Effects of differences in the initial body weight of groups on laying performance and egg quality parameters of Lohmann laying hens

E. Lacin[1], A. Yildiz[1], N. Esenbuga[2], M. Macit[2]

[1]Department of Animal Husbandry, College of Veterinary Medicine, Atatürk University, Erzurum, Turkey

[2]Department of Animal Science, College of Agriculture, Atatürk University, Erzurum, Turkey

ABSTRACT: This study was carried out to investigate the effect of different body weight groups (light (L) = 1 400–1 500; medium (M) = 1 500–1 600 and heavy (H) = 1 600 < g) on performance and egg quality traits of Lohmann hens, 24 weeks of age, in different laying periods. A total of 288 Lohmann White layers were allocated randomly to three groups with respect to live weight, each consisting of 24 replicated cages as subgroups, comprising four hens. The study period lasting for 60 weeks was investigated as four different age periods (first period = 24–40 weeks; second period = 40–54 weeks; third period = 54–68 weeks; fourth period = 68–84 weeks). Differences in the initial live weight at the beginning of experiment among the groups continued to the end of experimental period. Considering the egg production, differences among the groups were not significant ($P > 0.05$) during the experimental period. Egg weight was determined to be lower in the group with low body weight (64.58 g) than in medium (64.97 g) and heavy hen groups (66.30 g). Differences in feed intake and feed conversion ratio among the groups were found significant, and the mean values were 123.93, 127.48 and 130.67 for feed consumption (g/day); 2.23, 2.28 and 2.27 for feed conversion ratio. Except for the feed conversion ratio, the effect of weight groups by age period interaction on performance parameters was significant ($P < 0.01$). The effects of body weight on shell strength, shell thickness and yolk index were not significant during the experimental period. However, different body weight groups significantly affected shape index, yolk colour, albumen index and Haugh unit parameters. Shell strength, yolk colour and yolk index values were affected by weight groups by age period interaction. In conclusion, Lohmann White hens in the light group in a uniform flock had higher egg production and lower feed conversion ratio values than those of other weight groups.

Keywords: body weight; laying hen; laying performance; egg quality traits

Like in the other animal sectors, the purpose of chicken production is to obtain the yield of a desirable level at the lowest cost. As the chickens spend their life in poultry houses, in order to be able to perform their production capacities entirely, they should be kept in good environmental conditions with a good care as well as genetic characteristics. Depending upon economic conditions and climatologic constraints, egg production normally takes place in either fully confined or semi-confined housing. Uniformity of body weight in pullets and laying hens is an important management concern. To achieve early maturity and egg production it is very important to have correct body weight and uniformity in the growing period. Sexual maturity in the growth period of pullets varies in relation to breed and hybrid. Average body weights of white laying pullets at the 6^{th}, 12^{th} and 16^{th} week were 430, 890 and 1 130 g, respectively (Anonymous, 2003). Studies aimed at selection for the live weight gain in laying hens showed that egg production decreased and egg weight and feed consumption increased as body weight increased because heavy birds consume more feed and lay larger egg with large egg yolk than light hens. Hence, the control of live weight in laying hens is very important. The uniformity of flock at the beginning and during the laying period is the main factor to increase egg production (Leeson et al., 1997). Body weight and egg weight are two relevant productive traits in poultry (Festing and Nordskog, 1967; Sorensen et al., 1980). The relationship among egg production, egg weight and mature body weight follows the same pattern as observed in the body weight at sexual maturity (Ayorinde et al., 1988; Oke et al., 2004). At the beginning of laying period, one of the most important factors determining egg weight is body weight of hen at the age of sexual maturity (Robinson and Sheridan, 1982; Summers and Leeson, 1983). Chemical composition of pullet body at the beginning of laying period is also as important as body weight because peak producing laying hens use body tissues and their desire for feed consumption decreases. This problem is solved by using good quality pullets being at the age of sexual maturity (Leeson and Summers, 1987). This practice resulted in segregating pullets as to age at sexual maturity (Harms et al., 2000).

This experiment was conducted to determine the effects of body weight on egg production and egg quality parameters during the different laying periods in Lohmann White hens raised in semi-confined poultry house with a multitier cage system.

MATERIAL AND METHODS

Poultry house and experimental animals

This research was carried out at the Atatürk University Research Farm in accordance with approval by Ethic Committee on Research Animal in Erzurum, Northeastern Turkish city (39°55'N, 41°16'W). Standard feeder, drinker, lighting and densities were used throughout the experiment.

Experimental design

A total of 288 Lohmann White layers at 24 weeks of age were assigned to 3 experimental groups according to BW (light (L) = 1 400–1 500; medium (M) = 1 500–1 600 and heavy (H) = 1 600 < g) and each experimental group consisted of 24 replicated cages comprising 4 layers. Hens were placed into 3-tier cages (50 × 46 × 46 cm in width × depth × height). For each hen 575 cm^2 of floor space was allocated. Hens in each group were equally put into cages in upper, middle and bottom levels. The experiment lasted for 60 weeks and comprised 4 periods (Period I = 24–40 weeks; Period II = 40 to 54 weeks; Period III = 54–68 weeks and Period IV = 68–84 weeks). The diet offered *ad libitum* once daily at 08:30 h in the experiment is described in Table 1, and water through nipples were available all the time. Hens were also subjected to a 17L:7D cycle. The chemical composition was determined according to AOAC procedure.

Table 1. Ingredients and chemical composition of the experimental diet

Ingredients	(%)
Maize	46.00
Soybean meal	21.00
Wheat	7.00
Barley	3.00
Wheat bran	8.75
Molasses	9.00
Limestone	0.40
Salt	2.00
Dicalcium phosphate[1]	2.00
Vitamin-mineral premix[2]	0.40
Methionine	0.15
Lysine	0.15
Ethoxyquin	0.15
Analysis (g/kg; dry matter basis)	
Dry matter (%)	89.00
Crude protein (%)	16.70
Crude fibre (%)	3.60
Ether extract (%)	3.16
Ash (%)	10.40
Ca (%)	2.65
P (%)	0.71
ME (kcal/kg)	2 690.00

[1]each kilogram contained Ca 24% and P 17.5%
[2]each kilogram contained vitamin A 15 000 IU; cholecalciferol 1 500 ICU; DL-α-tocopheryl acetate 30 IU; menadione 5.0 mg; thiamine 3.0 mg; riboflavin 6.0 mg; niacin 20.0 mg; pantothenic acid 8.0 mg; pyridoxine 5.0 mg; folic acid 1.0 mg; vitamin B1 15 μg; M 80.0 mg; Z 60.0 mg; F 30.0 mg; Cu 5.0 mg; 2.0 mg; and Se 0.15 mg

Data collection

Productive performance was evaluated by measuring egg production, feed intake and feed conversion ratio (FCR). Feeding, egg collection and recording were done once daily in the morning. Egg production was recorded daily. Feed was weighed at feeding time, usually every day, and then the feed left in the feeder at the end of the week was weighed and subtracted from the total amount supplied during the week. This gave the total feed intake per 1 week, and from this total the daily feed intake per hen was calculated. Feed conversion ratio was expressed as kilograms of feed consumed per kilogram of egg produced. Egg weights and body weights were measured bi-weekly; egg quality parameters were measured monthly. A total of 144 eggs were randomly collected from 3 groups to assess egg quality parameters which were shape index, shell strength, shell thickness, albumen index, yolk index, yolk colour and Haugh unit. Egg quality parameters were calculated using the following formulas and methods as summarized by Yoruk et al. (2004). Before the egg quality parameters were determined, eggs were stored for 24 h at a room temperature. Shape index (%) = (egg width, cm/egg length, cm) × 100; shell strength (kg/cm^2) was determined by using a machine with the "spiral pressure system", shell thickness (mm × 10^{-2}) was determined in 3 different parts with a micrometer; albumen index (%) = (albumen height, mm/average of albumen length, mm and albumen width, mm) × 100; yolk index (%) = (yolk height, mm/yolk diameter, mm) × 100; yolk colour was determined with a commercially available "yolk colour fan" according to the CIE standard colorimetric system (Yolk Colour Fan, the CIE standard colorimetric system, F. Hoffman-La Roche Ltd., Basel, Switzerland), and Haugh unit = 100 × log(AH + 7.57 – 1.7 × EW$^{0.37}$), where AH = albumen height (mm) and EW = egg weight (g).

Statistical analysis

The experiment was arranged in a complete randomized design. Then 2-way ANOVA was employed using the GLM procedure and differences among groups were evaluated by Duncan's multiple comparison test (SPSS for Windows Release 10.01, SPSS Inc. 1996). The linear model to test the effects of treatment groups on laying performance and egg quality parameters was as follows.

$$Y_{ijk} = \mu + G + A + (G \times A) + e_{ijk}$$

where:
Y_{ijk} = response variable
μ = population mean
G = treatment group
A = age period group
e_{ijk} = experimental error

RESULTS AND DISCUSSION

Table 2 shows the laying performance parameters of treatment groups. Average body weight values at 24 weeks of age were 1 541.50, 1 608.30 and 1 748.69 g for L, M and H groups respectively, and these values continued from the beginning to the end of study. Laying performance traits were affected by the particular laying periods (I, II, III and IV). Overall egg production for L, M and H groups was found to be 87.59, 87.88 and 88.07%, respectively. Egg production was not affected by body weight. Similarly to the present study, other studies reported no change in egg production depending upon body weight (Harms et al., 1982; Cerolini et al., 1994; Harms et al., 2000; Kirikci et al., 2004). However, Harms and Russell (1996) and Akbas and Takma (2005) found that body weight was positively related to egg production. The effect of weight group by age period interaction on hen day production parameters was found highly significant ($P < 0.001$). In the first cycle (24–40 weeks) of laying period, H group had higher egg production than M and L groups. But hens in L group showed higher egg production than those of hens in M and H groups as the experiment continued. Marks (1979) reported that egg production decreased depending on selection as to body weight of quails as the body weight increased. In addition, as body weight increased, feed consumption also increased, and differences in the feed consumption among the groups were determined to be significant from the beginning to the end of experiment (Table 2). The hens in H group had higher feed consumption than M and L groups. The mean values of daily feed consumption at the end of experiment were 123.93, 127.48 and 130.67 g for L, M and H groups, respectively. Leeson and Summers (1987) and Harms et al. (1982) noted that there was a significant relationship between feed consumption and body weight. As body weight increased, feed consumption of hens also increased. Daily feed consumption was affected by weight group by age period interaction ($P < 0.01$). Feed conversion ratio

Table 2. The effects of different body weight and age periods on laying performance parameters of L, M and H hen groups

Group[1]	Response variables[2]				
	HDP (%)	EW (g)	FC (g)	FCR	BW (g)
P<[3]	NS	**	**	*	**
L	87.59	64.58^{c}	123.93^{c}	2.23^{b}	1 585.37^{c}
M	87.89	64.97^{b}	127.48^{b}	2.28^{a}	1 674.55^{b}
H	88.07	66.30^{a}	130.67^{a}	2.27^{a}	1 814.96^{a}
SEM	0.36	0.13	0.50	0.14	3.89
Age period					
P<	**	**	**	**	**
I	89.68^{b}	62.89^{c}	131.64^{a}	2.37^{b}	1 632.81^{d}
II	91.46^{a}	65.49^{b}	130.79^{a}	2.19^{c}	1 687.91^{c}
III	89.31^{b}	65.34^{b}	118.48^{c}	2.04^{d}	1 736.21^{a}
IV	80.95^{c}	67.41^{a}	128.52^{b}	2.42^{a}	1 709.58^{b}
SEM	0.42	0.15	0.58	0.02	4.49
G × A					
P =	0.0001	0.0001	0.01	0.064	0.001

[1]L = light; M = medium; H = heavy; I = 24– 0 weeks; II = 40–54 weeks; III = 54–68 weeks; IV = 68–84 weeks
[2]HDP = hen day production; EW = egg weight; FC = feed consumption (g/day); FCR = feed conversion ratio (kg feed consumed per kg of eggs produced); BW = body weight
[3]statistical significance; NS = non-significant; SEM = standard error of means; ^{a,b,c}means in the same column having different superscripts are significantly different $^{**}P < (0.01)$; $^{*}P < (0.05)$; G × A = group × age period interaction effect

(FCR) varied as the experiment continued. The mean FCR values were 2.23, 2.28 and 2.27 for L, M and H groups, respectively (Table 2). The effect of body weight on FCR was found significant, and hens in L group had the lower FCR value than M and H groups. In agreement with the present results, Harms et al. (1982) reported that feed consumption per kg of egg production increased as the body weight increased. Feed conversion ratio was not affected by weight group by age period interaction. The mean values of egg weight were 64.58, 64.97 and 66.30 g for L, M and H groups respectively, and there was a highly significant difference in egg weight among the groups. In agreement with the present experiment, Summers and Leeson (1983) reported that an increase in body weight positively increased egg weight. Each 100 g increase in body weight was associated with approximately 3.5 g increase in feed intake and 1.2 g increase in egg weight (Leeson and Summers, 1987). Smaller birds consistently ate less feed throughout lay, regardless of the strain, and this resulted in a loss of egg weight (Leeson et al., 1997). The effect of weight group by age period interaction on egg weight was found highly significant ($P < 0.001$). Mean egg weights increased at the 1st, 2nd and 3rd cycle of laying period as body weight increased. This is supported by Du Plessis and Erasmus (1972), Harms et al. (1982) and Leeson and Summers (1987), who reported that higher body weight resulted in large egg length, width and mass, all factors affecting egg weight. Egg weight in the 4th period (68–84 weeks) was similar in L and M groups, and H group had the lowest egg weight within the groups.

The effects of different body weight groups and age periods on egg quality parameters are presented in Table 3. All the egg quality parameters were affected by laying periods (I, II, III and IV). The effect of body weight groups on shell strength, shell thickness and yolk index values was found insignificant. Shape index values of L, M and H groups were 74.86, 75.06 and 74.37%, respectively. While there was a significant difference in shape index among the groups, the effect of weight group by age period interaction on shape index was insignificant. Shape index values were similar in L and M groups, and these groups had higher shape index values than H group. Yannakopoulos and Tserveni-Gousi (1986) noted that shape index was affected by the laying

Table 3. The effects of different body weight and age periods on egg quality parameters of L, M and H hen groups

Group[1]	Response variables[2]						
	SI (%)	SS (kg/cm^2)	ST (mm × 10^{-2})	YC	AI (%)	YI (%)	HU
$P<$[3]	**	NS	NS	*	**	NS	**
L	74.86^a	1.68	0.373	9.64^b	9.04^a	42.00	83.15^a
M	75.06^a	1.65	0.372	9.85^{a,b}	8.62^b	42.05	81.63^b
H	74.37^b	1.63	0.371	9.88^a	8.34^c	41.91	80.57^c
SEM	0.14	0.03	0.002	0.07	0.09	0.15	0.40
Age period							
$P<$	**	**	**	**	**	**	**
I	76.05^a	2.45^a	0.384^a	10.47^a	9.42^a	43.63^a	85.10^a
II	74.96^b	1.85^b	0.379^a	9.60^b	9.28^a	42.16^b	84.42^a
III	74.13^c	1.32^c	0.362^b	9.28^c	8.03^b	40.02^c	79.34^b
IV	73.90^c	1.00^d	0.363^b	9.81^b	7.93^b	42.15^b	78.28^b
SEM	0.17	0.35	0.002	0.07	0.12	0.15	0.43
G × A							
P =	0.254	0.001	0.722	0.007	0.391	0.02	0.292

[1]L = light; M = medium; H = heavy; I = 24–40 weeks; II = 40–54 weeks; III = 54–68 weeks; IV = 68–84 weeks
[2]SI = shape index; SS = shell strength; ST = shell thickness; YC = yolk colour; YI = yolk index; AI = albumen index; HU = Haugh unit
[3]statistical significance; NS = non-significant; SEM = standard error of means; [a,b,c]means in the same column having different superscripts are significantly different $^{**}P < (0.01)$, $^{*}P < (0.05)$; G × A = group × age period interaction effect

period of quail. A depression in the shape index value in the present experiment could be attributed to increased body weight. The effect of weight group by age period interaction on shell strength was found highly significant ($P < 0.001$). In the 4th cycle of laying period L and M groups were similar and had greater shell strength than H group. As egg weight in H group increased, shell strength values decreased in the 4th cycle of laying period. As body weight increased, shell strength values decreased. Average albumen index values of L, M and H groups were 9.04, 8.62 and 8.34%, respectively. H group had a higher albumen index value than hens placed in L and M groups, differences in this parameter among the groups were determined to be highly significant ($P < 0.001$). Contrary to the present experiment, Leeson et al. (1997) noted that body weight did not affect albumen index. The effect of weight group by age period interaction on albumen index was not significant. Yolk colour values were affected by different weight groups. Yolk colour values were 9.64, 9.85 and 9.88 for L, M and H groups, respectively, and the effect of weight group by age period interaction on this parameter was significant ($P < 0.007$). In addition, yolk index values were affected by weight group by age period interaction ($P < 0.02$). Hens in L group had the highest Haugh unit in the whole laying period, and the effect of body weight on this parameter was reported by Altan et al. (1998) not to be significant.

In conclusion, this study showed that body weight influenced some important parameters of laying performance and egg quality in hens. Egg weight was determined to be lower in the group with low body weight than in medium and heavy hen groups. However, egg production in light group was higher than that of heavy group (periods III and IV). Feed consumption was found to be higher in medium and heavy groups than in the light group. As body weight increased, egg weight increased but hen-day egg production decreased. Briefly, when feed consumption and feed conversion ratio (FCR) values are considered by poultry breeders, hens having light body weight with uniformity of 94% may be preferable to medium and heavy hens because a uniform flock with light weight realises profit due low feed consumption, high egg production and improved feed conversion ratio.

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Corresponding Author

Asst. Prof. Dr. Ekrem Lacin, Department of Animal Husbandry, College of Veterinary Medicine, Atatürk University, Erzurum 257 00, Turkey
Tel. +90 442 631 4193, fax +90 442 631 4188, e-mail: ekremlacin@hotmail.com or elacin@atauni.edu.tr