Research Article

EFFECTS OF INITIAL BODY WEIGHT AND FEED INTAKE ON INDIVIDUAL WEEKLY EGG PRODUCTION CURVE OF LAYING HENS

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ABSTRACT

The main objectives of this study were to compare eight mathematical models for ability to describe weekly egg production curve of individual hens, and to examine any relation of egg production curve parameters with initial body weight (BW) and feed intake (FI) when they are fed a single diet. After determining the best model, the model was also investigated to assess whether it was sensitive to increase in egg production intervals; from weekly (1W) to 2 weekly (2W) to four weekly (4W) productions. Data were obtained from 114 Nick Brown laying hens raised in the same environmental conditions. The models were compared using residual mean (RM), coefficients of determination (R^2), correlation between the observed and the estimated egg production curves (r), AIC and BIC statistics.

With respect to the goodness-of-fit criteria, among the eight models, GK2001 model with 3 parameters performed best to describe the curve of individual weekly egg production. RM, R^2, r, AIC and BIC values were 0.00, 0.99, 0.59, -183.83 and -175.37 for GK2001 followed by POL5 with 6 parameters (0.00, 0.99, 0.59, -194.38 and -177.45) and POL4 with 5 parameters (0.70, 0.99, 0.56, -188.09 and -173.99). The parameters of GK2001 model were not affected by variation in body weight or feed intake. It was concluded that GK2001 model could conveniently be used to describe individual weekly egg production of hens fed the same diet, but increasing egg production interval for summarizing data was resulted in underestimating the actual annual egg production.

Keywords: Initial feed intake, Initial body weight, Individual weekly egg production, Laying hen

BAŞLANGIÇ YEM TÜKETİMİ VE CANLI AĞIRLIĞININ YUMURTA TAVUKLARININ HAFTALIK BİREYSEL YUMURTA VERİM EĞRİSİNE ETKİSİ

ÖZET

Bu çalışmanın amacı, aynı yemle beslenen yumurta tavuklarının haftalık bireysel yumurta verim eğrilerini tanımlayabilmek bakımından sekiz matematiksel modeli karşılaştırmak ve yumurta verim eğrisi parametreleri ile çevresel farklılıklar (başlangıç vücut ağırlığı-VA ve yem tüketimi-YT) arasında olası ilişkileri incelemektir. Veriler aynı çevre şartlarında yetiştirilen 114 yumurtacı tavuktan elde edilmiştir. En iyi model belirlendikten sonra, belirlenen model yumurta verim aralığının artırılmasına karşı (haftalık-1H, iki haftalık-2H ya da dört haftalık-4H yumurta verimi) hassas olup olmadığının anlaşılması için de test edilmiştir. Modeller, kalıntı ortalaması (KO), determinasyon katsayısı (R^2), gözlenen ve tahmin edilen yumurta verim eğrileri arasındaki korelasyon (r), AIC ve BIC istatistikleri kullanılarak karşılaştırılmıştır.

Karşılaştırma ölçütleri değerlendirildiğinde, haftalık bireysel yumurta verim eğrisini tanımlamak bakımından sekiz model arasından 3 parametreli GK2001'in en iyi performansı gösteren model olduğu tespit edilmiştir. GK2001 modelinin KO, R^2, r, AIC ve BIC değerleri 0.00, 0.99, 0.59, -183.83 ve -175.37 olarak bulunmuş, bunu sırasıyla 6 parametreli POL5 modeli (0.00, 0.99, 0.59, -194.38 ve -177.45) ve 5 parametreli POL4 modeli (0.70, 0.99, 0.56, -188.09 ve -173.99) izlemiştir. GK2001 modelinin parametreleri vücut ağırlığı ya da yem tüketimindeki farklılıklardan etkilenmemiştir. Bu modelinin haftalık bireysel yumurta verim eğrilerinin tanımlanmasında kullanılmasının uygun olduğu, ancak yumurta üretim aralığının artırılması durumunda yıllık gerçek yumurta veriminin olduğundan düşük olarak tahmin edilmesine yol açacağı sonucuna varılmıştır.

Anahtar sözcükler: Başlangıç yem tüketimi, Başlangıç canlı ağırlığı, Bireysel haftalık yumurta verimi, Yumurta tavukları

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INTRODUCTION

The National Research Council in 1994 expressed the nutrient requirement of the commercial laying hen as a percentage of the diet when did the bird consumes 80, 100 or 120g/day. On the other hand other hand, it has been suggested that, in order to obtain more uniform flocks, pullets should be housed based on body weight (BW), i.e. their nutrient requirement (Quisenberry et al., 1967; Thornberry and Quisenberry, 1968; Bell, 1968; Leeson and Summers, 1987). A common view in today's laying hen feeding is to offer nutrients based on the average feed intake (FI) of the flock even though flocks are rarely uniform in their needs (Harms et al., 1978; NRC, 1994). It was recommended that the percentage of the nutrients in the feed should be changed when the feed intake of the flock is changed (Harms and Douglas, 1981). It is known that once egg production begins, small birds remain small and large birds remain large throughout the laying cycle and birds of different body weight have different feed intake (Harms et al., 1982; Cadirci, 2011). Consequently, the mean value for feed intake might be misleading and it might be difficult to match nutrient intake correctly to the requirements of all birds in the flock and they might produce different egg output. Therefore, this criterion becomes critical in the assessment of nutritional status. The diet must contain an adequate concentration of nutrients if the different body weight birds in the flocks are going to be expected to perform to their full genetic potential throughout the laying cycle and, in turn, be a profitable flock.

Describing egg production curve has also been the interest of researches on the basis of a flock or a hen due to the reason that the curve follows different patterns according to these two situations (North and Bell, 1990). Because the ages at first egg show variability for individual hens, the egg production curve for a flock shows a slow and smooth increase at the first phase (about two months) followed by a slow and smooth decrease at the second phase until the end of the production period (52 w) (North, 1990). On the other hand, a rapid increase is observed in the first phase (about 2 w) followed by a several decreasing phases during the second period of production for individual hens (North and Bell, 1990; Grossman and Koops, 2001). Moreover, it was stated that various segment of egg production curve could have different heritabilities indicating fluctuation in egg production trajectory through 52 w period (Flock, 1977; Muir, 1990).

Various mathematical models have been applied to describe the egg production curve in terms of flock or hen basis. Among them, some researchers used logistic function for a flock (Adams and Bell, 1980; Cason and Britton, 1988; Yang and McMillan, 1989; Cason and Ware, 1990; Savegnago et al., 2011), the compartmental model (Gavora et al., 1971; McMillan, 1981; Gavora et al., 1982; McMillan et al., 1986), a linear function (Adams and Bell, 1980), an exponential function (Cason and Britton, 1988; Yang et al., 1989; Cason and Ware et al., 1990; Gavora et al., 1971; McNally, 1971; Foster et al., 1987; Cason, 1990), polynomial function (Cason, 1990), linear or curvilinear functions (Cason and Ware, 1990), a cyclic function (Bell and Adams, 1992), segmented polynomials (Fialho and Ledur, 1997) and smoothed intersecting straight lines (Grossman et al., 2000). However, it was emphasized on the importance of selecting individuals on the basis of egg production curve parameters (McMillan, 1981). Compartment model (Gavora et al., 1971), smoothed intersecting straight lines (Grossman et al., 2000), and logistic function (Grossman and Koops, 2001) were applied on the data of individual hens. Moreover, it is essential to investigate the egg production in the individual hen basis for the clear understanding of the biology of egg production (Koops and Grossman, 1992).

Therefore, main aims of the present study were to investigate the relationship of body weight (BW) at eighteen weeks of age or feed intake (FI) (during the first two months of egg produced) to weekly (1W), two-weekly (2W) and four-weekly (4W) egg production curve and egg mass production, and to determine whether the egg production curve parameters are affected by the variation in BW or FI when the hens were fed the same diet.

MATERIALS AND METHODS

One hundred and twenty Nick Brown pullets of eighteen weeks of age were weighed at the beginning of the experiment and randomly placed individually in one of three body weight groups (BW): *light*, *medium* and *heavy*. The ingredients and the calculated nutrient content of the diet formulations used in this study are shown in *Table 1*. The ranges of body weight for the *light*, *medium* and *heavy* groups were 1481 to 1564 g, 1596 to 1640 g and 1663 to 1752 g, respectively (*Table 2*). Temperature control system of the house was set to maintain a daily average of 23±2°C by controlling the two air conditioners (White Westinghouse). The birds were kept in a windowless house and given conventional artificial light. Light was supplied by 40 Watt tungsten bulbs.

Table 1. Composition of experimental diet.

Ingredient composition	g/kg
Maize (7.57 CP) [3]	616.60
Soybean meal(48.07 CP) [3]	245.10
Maize Oil	32.40
Limestone	83.70
Dicalcium phosphate [2]	14.80
NaCl	4.00
Vitamin-mineral premix [1]	2.50
Dl-Methionine	0.80
Calculated nutrient composition	
Crude protein [4]	165.00
Calcium[5]	36.00
Available phosphorus[5]	4.00
Sodium[5]	1.80
Arginine	1.08
Lysine[5]	8.90
Methionine[5]	3.60
Methionine + cystine[5]	6.45
Threonine[5]	6.37
Tryptophan[5]	2.18
Apparent Metabolizable Energy (AME) [MJ/kg] [5]	12.14

[1] The composition of vitamins and minerals in the premix provided the following amounts per kilogram of diet: Vit A 12 000IU, Vit D_3 2 500IU, Vit E 30mg, Vit K_3 4mg, VitB_1 3mg, Vit B_2 7mg, Vit$_6$ 5mg, VitB_{12} 0.015mg, VitC 50mg, Niacin 30mg, Calpan 10mg, Biotin 0.045mg, Folic Acid 1mg, Choline Chloride 200 mg, Canthaxanthin 2.5mg, Apo-Carotenoic Acid Ester 0.5mg, Manganese 80mg, Iron 60mg, Zinc 60mg, Copper 5mg, Iodine 1mg, Cobalt 0.2mg, Selenium 0.15mg, Antioxsidant 10mg.

[2] The composition of dicalcium phosphate provided the following amounts per kilogram of diet: Ca 23% and P 20%.

[3] Result of analysis

[4] Based on analysis of maize and soybean meal.

[5] Based on NRC 1994 values for maize and soybean meal

The nutrient specifications were set to meet or exceed nutrient requirements (NRC, 1994) at this stage. One feed-trough were located at the front of each cage. Each day, the hens were allocated enough feed (250 g) to exceed the expected daily feed intake for hens of this strain. Feed and water were consumed *ad libitum*. For each bird feed consumption was recorded daily during the first two months of egg production period. Feed intake (FI) groups were formed by allocating the birds in one of three groups based on average daily feed consumption during the first two months after the first egg produced: *less* (100±0.7 g/day), *moderate* (109±0.4 g/day) and *more* (120±0.09 g/day) (*Table 2*).

All data were obtained on an individual hen basis. After 52 weeks of production, only 114 out of 120 hens completed the production period. Experimental data were subjected to statistical analysis using the following egg production curve models:

Logistic model (LOGIS):

$$y_w = \frac{a}{1 + be^{-cw}}$$

Rational model (ROT):

$$y_w = \frac{a + bw}{1 + cw + dw^2}$$

MMF model (MMF):

$$y_w = \frac{ab + cw^d}{b + w^d}$$

Second degree polynomial (POL2):

$$y_w = a + bw + cw^2$$

Third degree polynomial (POL3):

$$y_w = a + bw + cw^2 + dw^3$$

Fourth degree polynomial (POL4):

$$y_w = a + bw + cw^2 + dw^3 + ew^4$$

Fifith degree polynomial (POL5):

$$y_w = a + bw + cw^2 + dw^3 + ew^4 + fw^5$$

Grossman and Koops model (GK2001):

$$y_w = k\,m\left(\frac{1 - e^{-w}}{1 + e^{-w}}\right) - k\,(m - d)\left(\frac{1 - e^{-w}}{1 + e^{-(w-p)}}\right)$$

where, y_w was the total egg production at the time *w* as week, and *a, b, c, d, e, f, m and p* were the model parameters. In GK2001 model, *k* takes different values on the basis of time: for example, k=7 for weekly (1W), 14 for two-weekly (2W) or 28 for four-weekly (4W) egg production that can also be defined as it is the maximum number of eggs that can be produced by an individual for a given period of time.

Table 2. Body weight (BW) and feed intake (FI) groups and descriptive statistics for the first-two months of egg production

	N	Mean±SE	Min	Max	CV%
BW					
Light	38	1531±4.1	1481	1564	1.76
Medium	37	1617±2.0	1596	1640	0.84
Heavy	39	1699±4.0	1663	1752	1.54
FI					
Less	41	100±0.7	87	106	4.46
Moderate	33	109±0.4	106	113	2.14
More	40	120±0.9	113	136	4.95

BW: body weight, FI: feed intake, N: number of observation, Min: minimum, Max: maximum, CV%: coefficient of variation

Statistical analyses were conducted using SAS (SAS, 2000) statistical software package. The models were fitted to weekly egg production of each of 114 hens seprately to remove possible bias in the statistical inference on the egg production curve parameters because of the reason that repeated measurements are usually autocorrelated. The models were compared on the basis of the goodness-of-fit statistics: the residual mean (RM), coefficient of determination (R^2), correlation (r) between the observed and the estimated weekly egg production curve, Akaike's Information Criterion (AIC) and Bayesian Information Criterion (BIC). The goodness-of-fit statistics were calculated by all models for each hen using NLIN procedure and averaged (*Table 3*). Levenberg-Marquardt algorithm was the fitting algorithm in the model estimation stage and the convergence criterion was the relative reduction between successive residual sums of squares and was set to 10^{-8}. In addition, in order to see if the selected model could be generalized to production intervals other than weekly, the selected model was further used to estimate the weekly (1W), two-weekly (2W) and four-weekly (4W) egg production curve parameters for each hen individualy. *Glm/Lsmeans/LSD* (SAS, 2000) procedure was used to test the mean differences of the parameters among the levels of the grouping factors. Correlations among the model parameters, observed total 52-w egg production (TEP) and estimated total 52-w egg production (ETEP) were obtained using *Corr* procedure in SAS.

RESULTS and DISCUSSION

Model Comparisons

The criteria for comparing the egg curve models are given in *Table 3*. RM and standard errors were smallest for GK2001 and POL5 followed by LOGIS, POL4, POL3, POL2, MMF and ROT models. Although the all models produced small RM, the only models produced RMs not different from 0 were GK2001 and POL5. In regard to R^2, except for ROT and MMF models, the values were very high and the same for all models in this study indicating a significant relationship between week and egg production.

One other criteria for comparing the models was the correlation (r) between the observed and the predicted egg production curves. After obtaining the parameters for every model, weekly egg productions for each hen were predicted using the parameters produced by them, and then, correlations between the observed and the estimated curves were calculated. Regarding *Table 3*, GK2001 and POL5 models produced the highest correlation (0.59) and the smallest estimates of *r* were obtained from fitting of MMF, ROT and LOGIS models. In this study, decision on appropriateness and the ability of the models for describing individual weekly egg production curve of hens has also been made by examining the AIC and BIC statistics produced by the models. A comparison among the models in this study on the basis of AIC and BIC showed that POL5 produced the smallest values for both criteria followed by POL4 and GK2001 models.

Based on the comparison criteria of RM, R^2, r, AIC and BIC used in the present study and also the number of parameters (p) of each model (*Table 3*), the GK2001 model (the higest r=0.59 and small number of parameters p=3) was determined to be the most appropriate models to describe the association between the time (week) and individual egg production,and to explain the individual weekly egg production trajectory. Thus, the GK2001 model was further used to assess the parameters of the weekly egg production curves of individual hens.

Table 3. Comparison criteria for the models used to describe weekly egg production

Model	RM	R^2	r	p	AIC	BIC
ROT	4.76±0.039	0.24±0.007	-0.27±0.025	4	326.67	337.95
MMF	2.31±0.035	0.69±0.033	0.16±0.040	4	220.11	237.39
LOGIS	0.20±0.012	0.98±0.002	0.27±0.034	3	-113.88	-105.42
POL2	0.80±0.010	0.98±0.001	0.37±0.015	3	-159.86	-151.40
POL3	0.75±0.010	0.99±0.001	0.48±0.013	4	-173.26	-161.98
POL4	0.70±0.009	0.99±0.001	0.56±0.013	5	-188.09	-173.99
POL5	0.00±0.009	0.99±0.001	0.59±0.013	6	-194.38	-177.45
GK2001	0.00±0.009	0.99±0.001	0.59±0.012	3	-183.83	-175.37

RM: residual mean; R^2: coefficient of determination; r: correlation between observed and estimated egg production curves; p: number of model parameters; ROT: rotational function; MMF: MMF function; LOGIS: logistic function; POLi: i^{th} degree polynomial function; GK2001: Grossman and Koops 2001 function; AIC: Akaike Information Criterion; BIC: Bayesian Information Criterion

Effects of Initial Body Weight and Feed Intake

Least square means and standard errors of observed and estimated weekly (1W), two-weekly (2W), four-weekly (4W), total observed and estimated (TEP and ETEP, respectively) egg productions in 52-w period, and the model parameters by BW and FI groups and overall are presented in *Table 4*. Overall, the hens produced 334±1.6 eggs and reached upper level of about 98% of maximum (*m*) during the increasing period, sustained that level until about 24 w of production (*p*), that means, overall persistency was about 24 wk, then decreased to about 89% of maximum (*d*) during the decreasing period. ETEP was 332±1.2 and differed from TEP only by 2 eggs. Depending on the BW and FI groups, the hens reached upper level of about 98-100% of production during the increasing period (*m*), and sustained that level about 24 w, 13 couple w (26 w) and 8 quadruple w (32 w) (*p*) and declined to about 86-89% of maximum production during the decreasing period (*d*). The graphs of average observed and estimated 1W, 2W and 4W egg production and residuals are presented in *Figure 1*. *Figure 1a* and *b* show that the model slightly underestimated the egg yield during the first month of production as the production interval increased from 1W to 2W, and from 2W to 4W.

In regard to the environmental grouping of BW, TEP was 334±2.7, 334±5.5 and 333±2.5 eggs in *light*, *medium* and *heavy* hens, respectively (*Table 4*), and they were higher about 1 to 19 eggs in comparison to ETEP estimated by the model. The differences between TEP and ETEP were getting larger when the production interval was increased (for example; from 1W to 4W). Hens in all groups reached upper level of about 98-100% of production during the increasing period (*m*), and sustained that level about 24-25 w, 13-14 couple w (26-28 w) and 7-8 quadruple w (28-32 w) (*p*) and declined to about 85-89% of maximum production during the decreasing period (*d*). These results show that GK2001 model, especially the persistency parameter (*p*), is sensitive to amount of data fitted, that is, the fitting of the 1W data resulted in 24-25 w continuous maximum production in comparison to 28-32 w when fitting the 4W data.

In FI groups, TEP was 329±2.6, 336±2.7 and 335±2.5 eggs in *less*, *moderate*, and *more* groups, respectively (*Table 4*), and they were higher about 2 to 19 eggs in comparison to ETEP estimated by the model. As the situation observed in BW grouping, the differences between TEP and ETEP were getting larger when the production interval was increased. Hens in all groups reached upper level of about 98-100% of production during the increasing period (*m*), and sustained that level about 23-25 w, 12-14 couple w (24-28 w) and 7-8 quadruple w (28-32 w) (*p*) and declined to about 85-90% of maximum production during the decreasing period (*d*).

Table 4. Model parameters of Grossman and Koops 2001 (GK2001) function (±SE), observed and estimated mean and standart error of total 52-w egg production (TEP±SE and ETEP±SE), correlation coefficient among model parameters, TEP and ETEP

	N	*p*	*m*	*d*	TEP	ETEP
BW						
Light	1W	24±0.9	0.98±0.006	0.89±0.012	334±2.7	333±2.6
	2W	13±0.7	0.99±0.005	0.88±0.013	--	328±2.6
	4W	7±0.3	1.00±0.001	0.87±0.014	--	316±2.5
Medium	1W	25±0.9	0.98±0.005	0.88±0.011	334±2.5	333±2.4
	2W	13±0.7	0.99±0.005	0.88±0.012	--	327±2.3
	4W	8±0.3	1.00±0.001	0.86±0.013	--	315±2.3
Heavy	1W	24±0.9	0.98±0.005	0.89±0.011	333±2.5	332±2.4
	2W	14±0.7	0.99±0.005	0.88±0.012	--	327±2.3
	4W	8±0.3	1.00±0.001	0.85±0.013	--	315±2.3
FI						
Less	1W	23±0.9	0.98±0.006	0.87±0.011	329±2.6	329±2.4
	2W	12±0.7	0.99±0.005	0.86±0.012	--	323±2.4
	4W	7±0.3	1.00±0.001	0.85±0.013	--	311±2.3
Moderate	1W	25±0.9	0.98±0.006	0.90±0.012	336±2.7	335±2.6
	2W	14±0.7	0.99±0.005	0.89±0.013	--	330±2.6
	4W	8±0.3	1.00±0.001	0.88±0.014	--	319±2.5
More	1W	25±0.8	0.98±0.005	0.89±0.011	335±2.5	334±2.3
	2W	14±0.7	0.99±0.004	0.88±0.011		329±2.3
	4W	8±0.3	1.00±0.001	0.87±0.013		317±2.2
Overall	1W	24±0.49	0.98±0.003	0.89±0.006	334±1.6	332±1.2
	2W	13±0.4	0.99±0.003	0.88±0.007	--	327±1.3
	4W	8±0.1	1.00±0.001	0.86±0.007	--	315±1.3
Correlations						
p	1W		0.249**	-0.110	0.191*	0.185*
	2W		-0.131	-0.117	0.162	0.227*
	4W		-0.212*	-0.097	0.290**	0.330**
m	1W			0.137	0.468**	0.434**
	2W			0.081	0.361**	0.298**
	4W			-0.063	0.115	-0.007
d	1W				0.892**	0.913**
	2W				0.834**	0.850**
	4W				0.828**	0.861**
TEP	1W					0.992**
	2W					0.976**
	4W					0.957**

m, p, d : parameters of GK2001 function, TEP: 52-week total egg production, ETEP: estimated 52-week total egg production, BW: body weight groups, FI: feed intake groups, *P<0.05, **P<0.01

Correlations

Correlations among model parameters are presented in *Table 4*. There were small but significant (P<0.05) correlations between persistency (*p*) with upper level of production in the increasing stage (0.249 in 1W and -0.212 in 4W), but insignificant negative correlations with upper level of production in the decreasing (*d*) stage (-0.110 in 1W and -0.097 in 4W) were observed. Correlations between *p* with *m* and *d* in 2W data, and between *m* and *d* were not significant implying any association between the egg productions in the increasing stage and in the decreasing stage.

Observed total egg production (TEP) had a positive and significant (P<0.05) correlations with *p* (0.191 in 1W and 0.290 in 4W), *m* (0.468 in 1W and 0.361 in 2W) and d (0.892 in 1W, 0.834 in 2W and 0.828 in 4W). These

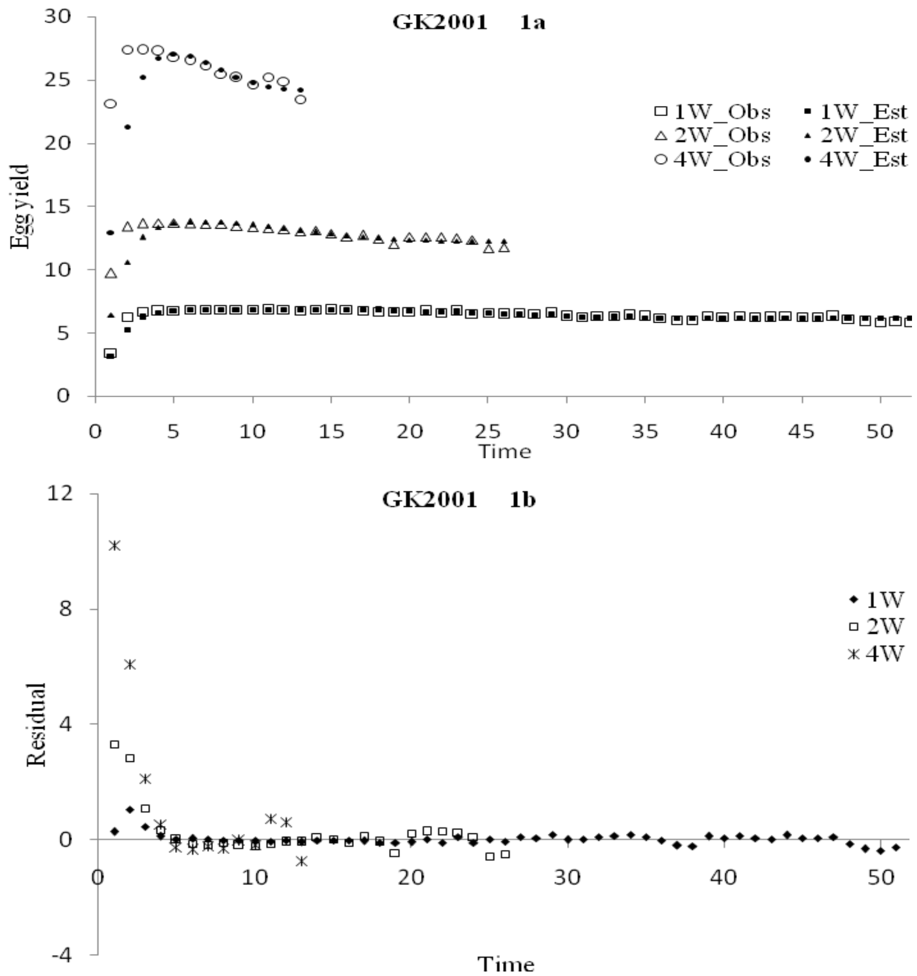

Figure 1. Weekly (1W), 2 weekly (2W) and 4 weekly (4W) observed and estimated egg production (above) and residuals (below). (Time = week for 1W, 2 weeks for 2W and 4 weeks for 4W)

results strongly indicates that selection especially on the parameter *d* regardless of the length of production interval, and on the parameter *m* when the data include 1W or 2W production interval and on the parameters *p* when the data include 1W or 4W production interval could improve the 52 w total egg production.

DISCUSSION

Eight different mathematical models (ROT, MMF, LOGIS, POL2-5 and GK2001) were fitted to individual weekly egg production curve. Among them, ROT and MMF models produced small R^2 values, 0.24 and 0.69, respectively, and these were smaller than the findings in previous report (Bindya et al., 2010). The ROT model was also fitted to average egg production of egg type laying hens (Thomas et al., 1994; Lal et al., 2003) and their reports of R^2 were also higher than our findings. This could be attributable to reason that they fitted the models to average egg production of broiler type laying hens data. Some other studies (Cason and Britton, 1988; Cason, 1990; Cason, 2003) fitted the Compartmental, Adams-Bell and logistic-curvilinear functions to weekly egg data and reported that the Adams-Bell model was the best for goodness of fit criteria. On the other hand, logistic function among ten different non-linear functions was the best to fit egg production of 17 to 70 w of White Leghorn laying hens (Savegnago et al., 2011). In the present study, considering all the googness of fit criteria, GK2001 model was the best fitting model to individual weekly egg production curve of Nick Brown chickens used in the analyses.

The primary objectives of this study were to compare mathematical models for ability to describe egg production trajectory of individual hens, and to investigate any association between individual weekly egg production and egg production curve of individual hens with the variation on body weight (BW) and feed intake (FI) when they are fed the same diet. Selected model (GK2001) was also tested in order to reveal whether it was sensitive to summarizing the data in different egg production intervals; weekly (1W), 2 weekly (2W) or four weekly (4W) egg productions. The proportion of variance (R^2) explained by GK2001 model was 0.99±0.001 for egg production expressed by weekly intervals and was higher than those (0.48 to 0.51) of previous researches (Grossman and Koops, 2001; Gavora et al., 1971; Grossman et al., 2000). Persistency (*p*) was the average of 24 w ranged from 23 to 25 w depending on the BW and FI and although there was no significant difference observed among the levels within BW and FI groups. The *p* values obtained in this research were smaller than those (25 to 30 w) of previous report (Grossman and Koops, 2001). They also stated that if the total 52 w egg productions are to be estimated using part records, using the part records prior to the time of transition (the point of time passing from peak yield to declining stage of egg production) would result in overestimating the annual egg production. Therefore, in the present study it could be suggested in terms of selection of individual hens that, to avoid the overestimation of annual egg production, the part records covering until the week 25 could conveniently be used for Nick Brown hens.

Estimated total 52 w egg productions was within 0 or 1 egg of observed production, however, observed 52 w egg production was underestimated as the production interval increased from 1 week to 2 weeks, and from 2 weeks to 4 weeks (*Table 4*). However, the amount of decrease was larger in the present study (0 to 19 eggs) than those (1 to 4 eggs) reported as the interval increased from 1 to 4 weeks (Grossman and Koops, 2001).

CONCLUSION

In conclusion, the choice of the best fit model to describe egg production curves of chickens depends on various factors. Previous studies and the present study show that the amount of data point fitted, summarizing data in different interval (for example, weekly or monthly), fitting individual data or hen house average result in concluding different functions best to describe egg production curves of chickens. In the present study, the model developed earlier (Grossman and Koops, 2001) was the most appropriate model for describing individual weekly egg production of Nick Brown laying hens, and the model parameters were not affected by fluctuation in body weight or feed intake when hens fed the same diet. However, summarizing data in larger interval than a week resulted in increased underestimation of actual annual egg production. Therefore, these results confirm that hens eat primarily to satisfy their energy needs and have a genetic potential of producing a given amount of egg mass. Thus, this potential partially regulates the hens nutrient intake as a major portion of the nutrient is used for egg production. The bird also has a nutrient requirement for maintenance. Therefore, the differences in initial body weight or feed intake are not sufficient to change the number of egg produced by the birds.

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