No significant interaction for LAG suggested that hens in the four lines showed the same trend in oviposition intervals at different stages of laying.

Means and standard deviations of the clutch traits for each line obtained from pooled data are shown in Table 3. LAG in the H line was significantly shorter than that in the L line. LAG values in the J (0.28 hours) and X (0.22 hours) lines did not significantly differ from each other, but were significantly shorter than those in the H and L lines. Significant differences between the commercial and selected lines for LAG, CN, CL and CS values suggest that when the hen lays eggs at short intervals, CS and CL values increase, hence CN values decrease. Thus, CS values in the J and X lines were 15 and 14 eggs, with corresponding LAG values of 0.28 hours and 0.22 hours. On the contrary, CS values in the H and L lines were 6 and 5 eggs and LAG values of these lines was 1.04 hours and 1.32 hours, respectively. DELAY values were the same in the H and L lines but were significantly longer than those in the J and X lines. IP values in the H and L lines were 9.94% and 7.75%, respectively, and were higher than those in the J and X lines (4.22% and 5.54%, respectively).

The prediction of egg production by the multiphasic model is presented in Table 4 and Fig. 1. Correlation coefficients between actual and predicted egg number were higher in the H line than in the L line for both predictions of EP270 and EP360. A higher correlation was observed in the X line (0.88) than in the J line (0.83) for prediction of EP270. However, when prediction for EP360, the correlation in the X line decreased to 0.75 and was lower than that in the J line (0.83). The correlations for both predictions of EP270 and EP360 were higher in the commercial lines (J and X) than in the selected

Table 3. Means and standard deviations of the clutch traits

Trait[2]	Line[1] (Number of hens)							
	H (757)		L (742)		J (43)		X (67)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
LAG	1.04[b]	0.76	1.32[a]	0.90	0.28[c]	0.39	0.22[c]	0.32
DELAY	17.50[a]	4.53	17.40[a]	3.78	13.77[b]	9.54	15.45[a]	9.48
IP	9.94[a]	11.93	7.77[ab]	11.55	4.22[b]	7.65	5.54[ab]	7.72
CN	4.92[a]	1.94	5.49[a]	2.01	2.68[b]	1.65	2.70[b]	1.46
CL	178.48[b]	125.78	153.45[b]	100.29	369.74[a]	216.50	348.98[a]	202.51
CS	6.21[b]	5.34	5.30[b]	4.29	15.02[a]	9.62	13.78[a]	8.58

[abc] Means within trait with different superscripts differ at $p<0.01$.

[1] See footnote to Table 1.

[2] See footnote to Table 2.

Table 4. Means with standard deviations and correlation coefficients between actual and predicted egg number for 270 and 360 days of laying periods (EP270 and EP360, respectively)

Line[1]	N	EP270			EP360		
		Actual	Predicted	r	Actual	Predicted	r
H	212	201±37	215±32	0.75	236±55	287±43	0.69
L	207	199±38	213±27	0.67	237±55	283±36	0.60
J	11	238±16	245±18	0.83	309±17	326±24	0.83
X	17	243±15	235±23	0.88	302±22	313±31	0.75
Total	447	202±38	216±30	0.72	241±56	287±40	0.67

[1] See footnote to Table 1.

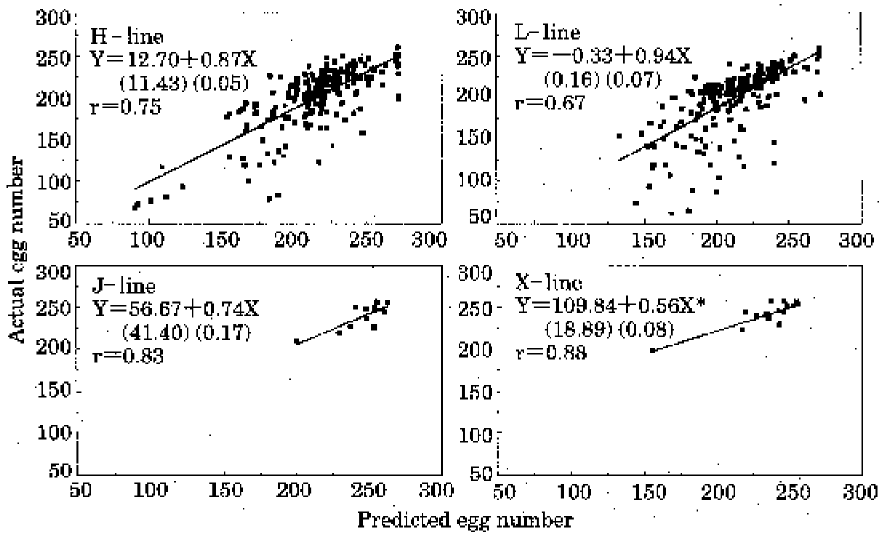

Fig. 1. Plots between actual (Y) and predicted (X) egg number for 270 days of egg production

Note : The figures in the parentheses are standard errors.

* Significant differences from 0 and 1 at $p<0.05$ for intercept and slope, respectively.

lines (H and L) (Table 4). However, significant differences from 0 and 1 correspondingly for the intercept and slope were estimated in the X line for prediction of EP270 (Fig. 1).

Correlation coefficients for EP270 were slightly higher than those for EP360 (Table 4), suggesting that a higher accuracy of prediction could be expected for the prediction of EP270. The multiphasic model overestimated predictions of both EP270 and EP360 except for EP270 in the X line. The difference between actual and predicted values for EP360 was 46 eggs, being higher than that for EP270 of 14 eggs. The overestimation of the model can be explained by the persistency of egg production. The hens that are poor laying show a rapid decline on persistency of lay after peak as observed by Miyoshi *et al.* (1996). The accuracy of prediction was the same for both predictions of EP

270 and EP360 in the J line, indicating that hens of this line maintained persistency of lay in the whole production period. Moreover, the higher IP in the H and L lines associated with the higher numbers of overestimated eggs in these lines (14 eggs in both lines for EP270, and 46 and 51 eggs in the H and L lines, respectively, for prediction of EP360). On the contrary, the lower numbers of overestimated eggs were observed in the J and X lines (7 eggs in the J line for EP270, and 11 and 17 eggs in the J and X lines, respectively, for prediction of EP360), the IP of these lines were relatively low.

Fig. 1 presents the plots between actual and predicted egg number for 270 days of laying period in the four lines. It is difficult to obtain a precise comparison between the commercial and selected lines owing to difference in number of hens. However, when considering the hens with high egg production in the selected lines, the figure revealed that a higher prediction accuracy of the model may be expected for the hens that laid more than 200 eggs for 270 days of egg production period.

Acknowledgements

The authors would like to thank Dr. M. SUZUKI for statistical assistance and the fourth year students of the Laboratory of Animal Breeding and Genetics of Obihiro University of Agriculture and Veterinary Medicine for their assistance in the collection of data.

References

BAHR, J.M. and S.S. PALMER (1989) The influence of aging on ovarian function. Critical Reviews in Poultry Biology 2 (2) : 103–110.

FOSTER, W.H. (1981). A selection experiment on a White Leghorn strain under ahemeral light-dark cycles. British Poultry Science, 22 : 35–48.

KOOPS, W.J. and M. GROSSMAN (1992). Characterization of poultry egg production using a multiphasic approach. Poultry Science, 71 : 399–405.

LILLPERS, K. and M. WILHELMSON (1993). Age-dependent changes in oviposition pattern and egg production traits in the domestic hen. Poultry Science, 72 : 2005–2011.

LILLPER, K. (1993). Oviposition patterns and egg production in the domestic hen. Ph.D. thesis, Swedish University of Agricultural Sciences, Uppsala.

LUC, K.M., S. MIYOSHI, and T. MITSUMOTO (1995). Multiphasic model of egg production in laying hens. Japanese Poultry Science, 32 : 161–168.

LUC, K.M., S. MIYOSHI, M. SUZUKI and T. MITSUMOTO (1996). Heritability estimates of some clutch traits in the laying hen. Japanese poultry Science, 33 : 23–28.

MCCLUNG, M.R., ALBERT, B.S. WANG and W.T. JONES (1976). Response to selection for time interval between oviposition time in the hen. Poultry Science, 55 : 160–171.

MITSUMOTO, T. and S. MIYOSHI (1989). Responses to divergent selection for high and low yolk albumen ratio and relaxation of selection in White Leghorn, Proceeding of the 6th International Congress of SABRAO, Tokyo. II 893–896.

MIYOSHI, S., K.M. LUC, K. KUCHIDA and T. MITSUMOTO (1996). Application of non-linear models to egg production curves in chickens. Japanese Poultry Science, 33 : 178–184.

NAITO, M., K. NIRASAWA, T. OISHI and T. KOMIYAWA (1989) Selection experiment for increased egg production under 23 H and 24H light-dark cycles in the domestic fowl. British Poultry Science, 30 : 49–60.

SAS Institute (1985). SAS® User's guide : Statistics. Version 5 edition. SAS Institute Inc., Cary, NC.

SAS Institute (1991). SAS® System for linear models. Third edition. SAS Institute Inc., Cary, NC 27513.

SHELDON, B.L., B.H. YOO and R.N. PODGER (1984). Increasing egg yield under normal light cycles by selecting for short interval between eggs under continuous light. Annales Agricultural Fenniae, 23 : 216-225 (CSIRO Div. of Anim. Production, Propet, NSW, Australia).

産卵鶏におけるクラッチ形質と multiphasic モデルによる予測年間産卵数の系統間の比較

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本研究の目的は，産卵鶏の系統間でのクラッチ形質と予測産卵数を比較することである。放卵時刻のデータは初産後 120 日から 330 日までの 4 つの期間について 2 年間観察した。各期間での観察日数は 30 日である。実験に用いた系統は H，L，J および X の 4 系統である。H と L は長期間にわたって卵黄・卵白比に対しそれぞれ高および低方向に選抜された系統であり，J および X は市販系統である。クラッチ形質は，LAG（クラッチ内放卵間隔と日長との差），DELAY（休産日の長さと日長との差），卵際率（IP），クラッチ数（CN），クラッチ長（CL）およびクラッチサイズ（CS）である。

全てのクラッチ形質では系統間および期間の間に有意差が認められた。LAG は J 系統（0.28 時間）および X 系統（0.22 時間）が H 系統（1.04 時間）および L 系統（1.32 時間）に比較して有意に短かった。ゆえに，CL および CS は J および X 系統で長く，CN は小さく推定された。DELAY は，J 系統を除き，系統間に有意差が認められなかった。IP は H 系統（9.94%）および L 系統（7.75%）が，J 系統（4.22%）および X 系統（5.54%）より高く推定された。

最初の観察期間から推定されたクラッチ形質を用い，multiphasic モデルで 270 日間の産卵数（EP270）および 360 日間の産卵数（EP360）を予測した。4 系統における平均の予測値と実測値との相関係数は，EP270 で 0.72，EP360 で 0.67 が推定された。また，高産卵を示した J および X 系統（360 日間で 300 個以上）の相関係数は 0.75～0.88 が推定されたのに対し，低い産卵を示した H および L 系統（360 日間で 240 個）のそれは 0.60～0.75 であった。

（家禽会誌，*33* : 235-241, 1996）

キーワード： クラッチ形質，産卵予測，マルチファジックモデル，産卵鶏

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