PERFORMANCE AND PROFITS OF COMMERCIAL LEGHORNS AS INFLUENCED BY CAGE ROW POSITION[1]

D. A. ROLAND, SR.[2] and M. BRYANT
Department of Poultry Science, Auburn University, AL 36849
AL ROLAND
Roland Consulting, Auburn, AL 36830
JACK SELF
Cal-Maine Foods, Jackson, MS 39207

Primary Audience: Researchers, Egg Producers, Nutritionists, Extension Specialists

SUMMARY

Producers commonly feed commercial leghorns based on flock average feed intake to control egg size and nutrient intake. However, results of these experiments indicate that this procedure may not yield maximum profits. Results indicate that hens housed in the bottom row of cages have significantly greater egg size and feed consumption than those on the top row. Most of the differences associated with cage row level cannot be explained by variation in temperature. Our results suggest that most commercial leghorns are either overfed or underfed depending on cage row position and that profits could be increased by feeding hens based on feed intake as determined by cage row position rather than by average flock intake.

Key words: Cage row position, hens, performance, profits

1997 J. Appl. Poultry Res. 6:284–289

DESCRIPTION OF PROBLEM

Feed consumption and egg size are two of the most important factors determining profits for commercial egg producers. With average feed prices, overconsumption of feed by only 1 lb/100 hens/day reduces profits about 1¢/doz. Each additional 0.1 g egg weight could be worth 0.3¢/doz. or more depending upon egg price and price spread due to size. Because of this, much research [1, 2, 3, 4, 5, 6] has focused on the effect of factors (dietary energy level, fat, environmental temperature, TSAA level, linoleic acid, light, and age of sexual maturity) that can influence feed consumption and egg size.

The purpose of this paper is to describe a natural phenomenon that affects egg size and feed consumption in new computerized, environmentally controlled cool-cell houses and in older open-sided houses. The authors discovered that row position (top to bottom) had a significant influence on egg size and feed consumption. For the last 5 yr, a large volume of data has been obtained from our laboratory which demonstrates this effect. Although it is

1 Alabama Agricultural Experiment Station Journal Series No. 12-965758
2 To whom correspondence should be addressed

not known why hens housed on the bottom row produce larger eggs and consume more feed than those on the top row, adjusting feed to compensate for this difference may enable producers to increase profits.

Materials and Methods

In Experiments 1–4, commercial-type corn-soy diets were hand fed to 6720 first-, second-, or third-cycle hens during Phase I (16 wk for Experiment 1 and 12 wk for Experiments 2–4). The experiments were conducted during cooler months in computerized, environmentally controlled buildings at two temperatures: cool, 60–74°F, (average 68°F) and warm, 70–84°F (average 78°F). Equal numbers of hens were replicated in groups of five 12" × 16" cages with four hens per cage on top and bottom of a two-tier cage system. Egg weight, production, feed consumption, and egg specific gravity were measured weekly. All eggs laid during a two-day period each week were used for egg specific gravity and egg weight determinations.

In Experiment 5, water consumption was determined for second-cycle Hy-Line W-36 hens fed a commercial-type diet and housed at two environmental temperatures: hot, 74–89°F (average 83°F) and warm, 70–84°F (average 78°F). Water consumption was determined for 16 individually caged hens on the top and bottom rows for two 24-hr periods.

In Experiment 6, the first industry trial, eggs were collected from 55-wk-old Hy-Line W-36 hens. The open-sided curtain house had a two-tier cage system with 12 rows (6 top and 6 bottom). The house contained 20,000 hens. All eggs were removed by 10:30 a.m. from four top and four bottom rows at selected locations. The next three flats of eggs (90 eggs) laid from four top rows and four bottom rows were collected and egg weight determined.

In Experiment 7, eggs were collected from 40-, 60-, and 93-wk-old W-36 hens housed in an in-line complex containing a three-tier cage system (top, middle, and bottom). The houses were environmentally controlled, computerized cool-cell houses containing 70,000 hens. At approximately 9:00 a.m., all eggs were removed from selected locations and the next three flats of eggs laid from four top, bottom, and middle rows were collected from each house and egg weight determined. Data were analyzed statistically using SAS [7, 8].

Results and Discussion

The results of Experiments 1, 2 and 3 indicated that egg weights from hens housed in the cool environment were heavier than those from hens housed in the warm environment by 0.8, 1.4, and 0.7 lbs/case for first-, second-, and third-cycle hens, respectively (Table 1). The hens on the bottom row also had significantly heavier egg weights than those on the top. The differences were 0.4, 0.8, and 0.9 lbs/case for first-, second-, and third-cycle hens, respectively.

Egg weight difference due to row position for first-cycle hens (0.4 lbs/case) was 50% as much as the difference due to a 10°F difference in temperature (0.8 lbs/case). The difference due to row position for third-cycle hens (0.9 lbs/case) was 40% greater than the difference due to a 10°F difference in temperature (0.7 lbs/case). There were no temperature × level interactions.

Feed consumption was also significantly greater for hens housed on the cool side vs. warm side by 1.4, 1.5, and 0.8 lbs./100 hens/day, for first-, second- and third-cycle hens, respectively. Hens on the bottom row ate significantly more (0.97 lb/100 hens/day average) than hens on the top row. Again, the average difference in feed consumption due to row position or level (0.97 lb/100 hens/day) was only slightly less than the difference due to temperature (cool vs. warm, 1.2 lb/100 hens/day). There were no temperature × level interactions.

Egg specific gravity was also significantly greater for hens housed in the cool environment than for those in the warm for each cycle by at least 0.001 units. For each cycle, hens housed on the bottom row had greater egg specific gravities than those housed on the top row. The difference in egg specific gravity (bottom vs. top row) is apparently attributable to differences in calcium intake (feed intake). The difference due to temperature and cage row level was about the same. There were no interactions.

Temperature or row level had no effect on production for first- and second-cycle hens, but third-cycle hens showed slightly improved production at the warm temperature and bottom row level. The reason for this is unknown.

TABLE 1. Egg weight, feed consumption, egg specific gravity, and egg production of first-, second-, and third-cycle (Phase I) as influenced by temperature and cage row level, respectively[A] (Experiments 1, 2, and 3)

	1ST CYCLE	2ND CYCLE	3RD CYCLE	1ST CYCLE	2ND CYCLE	3RD CYCLE
	EGG WEIGHT (Lbs/Case)			FEED CONSUMPTION (Lbs/100 Hens/Day)		
Temperature	***	***	***	***	***	***
Cool (68°F)	40.6	50.1	50.8	20.3	20.7	20.6
Warm (78°F)	39.8	48.7	50.1	18.9	19.2	19.8
Difference	0.8	1.4	0.7	1.4	1.5	0.8
Level	***	***	***	***	***	***
Bottom	40.4	49.8	50.9	20.1	20.3	20.8
Top	40.0	49.0	50.0	19.1	19.6	19.6
Difference	0.4	0.8	0.9	1.0	0.7	1.2
	EGG SPECIFIC GRAVITY			EGG PRODUCTION (%/Hen/Day)		
Temperature	***	***	***			*
Cool (68°F)	1.088	1.084	1.080	91	71	65
Warm (78°F)	1.086	1.083	1.079	91	71	67
Difference	0.002	0.001	0.001	0	0	-2
Level	***	***	***			*
Bottom	1.087	1.084	1.080	91	70	67
Top	1.086	1.083	1.079	91	72	65
Difference	0.001	0.001	0.001	0	-2	2

[A]All 1st cycle values represent 16-wk averages. All 2nd and 3rd cycle values represent 12-wk averages.

*Significantly different (P≤.05); ***Significantly different (P≤.001).

In most cases, the effect of cage row level on egg size, feed consumption, and egg specific gravity was observed within 2 or 3 wk.

Experiment 4 (Table 2) yielded results similar to those of Experiments 1–3. Hens housed in the cool environment had significantly greater egg weight (0.6 lb/case), feed consumption (1.4 lb/100 hen/day) and egg specific gravity (0.002 units). The hens on the bottom row also had significantly greater egg weights (0.4 lb/case), feed consumption (0.4 lb/100 hens/day) and egg specific gravity (0.002 units). Environmental temperature or cage level had no influence on egg production. There were no interactions.

The results of Experiment 5 indicated that environmental temperature and cage row level significantly influenced water consumption (Table 3). Hens housed in the hot environment consumed 36 mL more water/hen/day than hens housed in the warm environment. Hens on the top row consumed 21 mL more water/hen/day than hens housed on the bottom row.

These results indicate that hens housed on the bottom row of our university two-tier cage house had significantly greater egg size, feed consumption, and egg specific gravity than those on the top row. To confirm that cage level had a similar influence in industry houses, we conducted two industry trials.

The results of these trials (Experiment 6) indicated that eggs from hens on the bottom row weighed 1.28 lbs/case more than those from top row hens (46.96 bottom vs. 45.68 top, Table 4). The results of Experiment 7 indicated, as expected, a significant age effect on egg weight. Case weights ranged from 46.9 lbs for 40-wk-old hens to 50.0 lbs for 95-wk-old hens (Table 5). Cage level also had a significant influence on egg weight, and there were significant age × cage level interactions. As hen age increased, the difference in case weight due to cage level increased. The case weight differences between top and bottom were 0.97 lb for 40-wk-old hens, 2.12 lb for 60-wk-old hens, and 2.78 lb for 95-wk-old hens. These results indicate that the older the hen (the longer hens have been housed), the

TABLE 2. Egg weight, feed consumption, egg specific gravity (ESG), and egg production of first-cycle hens as influenced by temperature and cage row level (Experiment 4)

	EGG WEIGHT	FEED CONSUMPTION	ESG	PRODUCTION
	Lbs/Case	Lbs/100 Hens/Day		%/Hen/Day
Temperature	***	***	***	
Cool (68°F)	39.6	18.7	1.085	76
Warm (78°F)	39.0	17.3	1.083	76
Difference	0.6	1.4	0.002	0
Level	*	***	**	
Bottom	39.5	18.1	1.085	76
Top	39.1	17.8	1.083	76
Difference	0.4	0.4	0.002	0

[A]All value represent 12-wk averages (21–33 wk of hen age)

*Significantly different (P≤.05); **Significantly different (P≤.01); **Significantly different (P≤.001).

greater the effect of cage row level on egg weight. Feed consumption could not be determined in industry trials.

In addition to these trials, two producers were asked to collect weight data on eggs from top-row and bottom-row hens. Both producers had in-line complexes: one had a three-tier cage system; the other had a six-tier cage system. Both producers confirmed our results: eggs from the bottom row were heavier than those from the top row. One producer also reported that per hen body weight was approximately 0.25 lbs greater on the bottom row than the top.

What causes the difference in egg weight and feed consumption associated with row level? A number of factors can influence egg size and feed consumption (energy level, protein level, methionine level, linoleic acid level, strain, body weight, temperature, age of maturity, etc. [1, 2, 3, 4, 5, 6]), but most of these factors can be eliminated. In these trials, all hens were of the same strain, fed the same diet, and housed in the same environment. Only cage row level varied.

It has been reported that when ventilation rates are low, temperature may range more than ±10°F at different locations in a house depending on the building design and environmental control system [9]. With the six-tier system [9], differences in temperature could be greater than the values reported in this

TABLE 3. Water consumption of second-cycle hens as influenced by temperature and cage row level (Experiment 5)

	WATER CONSUMPTION
	mL/Hen/Day
Temperature	***
Hot (83°F)	197
Warm (78°F)	160
Difference	36
Level	**
Bottom	168
Top	189
Difference	21

**Significantly different (P≤.01); ***Significantly different (P≤.001).

TABLE 4. Egg weight of 55-wk-old W-36 hens housed in two-tier cage system as influenced by cage row level in open-sided house (Experiment 6)

	EGG WEIGHT
	Lbs/Case
Level	***
Bottom	46.96
Top	45.68
Difference	1.28

***Significantly different (P≤.001).

TABLE 5. Egg weight of W-36 hens housed in a three-tier cage system as influenced by hen age and cage row level in an in-line complex (Experiment 7)

TREATMENT	EGG WEIGHT
Age	***
40 wk	46.9[a]
60 wk	48.1[b]
95 wk	50.0[c]
Cage Level	***
Bottom	49.5[a]
Middle	47.9[b]
Top	47.6[b]
Age × Cage Level	***
40 wk	
Bottom	47.58[a]
Middle	46.54[b]
Top	46.61[b]
Difference	0.97 lb (B vs. T)[A]
60 wk	
Bottom	49.32[a]
Middle	47.75[b]
Top	47.20[c]
Difference	2.12 lb (B vs. T)
95 wk	
Bottom	51.67[a]
Middle	49.32[b]
Top	48.89[b]
Difference	2.78 lb (B vs. T)

[A]B = Bottom, T = Top

[a–c]Values with different letters are significantly different ($P \leq .05$).

***Significantly different ($P \leq .001$).

paper. However, with the two or three-tier systems tested in the Southeast, the difference in temperature between the top and bottom rows was less than 1°F (average of three locations for every row).

Environmental temperature influences feed consumption, but it cannot account for all of the cage row level effects. Temperatures of top and bottom rows at any given location varied by less than 1°F. If differences were caused by temperature, 1/10 of the change in egg weight and feed consumption due to cage row levels (1°F) should be comparable to that which occurs with a 10°F difference in environmental temperature. However, almost as much difference was observed due to cage row level, with a less than 1°F difference in temperature, as was observed with a 10°F difference. Therefore, difference in temperature can account for only a small part of the difference observed between cage row levels.

Another possibility considered was that the flush manure removal system used in the University trials (Experiments 1, 2, and 3) and in the in-line complexes (Experiment 7) could make hens feel cooler on the bottom row. However, that hypothesis was discarded because similar differences occurred due to cage row position in the non-flush industry house (Experiment 6). Differences in air flow could also make birds feel cooler even at the same temperature, but that explanation was discarded because the same effect was observed in open-sided houses with no fans (Experiment 6) as in an in-line complex with excellent air flow (Experiment 7). No differences in air flow could be detected between top and bottom rows.

If for some reason hens on the bottom row had fewer feathers than hens on the top row, then hens on the bottom row would be cooler even at the same temperature. However, based on visual observation, there appeared to be no difference in feather coat due to row level. The most likely explanation at present is air quality. However, because cage row effects were observed in well-ventilated houses in cool weather and hot weather, that explanation is also questionable.

Other researchers have also reported performance differences due to cage level. Grover *et al.* [10] and Hurnick *et al.* [11] reported significantly higher feed consumption by hens in the upper tier of a two-tier system. Jackson and Waldroup [12] reported significantly greater feed consumption and egg weight for hens housed on the bottom tier. They suggested that the difference may be related to fear associated with differences in light intensity or varying exposure to visual stimuli.

The above explanations seem unlikely, but we have been unable to form a hypothesis to account for differences in feed consumption and egg production associated with cage row level. Egg producers, however, can still use our findings to increase profitability. For example, in Experiment 6, hens housed on the bottom row laid eggs weighing 1.28 lb/case more than those on the top. With a 20¢ spread, eggs from hens on the bottom row would sell for 2¢ more/doz. Hens on the bottom row would also eat approximately 1 lb more feed/100 hens/day. Thus, feed cost for the bottom row would be approximately 1¢ more/doz. In this scenario, hens on the bottom row could generate approximately 1¢ more/doz.

The potential for profit changes, however, if there is no difference in price between medium and large eggs. The hens on the bottom row could generate 1¢/doz. less than hens on the top row due to higher feed consumption. We believe that producers could prevent this loss by feeding the bottom row based on feed intake and increase income 0.5¢/doz. for hens on that row.

Another scenario: assume that eggs are graded either extra large or jumbo (Phase II & III hens). If hens on the bottom row have a 2 lb heavier case weight and are eating 2 lb more feed/100 hens/day, hens on the top row could be making 2¢ more/doz.

How can a producer take advantage of this knowledge? Most hens, especially in Phase II and III, receive feed based on average feed consumption of the flock. Thus, producers should feed hens based on average intake of hens on each row. Each 5% increase in nutrient intake above what is required (1 lb/100 hen/day) represents a waste of approximately 0.5¢/doz. in feed. For example, if bottom row hens are eating 22 lb/100 hens/day and hens are fed a diet formulated for 21 lb/100 hens/day feed, feed cost is increased approximately 0.5¢/doz. When there are no production benefits and no spreads between egg sizes, a more dense feed is not economically justified. Feeding hens based on feed intake determined by cage row position is a potentially profitable method of "fine tuning" the established practice of feeding diets formulated based on intake.

Conclusions and Applications

1. Hens on the bottom row consume more feed and produce larger eggs with better shell quality than hens on the top row.
2. Although environmental temperature is slightly lower on the bottom row than the top row in a two-tier or three-tier system, the difference in temperature is not great enough to explain the large influence of cage row level on egg weight and feed consumption.
3. Producers should note the possibility of increasing profits based on adjusting feed consumption according to hens' row position.

References and Notes

1. **Summers, J.D. and S. Leeson,** 1983. Factors influencing early egg size. Poultry Sci. 62:1155–1159.

2. **Koelkebeck, K.W., C.M. Parson, and R.W. Leeper,** 1993. Effect of early feed withdrawal on subsequent laying hen performance. Poultry Sci. 72:2229–2235.

3. **Shalev, B.A. and H. Pasternak,** 1993. Increment of egg weight with hen egg size in various commercial avian species. Br. Poultry Sci: 34:915–924.

4. **Hoyle, C.M. and J.D. Garlich,** 1987. Effect of a high fat diet fed prior to or at sexual maturity on egg weight. Poultry Sci. 66:1202–1207.

5. **Sell, J.L., C.R. Angel, and F. Eseribow,** 1987. Influence of supplemental fat on weights of eggs and yolks during early egg production. Poultry Sci. 66:1807–1812.

6. **Douglas, C.R., T.B. Charlie, A.S. Arafa, and R.A. Harms,** 1986. Egg Size as influenced by morning and evening lights. Poultry Sci. 65:864–867.

7. Experiments were analyzed as a 2 × 2 or 3 × 3 factorial with main effects and interactions determined using the general linear model (GLM) procedures of SAS [8]. Significant differences between treatment means (Experiment 7) were determined by student-Newman-Keuls.

8. **SAS Institute,** 1985. SAS User's Guide: Statistical. SAS Institute, Inc., Cary, NC.

9. **D'Afonso, T.H.,** 1994. Housing temperature and your bottom line. Egg Industry 99:14–20.

10. **Grover, R.M., D.L. Anderson, R.A. Dorman, Jr., and L.H. Ruggles,** 1972. The effects of bird density, dietary energy, light intensity, and cage level on the reproduction performance of heavy type chickens in wire cages. Poultry Sci. 57:565–575.

11. **Harnick, J.F., D.J. Piggins, B.S. Reinhart, and J.D. Summers,** 1974. The effect of visual position complexity of feeders on food consumption of laying hens. Br. Poultry Sci. 15:97–105.

12. **Jackson, M.E. and P.W. Waldroup,** 1987. Effect of cage level (tier) on the performance of White Leghorn chickens. Poultry Sci. 66:907–909.