Specific Gravity of Eggs and Eggshell Weight from Commercial Layers and Broiler Breeders in Relation to Time of Oviposition[1]

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ABSTRACT Eggs were collected from 1 day of production of Hy-Line® W36 commercial egg production hens 55 wk old. Also, eggs were collected from 1 day of production of Arbor Acres broiler breeder hens when they were 40 and 55 wk of age. The eggs were immediately weighed (EW) after collection and specific gravity (ESG) determined. The eggs were then broken and the contents removed. Shells were washed, air dried, and weighed. The weights of shells (ESW) were calculated using the following formulas: Broiler breeder $ESW = 1.9128 \times EW - \frac{1.9741\ EW}{ESG}$ and layer $ESW = 1.9140\ EW - \frac{1.9754\ EW}{ESG}$. Shell density (ESD) was calculated using a modification of this formula.

Egg weights of both commercial layers and broiler breeders were heaviest in the early morning. There was a steady decline in EW until 1545 h; EW increased thereafter. Specific gravity of eggs was highest in the morning, declined until 1245 h, and then increased thereafter. Shell weight was also highest in the morning, declined until 1245 h, and then increased thereafter. The calculated and measured ESW were highly correlated. The ESD was 2.147 and 2.160 for the commercial layers and broiler breeders, respectively. (*Key words*: commercial laying hen, broiler breeder, egg specific gravity, egg weight, eggshell weight)

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INTRODUCTION

Roland *et al.* (1973a) reported that specific gravity of eggs (ESG) from commercial laying hens varied according to time of oviposition. They stated that the later in the afternoon the egg was laid the better the eggshell. In a subsequent paper, Roland and Harms (1974) reported that ESG and egg weight (EW) were related to time of oviposition. However, because EW did not continue to decrease in the afternoon as shell quality increased, these workers suggested that the decrease in EW was not responsible for the change in ESG.

Roland *et al.* (1977) reported that eggs laid before 1100 h were heavier and had lower eggshell weights (ESW) than those laid after 1400 h. These differences were observed regardless of whether the diet contained 2.25, 3.50, or 6.0% calcium. The difference in ESG for morning and afternoon eggs was .0050, .0060, and .0070 for eggs from hens receiving 2.25, 3.50, and 6.0% calcium, respectively. Obviously, EW influences ESG. A formula has been developed for predicting ESW (Harms *et al.*, 1990). When ESG was adjusted for EW, based on this formula, the differences were only .0028, .0049, and .0051, respectively. This indicated that a portion of the differences in the ESG of the morning and afternoon eggs was due to the differences in EW.

Arafa *et al.* (1982) found that hens laid the heaviest eggs between 0600 and 0800 h and that EW gradually decreased during the remainder of the day. The present study was conducted to determine the hourly change of EW, ESG, and calculated ESW for commercial layers and broiler breeder hens.

MATERIALS AND METHODS

Eggs from 1 day of production were collected at hourly intervals from 500 Hy-Line® W-36 hens[2] 55 wk of age. The hens consumed approximately 100 g per hen per day of a corn and soybean meal diet (Table 1). They were given 16 h of light with supplemental artificial light from 0430 to 2030 h when necessary.

[1]Florida Agricultural Experiment Stations Journal Series Number R-00778.

[2]Hy-Line International, Dallas Center, IA 50063.

TABLE 1. *Composition of diets*

Ingredient	Commercial layer	Broiler breeder
	(%)	
Yellow corn	72.82	79.11
Soybean meal (48% CP)	16.83	11.51
Limestone	8.03	5.72
Dicalcium phosphate (18.5% P + 21% Ca)	1.33	.94
Microingredients[1]	.50	.50
Salt	.41	.19
DL-methionine	.08	. . .
Animal fat	. . .	2.03

[1]Supplied per kilogram of diet: vitamin A, 6,600 IU; vitamin D_3, 2,200 ICU; menadione dimethylpyrimidinol bisulfite, 2.2 mg; riboflavin, 4.14 mg; pantothenic acid, 13.2 mg; niacin, 39.6 mg; vitamin B_{12}, .022 mg; ethoxyquin, 125 mg; manganese, 60 mg; iron, 50 mg; copper, 6 mg; iodine, 1.1 mg; zinc, 35 mg; selenium, .1 mg.

Eggs from 1 day of production were collected at hourly intervals from a flock of Arbor Acres broiler breeder hens[3] 40 and 55 wk old. Eggs were collected from 600 hens at 40 wk of age and 280 hens at 55 wk of age. The hens had been given a daily feed allowance of 168 g of a corn and soybean meal diet (Table 1). They were given 16 h of light, with supplemental light furnished from 0400 to 2000 h.

Eggs were weighed immediately after collection, and ESG was then determined by using the procedure of Voisey and Hamilton (1977), taking measurements in increments of .0025. Eggs were then broken and the contents removed. The shells were washed, air dried, and weighed to the nearest .1 g. Weight of the shell was also calculated using modifications of a formula suggested by Harms *et al.* (1990):

$$\text{Broiler breeder ESW} = 1.9128 \times \text{EW} - \frac{1.9741\ \text{EW}}{\text{ESG}}$$

$$\text{Commercial layer ESW} = 1.9140\ \text{EW} - \frac{1.9754\ \text{EW}}{\text{ESG}}$$

The correlation coefficients were calculated for measured and calculated ESW.

The following formula was used to calculate the density of the eggshell plus membrane (ESD):

$$\text{ESD} = \frac{\text{ESW}}{(\text{EW} + \text{Dt} \times \text{ESG}) - (\text{EW} - \text{SW} + \text{ECD})}$$

where ECD = egg content density and Dt is the density of water at 4 C (.988). The formula for calculating ESD was derived from Step 4 that Harms *et al.* (1990) used in deriving the original formula for calculating ESW.

The standard error of the mean and pooled standard error of the mean was calculated for each hourly measurement for commercial layers and broiler breeders. Comparisons of means were made by the *t* test (Steel and Torrie, 1960).

RESULTS AND DISCUSSION

Egg Weights

Egg weights from commercial laying hens declined between 0745 and 0845 h [67.2 ± .5 (SE) versus 63.8 ± .7] (Table 2). Egg weight declined steadily until 1545 h from 1145 to 1245 h (Table 2, Figure 1), but after 1545 h the EW increased. The decline in EW during the day agrees with the data reported by Arafa *et al.* (1982) for commercial laying hens.

Eggs from broiler breeders laid before 0745 h in Experiment 1 were significantly heavier than eggs laid during the remainder of the day, with the exception of those laid between 1545 and 1645 h (Table 3, Figure 1). In Experiment 2, EW did not decline until after 0845 h. After 0845 h, the EW remained relatively constant. These data would indicate that the change in EW during the day for eggs from broiler breeders is different from the change EW for commercial layers, because broiler breeder eggs did not increase after 1545 h.

[3]Arbor Acres Farm, Glastonbury, CT 06033.

TABLE 2. *Egg weight, egg specific gravity, calculated and measured shell weight, and shell density of eggs from commercial laying hens collected at hourly intervals*[1,2]

Time period	Egg weight[3]	Specific gravity[4]	Shell weight (g)[5]		Calculated shell density	Correlation of calculated and measured shell weight
			Calculated	Measured		
(h)	(g)		(g)			
1 Before 0745	67.2 ± .5 (90)[6]	800 ± 5	5.70 ± .07	5.67 ± .06	2.17 ± .01	.959
2 0745 to 0845	63.8 ± .7 (49)	783 ± 8	5.22 ± .09	5.38 ± .08	2.09 ± .01	.937
3 0845 to 0945	63.7 ± .6 (50)	786 ± 6	5.25 ± .08	5.26 ± .08	2.15 ± .01	.957
4 0945 to 1045	62.6 ± .7 (40)	801 ± 8	5.33 ± .11	5.35 ± .10	2.15 ± .02	.942
5 1045 to 1145	61.7 ± .6 (50)	802 ± 6	5.26 ± .07	5.36 ± .06	2.12 ± .01	.940
6 1145 to 1245	62.2 ± .8 (30)	843 ± 10	5.72 ± .12	5.60 ± .09	2.18 ± .02	.914
7 1245 to 1345	61.4 ± 1.1 (24)	823 ± 9	5.45 ± .13	5.39 ± .11	2.15 ± .02	.967
8 1345 to 1445	61.6 ± .8 (19)	851 ± 12	5.76 ± .12	5.71 ± .11	2.18 ± .01	.965
9 1445 to 1545	60.5 ± 1.0 (13)	810 ± 17	5.23 ± .18	NM[7]	NM	NM
10 1545 to 1645	64.1 ± .9 (18)	783 ± 11	5.23 ± .11	NM	NM	NM
11 After 1645	65.6 ± .9 (25)	807 ± 1	5.64 ± .12			
Pooled SEM	.9	10	.12	.09	.02	

[1]$\bar{x}$ ± SEM.

[2]Regression equations and R^2 for changes over time:

Egg weight $Y = 69.0 - 2.41x + .19x^2$, $R^2 = 91$.

Specific gravity $Y = 763.4 + 16.93x - 1.24x^2$, $R^2 = .59$.

Shell weight $Y = 5.46 - .02x + .003x^2$, $R^2 = 14$.

[3]Eggs laid from 0745 to 1145 h were significantly lower than eggs laid between 1145 and 1445 h.

[4]Coded 1.0xxx.

[5]Eggshell weight of eggs laid before 0745 were significantly higher than those laid later except for those laid between 1345 and 1445 h.

[6]Number of eggs measured is in parentheses.

[7]NM = not measured.

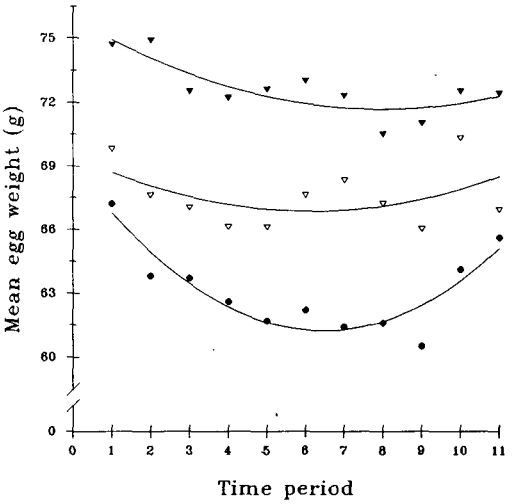

FIGURE 1. Regression equations and plots of changes in egg weights over time: for commercial layers (●) $Y = 69.0 - 2.41x + .19x^2$, $R^2 = 91$; broiler breeder Experiment 1 (▽) $Y = 69.5 - .85x + .07x^2$, $R^2 = 45$; and broiler breeder Experiment 2 (▼) $Y = 75.93 - 1.06x + .07x^2$, $R^2 = .82$. Time periods 1 to 11 represent the periods before 0745 h, 0745 to 0845 h, 0845 to 0945 h, 0945 to 1045 h, 1045 to 1145 h, 1145 to 1245 h, 1245 to 1345 h, 1345 to 1445 h, 1445 to 1545 h, 1545 to 1645 h, and after 1645 h, respectively.

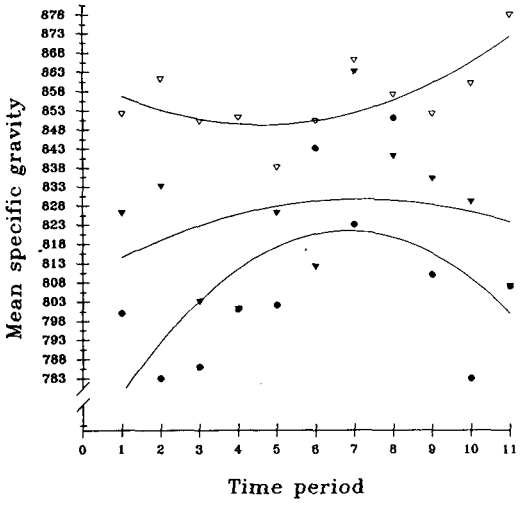

FIGURE 2. Regression equations and plots of changes in egg specific gravity (coded 1.0XXX) over time: for commercial layers (●) $Y = 763.4 + 16.93x - 1.24x^2$, $R^2 = .59$; broiler breeder Experiment 1 (▽) $Y = 861.4 + 5.29x + .57x^2$, $R^2 = 71$; and broiler breeder Experiment 2 (▼) $Y = 809.1 + 5.74x - .40x^2$, $R^2 = .26$. Time periods 1 to 11 represent the periods before 0745 h, 0745 to 0845 h, 0845 to 0945 h, 0945 to 1045 h, 1045 to 1145 h, 1145 to 1245 h, 1245 to 1345 h, 1345 to 1445 h, 1445 to 1545 h, 1545 to 1645 h, and after 1645 h, respectively.

Specific Gravity

The specific gravity of eggs laid by commercial layers from 0745 to 1145 h was significantly lower than ESG of eggs laid between 1145 and 1445 (Table 2, Figure 2). However, ESG declined after 1445 h. These data do not agree with the report by Roland *et al.* (1973b), which showed that the later in the afternoon the eggs were laid the better the ESG.

The ESG of eggs laid by broiler breeders in Experiment 1 remained relatively constant between the 0745 and 1545 h (Table 3, Figure 2). However, after this time ESG increased and this change was significant for eggs laid after 1645 h. In Experiment 2, ESG of eggs was significantly greater before 0845 h. However, it declined after this time until 1245 h. This cyclic nature of ESG is similar to that observed with commercial layers.

Eggshell Weight

The calculated ESW and measured ESW agreed very closely for the commercial layers (Table 2, Figure 3) and for the broiler breeders in Experiment 1 (Table 3, Figure 3). The ESW of

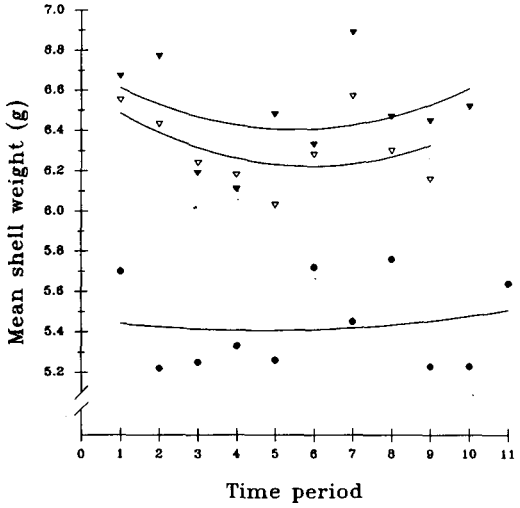

FIGURE 3. Regression equation and plots of changes in shell weight over time: for commercial layers (●) $Y = 5.46 - .02x + .003x^2$, $R^2 = .14$; broiler breeder Experiment 1 (▽) $Y = 6.60 - .13x + .01x^2$, $R^2 = .48$; and broiler breeder Experiment 2 (▼) $Y = 6.71 - .11x + .01x^2$, $R^2 = .32$. Time periods 1 to 11 represent the periods before 0745 h, 0745 to 0845 h, 0845 to 0945 h, 0945 to 1045 h, 1045 to 1145 h, 1145 to 1245 h, 1245 to 1345 h, 1345 to 1445 h, 1445 to 1545 h, 1545 to 1645 h, and after 1645 h, respectively.

TABLE 3. *Egg weight, egg specific gravity, eggshell weight (calculated and measured), correlation of measured and calculated egg shell weight, and density of eggshell plus membrane of eggs from broiler breeders at hourly ovipositions*[1,2]

Time period	Egg weight		Specific gravity[3]		Shell weight			Correlation of calculated and measured shell	Calculated density of shell[4]
					Experiment 1		Experiment 2		
	Experiment 1	Experiment 2	Experiment 1	Experiment 2	Calculated	Measured	Calculated		
(h)	(g)				(g)				
1 Before 0745	69.8 ± .6 (73)[5,6]	74.7 ± .9 (31)	852 ± 6	826 ± 7	6.55 ± .09	6.56 ± .07	6.67 ± .11	.903	2.16 ± .12
2 0745 to 0845	67.6 ± .8 (32)	74.9 ± .8 (22)	861 ± 8	833 ± 10	6.43 ± .13	6.45 ± .11	6.77 ± .12	.958	2.15 ± .11
3 0845 to 0945	67.0 ± .6 (89)	72.5 ± .8 (46)	850 ± 6	803 ± 8	6.24 ± .07	6.24 ± .07	6.19 ± .12	.925	2.16 ± .11
4 0945 to 1045	66.1 ± .5 (88)	72.2 ± 1.6 (31)	851 ± 5	801 ± 11	6.18 ± .07	6.14 ± .07	6.11 ± .17	.918	2.18 ± .02
5 1045 to 1145	66.1 ± .7 (46)	72.6 ± 1.2 (18)	838 ± 9	826 ± 12	6.03 ± .11	6.14 ± .09	6.48 ± .16	.966	2.11 ± .01
6 1145 to 1245	67.6 ± .8 (50)	73.0 ± 1.2 (21)	850 ± 9	812 ± 15	6.28 ± .10	6.24 ± .08	6.33 ± .19	.934	2.18 ± .01
7 1245 to 1345	68.3 ± .8 (23)	72.3 ± 1.0 (18)	866 ± 11	863 ± 14	6.57 ± .16	6.56 ± .13	6.89 ± .19	.961	2.16 ± .02
8 1345 to 1445	67.2 ± .1 (17)	70.5 ± .8 (11)	857 ± 10	841 ± 9	6.30 ± .16	6.28 ± .16	6.47 ± .11	.824	2.16 ± .04
9 1445 to 1545	66.0 ± 1.5 (15)	71.0 ± 1.3 (5)	852 ± 13	835 ± 20	6.16 ± .14	6.18 ± .13	6.45 ± .29	.820	2.16 ± .03
10 1545 to 1645	70.3 ± (10)	72.5 ± 2.2 (6)	860 ± 13	829 ± 16	NM[7]	NM	6.52 ± .31	NM	
11 After 1645	66.9	72.4 ± 1.8 (7)	878 ± 10	807 ± 20	NM	NM	NM	NM	
Pooled SEM	.7	1.3	10	.14	.13	.10	.16		.05

[1]$\bar{x}$ ± SEM.

[2]Regression equations for changes and R^2 over time.

Egg weight; Experiment 1 $Y = 69.5 - .85x + .07x^2$, $R^2 = 45$;

Experiment 2 $Y = 75.93 - 1.06x + .07x^2$, $R^2 = 82$.

Specific gravity; Experiment 1 $Y = 861.4 - 5.29x + 57x^2$, $R^2 = .71$;

Experiment 2 $Y = 809.1 + 5.74x - 41x^2$, $R^2 = .71$.

Shell weight; Experiment 1 $Y = 6.60 - .13x + .01x^2$, $R^2 = .48$;

Experiment 2 $Y = 6.71 - .11x + .01x^2$, $R^2 = .32$.

[3]Coded 1.0xxx.

[4]Measured in Experiment 1.

[5]Number of eggs measured is in parentheses.

[6]Significantly greater than all other times except between 1545 and 1645 h.

[7]NM = not measured.

commercial layer eggs laid before 0745 h was significantly greater than for eggs laid between 0745 and 1145 h. The ESW significantly increased between 1145 and 1245 h and remained greater through the remainder of the day with the exception of eggs laid between 1445 and 1645 h.

The ESW was significantly greater for broiler breeder eggs laid before 0845 h (Table 3). Between 0845 and 1245 h ESW significantly declined. After 1245 h the ESW significantly decreased until after 1445 h.

Eggshell Density

The eggshell density (ESD) was 2.147 (Table 2) for commercial layers and 2.160 (Table 3) for the broiler breeders. These values are considerably higher than the 2.028 value, which Harms *et al.* (1990) reported for the density of eggshells including membranes. The calculated ESW using the density of 2.028 as suggested by Harms *et al.* (1990) also resulted in a calculated ESW which was in good agreement with the measured weight. However, when the density of 2.147 was used, the correlation coefficients did not change but the agreement between calculated and measured ESW was much closer.

The present data indicate that ESW varied during the day in a similar pattern for commercial layers and broiler breeders. Also, ESG and ESW varied in a similar manner for commercial layers and broiler breeders in Experiment 2. The ESG of the eggs from broiler breeders in Experiment 1 did not show the hourly variation as was noted for the commercial layers and broiler breeders in Experiment 2. The commercial layers were fed for *ad libitum* intake, and therefore had access to feed for a longer time during the day than did the broiler breeders, which had a restricted feed allowance. The restricted feed allowance should have resulted in the intestinal contents of broiler breeders becoming deficient in calcium during the later part of the day and the early portion of the night. This would be expected to cause a change in the ESW and ESG of eggs laid during the early morning period. However, this was not the case. This finding would indicate that the disappearance of the calcium from the digestive system with commercial layers during the night may not be a major factor in eggshell quality as originally suggested by Roland *et al.* (1973b).

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