SOME EFFECTS OF CAGE AND FLOOR REARING ON COMMERCIAL WHITE LEGHORN PULLETS DURING GROWTH AND THE FIRST YEAR OF EGG PRODUCTION

by

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INTRODUCTION

The environment of hens kept for table-egg production has changed remarkably since the early part of this century (Craig, 1982). The use of multiple-hen cages has become widely spread in today's poultry industry. About 75% of all the commercial layers are now kept in cages in the world, and in the United States 93% of layers are in cages and over 50% of all egg strain pullets are reared in cages (North, 1984). Cage operations produce greater profit when hens are kept for table-egg production in the developed countries (Wildey, 1982; Elson, 1985). Among advantages cited for cage husbandry are: that keeping pullets and hens in cages requires less labor; birds are free from coccidiosis and diseases spread through the litter; and caged hens produce cleaner eggs (Perry et al 1971a,b; Hurnik et al. 1973; Dorminey, 1974; Appleby, 1984). There is little quantitative data available comparing the effects of cage and floor rearing of egg-strain pullets on their subsequent performance, feather loss, and nervous behavior when kept in multiple-hen cages during the laying phase.

It appears that chickens and other animals prefer familiar over novel environments (Dawkins, 1975, 1976; Beilharz, 1982) and Clark and Galef (1980, 1981) reported that gerbils reared in "open" cages rather than in a more natural environment, where they could hide, had faster growth, earlier sexual maturity, and smaller adrenal gland sizes. Therefore, it may be that laying hens which are to be kept in high-density cages may benefit from being reared in such an environment.

Several studies have been carried out to examine the effect of tiers of cages on performance of laying hens (Jaeger, 1967, Grover, 1972, Hurnik et al 1974, Sefton, 1976, Jackson and Waldrop, 1987), but no general conclusions appear to be warranted as the results have been inconsistent. It was speculated that differences in fearfulness of hens housed in different tiers may affect performance (Sefton, 1976).

The primary objectives of this study were to test whether cage and floor-pen rearing of pullets would: (1) cause differences in body weight and mortality during the rearing period, (2) cause differences in adaptation to multiple-hen cages during the laying period as indicated by productivity traits, nervousness and feather loss, and (3) have consistant effects on the traits measured when used with different commercial strains of White Leghorns.

LITERATURE REVIEW

Effects of rearing environments during the growing period.

Shupe and Quisenberry (1961) compared the performance of pullets experiencing floor pen, range, colony cage and individual cage rearing from 14 until 22 weeks of age. Pullets reared in colony cages were significantly heavier and had higher mortality than did those in floor pens at the end of the rearing period.

In four trials, Reece and Dealon (1971) compared broiler pullets reared at a density of 465 cm^2/bird in both cages and floor pens. Two trials were in summer and two in winter. Pullets reared in cages were heavier than those reared in pens. No difference in mortality was detected for cage- and floor-reared pullets. Leeson and Summers (1984) evaluated the effects of cage versus floor rearing on growing performance and subsequent caged broiler-breeder-hen performance. Pullets were reared with floor space of 292 cm^2/bird before 6 weeks and 585.6 cm^2/bird from 6 to 20 weeks in cages, and 2160 cm^2/bird in floor pens. Within each environment, two feeding systems, skip-a-day and every-day, were used. Cage rearing resulted in heavier and fatter pullets at maturity. During the rearing period, pullets fed every day were generally heavier than those fed on alternate days. An environment by feeding system interaction for body weight was found. With every-day feeding, rearing environments had no effect on body weight while with skip-a-day feeding, cage-reared birds were consistantly heavier at all ages. Floor-pen reared birds were smaller than cage-reared birds.

Anderson et al (1979) compared the effects of cage and floor rearing on growing turkey performance over the period from 8 or 9 through 18 weeks of age, with 1400 cm^2 floor space per bird in cages. The tests indicated that hens can be reared in cages with about the same rate of gain and feed efficiency as floor-reared birds.

Dawkins (1983) studied the effects of cage and deep-litter, floor-pen rearing of pullets on cage preferences at 17 and 29 weeks of age. Preference was assessed by comparing the time it took for pullets to move from a starting box into the test cage. The following four cages was assessed: small wire cage (0.38 X 0.43 m), large wire cage (0.76 X 0.86 m), small litter cage with the same size as the small wire cage, and large litter cage with the same size as the large wire cage. There were no observed effects of rearing condition. However, the results showed that all hens preferred the larger cages and litter floors over the small cages and wire floors.

Effects of rearing environments on subsequent performance of hens

Shupe and Quisenberry (1961), as indicated previously, raised pullets from 14 to 22 weeks in floor pens, on range, and in colony and individual cages. When those birds were kept subsequently in cages, performance traits of the birds from the different rearing treatments did not differ.

Meunier-Salaun et al., (1984) investigated the influence of group size, familiarity, and stocking density during rearing on adult productivity and the physiological condition of laying hens. From one-day to 19 weeks of age, pullets were reared in floor pens in group size of 10 with a stocking density of 1.7 birds/m^2 or in groups of 60 and 500, both with 10 birds/m^2. From 19 to 65 weeks of age, birds were housed in four-bird cages at a stocking density of 450 cm^2/bird. None of the rearing treatments had a significant effect on mortality, egg number, egg weight, proportion of cracked eggs or shell strength, feathering and foot health (claw and fold injuries). It was concluded that factors which can be easily manipulated in floor pens during the rearing period have no permanent effects on adult behavior, productivity, or the welfare of laying hens.

Leeson and Summers (1984) also failed to detect effects of cage and floor rearing on subsequent caged broiler-breeder-hen performance in terms of egg production or egg weight during the 20 to 44 week period.

Folsch (1981) studied the behaviors of hens as influenced by having pullets reared in cages and floor pens. At 18 weeks of age, pullets were assigned to floor pens containing 19 hens (2 hens per m^2), and 3-tier cages occupied by 1 to 4 hens per cage (480 cm^2 per hen). His results indicated that hens reared in deep litter pens had significantly more agonistic behavior (2.4 vs. 1.4%), more standing (23.8 vs. 17.5%), and were observed to feed and drink less often (42.3 vs. 47.5%), as compared with those reared in cages.

Craig et al (unpublished) found that cage- and floor-reared pullets did not differ in body weight at housing , age at 50% hen day rate of lay, egg weight, and livability.

<u>Genetic and housing effects on fearfulness.</u>

Flighty and placid strains of chickens have been identified (Murphy and Wood-Gush, 1978; Murphy and Duncan, 1977). Duncan and Filshie (1979) observed these strains when exposed to various frightening stimuli. Flighty-strain hens showed far more avoidance and panic to visual stimuli than placid strains. However, the heart rate of the so-called "placid" birds rose almost as much and took longer to recover than that of the so-called "flighty" birds.

These results suggest that behavioral studies of the "fearful" state should be combined with physiological studies.

There is evidence of genetic influences on duration of tonic immobility (e.g., Gallup, 1974b; Craig et al., 1984). Jones (1977b) and Jones and Faure (1980 a, b), using latency to recover from induced tonic immobility as the criterion of fearfulness, found that males were more fearful than females, cage-housed birds were more fearful than pen-housed birds, and light-weight hybrids were more fearful than medium-weight hybrids. Kujiyat et al (1983) found that hens in multiple-hen cages were more fearful than those in floor pens by the same criterion. In a later study, Kujiyat et al (1984) indicated that the longer duration of induced tonic immobility for hens tested late in the laying year appeared associated with reduced egg production.

Strain differences in the tendency of sexually mature hens to develop hysteria when kept in large-group-size cages were demonstrated by Elmslie et al., (1966) and Hansen (1976). They found that strains that are more susceptible to hysteria not only lose more feathers but also decrease in egg production because of hysteria.

Ouart and Adams (1982) observed that birds of one commercial White Leghorn strain produced more eggs with fewer body checks and cracks, tended to be less nervous, and had better feather scores than birds of the other strain.

Craig et al (1983) found genetic strains differing in nervousness score and feather loss. The strain having a higher level of escape and avoidance behavior lost more feather. Adams et al (1978) found that caged, egg-type chickens with heavy feather damage were fearful or nervous.

Okpokho et al (1987) found that pullets reared in cages and floor pens did not differ in escape and avoidance behavior or duration of induced tonic immobility at 23 and 40 weeks of age.

In two experiments, Craig et al (unpublished) reared White Leghorn pullets in floor pens and high-density cages. After pullets were placed in the laying house, their behavioral traits, feed consumption, and changes in body weight were studied. Both experiments indicated that the behavior of pullets from the two rearing environments differed initially after being placed in high-density, multiple-bird cages. However, those differences disappeared several days posthousing and there were no significant differences in body weight gain over the first two or three weeks posthousing.

Effects of cage tier.

Inconsistant results have been indicated for the performance of laying hens in different cage tiers and the explanations for those differences vary. In the study of Jaeger (1967), the birds in an upper cage row performed better on a hen-day basis, had heaver weight gain, and consumed more feed than those birds in the lower cage row. Grover et al (1972) found that birds housed in the top tier of cages began laying earlier, peaked at the same time and decreased at a more rapid rate than those in a bottom tier. Higher feed consumption, body weight gains, and hen-day production were found in the upper cages.

In contrast to the studies where upper-tier hens performed better, Sefton (1976) found that hens housed in the top tier of cages laid at a lower rate and exhibited a higher level of fearfulness as indicated by the method of Hughes and Duncan (1972). Sefton's study suggested that performance differences associated with tiers may be due to fear-related behavior. Jackson and

Waldrop (1987) found that egg production, egg weight, and mortality deteriorated in a linear progression from the bottom to the top in three and four-tier cages. However, birds in the top two tiers tended to be more efficient in feed efficiency than those in the bottom tier. They suggested that lowered productivity in the upper tier may result from less feed intake, and that differences in light intensity could partly explain the decline in productivity in higher-tier cages, exposed to higher light intensity.

Hurnik et al (1974) housed pullets individually in double-deck cages at 24 weeks of age and found that heavier eggs were laid by hens in the upper tier ($P<.05$). The total number of eggs produced and feed consumption did not differ between upper and lower tiers.

Jones (1985) studed the effect of tiers or cage levels on fear-related behaviors of laying hens. The pullets were reared in pens from hatching until their transfer to individual cages (45 X 30 X 45 cm) in the top and middle tiers of three-tier battery cages at 16 weeks of age. Light intensities at the front of cages of the top and middle tier were 80 and 41 lux, respectively. Induced tonic immobility and exposure to fearful-inducing stimuli in the home cages and in a pen were used to test individual birds at 72, 73 and 74 weeks of age, respectively. Hens caged in the top tier showed longer duration of tonic immobility, greater avoidance of a novel rod placed in their food trough (22.1 vs. 17.9), and a lower level of approach (49.4 vs. 63.1) when placed in a pen containing a novel object, than did their middle-tier counterparts. In a second experiment, in which birds were housed in groups, results consistant with those obtained for single-housed hens were obtained.

Evaluation of environmental quality and competitive effects.

Although differences among means are usually considered as adequate criteria for evaluating enviornmental quality, McBride (1960, 1962, 1968) has argued and provided some supporting data, that low environmental quality and especially competitive effects, will not only cause a decrease in mean performance, but will be associated also with increased variance within such populations of animals. Studies by Craig and Toth (1969), Biswas and Craig (1970), and Choudary and Craig (1972) provide indirect evidence in support of this method of evaluation.

MATERIALS AND METHODS

Rearing Phase

Chicks of three commercial White Leghorn-type strains, Babcock B300V, Hyline W-36 and H & N Nick Chick, were obtained from commercial hatcheries. They were wing-banded, vaccinated, and dubbed after being received on April 3, 1986 at the Avery Research Center, Kansas State University. The strain names and strain codes are shown in Table 1. Hereafter strains will be identified by code letter only.

Table 1. Strain names and codes.

Strain Code	Strain Name
B	Babcock B300V
H	Hyline W-36
N	H & N Nick Chick

The chicks were reared in a curtain-sided, naturally-ventilated, brooding and rearing house containing 305 X 380 cm floor pens and 76.2 cm wide X 57.0 cm deep cages, from 1-day-old to 19 weeks of age. The floor pens were along east and west walls and the cages were in 4 rows in a back-to-back, 2-level stairstep arrangement in the center of the room. The axis of the cage rows was north and south. Six floor pens (3 on each side) and 48 cages (12 on the lower and 12 on the upper deck on each side) were used. Heat was supplied as needed by natural-gas fired brooders.

For the brooding and rearing period, half of each genetic stock was divided into 2 floor pens with 112 birds per pen. Each pen had one corner blocked off so as to allow 930 cm^2 floor space per chick. From 1-day old to 2 weeks of age, 2 sets of 4 adjacent upper-deck cages had 30 chicks per cage from the remaining half of each genetic stock. At 2 weeks of age, chicks from the 4 adjacent cages within each set were subdivided so that half remained and other half were moved into 4 adjacent lower-tier cages. Extra chicks were removed so that 14 chicks were then present in each cage. Therefore, caged pullets had about 145 and 310 cm^2 floor space per bird from 1-day old to 2 weeks and from 2 to 19 weeks of age, respectively.

Initially, a sheet of newspaper was used over the wire-mesh bottom of the cage floor. The paper gradually deteriorated and remnants were removed at 2 weeks. An egg-flat, covered with feed and a 76.2 cm trough attached to the front of the cage provided feed initially. A jar waterer and two small-cup waterers were also present initially in each cage. The egg-flat feeder and jar waterer were removed after 7 days. Feeder trough space of cage-reared birds was about 5.4 cm from 2 to 19 weeks of age.

In the floor pens, three egg-flat feeders, three 90-cm trough feeders, three water jars and three small-cup waterers were used per pen during the first seven days. Feeder trough space was approximately 5 cm until five weeks of age. Three tube feeders provided about 4 cm feeder space per chick from 6 to 19 weeks of age.

The chicks received 24 hours of light daily for the first two weeks. From two to 11 weeks of age, light was decreased 15 minutes per week from 17 hours at the beginning to 15 hours at the end. Thereafter, until housing, light was provided entirely by natural daylight, amounting to 15 hours of light at 12 weeks and decreasing because of seasonal change to 14 hours at 19 weeks of age.

Chicks had their beaks trimmed at seven days of age and again at 19 weeks, when pullets were placed in the laying house. Individual body weights of chicks were obtained on the same sample of 22% from each rearing unit at mean ages of 0, 2, 5, 8, 11, 14, 17 and 19 weeks. Mortality was recorded daily. A summary of stock-environment combinations for the rearing period is presented in Table 2.

Statistical analysis

Analysis of variance was used to test for the effects of genetic strains and rearing environments on body weights at each age, using the General Linear Model (GLM) procedure in the Statistical Analysis System (SAS, 1982). Genetic strains and rearing environments were assumed to be fixed effects. Mean differences among strains were tested for significance by Duncan's multiple-range test (Duncan, 1955), when genetic strain differences were indicated as significant in the analysis of variance. A preliminary analysis was carried out on cage-reared pullets to determine whether those in upper and lower tiers differed in body weight. The statistical model in the preliminary analysis was:

$$Y_{ijk} = u + GS_i + T_j + (GS \times T)_{ij} + e_{ijk}$$

where GS = genetic stocks and T = tier of cages.

The statistical model used to test for differences involving both cage- and floor-pen reared birds was:

$$Y_{ijk} = u + GS_i + RE_j + (GS \times RE)_{ij} + e_{ijk}$$

where GS = genetic stocks and RE = rearing environments.

Statistical tests for homogeneity of variance were used to test variances of body weights (Ott, 1984). Significant differences were determined using F_{max} ratios. A chi-square analysis was conducted to test for rearing environment effects on mortality.

Table 2. Experimental design for comparing genetic strains and housing environments of chicks during rearing.

	Cages			Floor pens			
Genetic strain	No. units*	No. chicks /unit**	No. chicks /treatemnt	No. pens	No. chicks /pen	No. chicks /treatment	Total
B	2	112	224	2	112	224	448
H	2	112	224	2	112	224	448
N	2	112	224	2	112	224	448
Total	6	336	672	6	336	672	1344

* Four adjacent upper-level cages were considered as a unit from zero to two weeks and eight adjacent cages (four upper and four lower) were considered as a unit from two to 19 weeks.

** Thirty chicks were placed in each upper level cage at day-old; those were subdivided into two groups of 14 each (excess chicks were discarded) at two weeks.

Laying Phase

The pullets were moved to a 14 X 12 m fan-ventilated, windowless, cage-layer house at 19 weeks of age. The house contained 12 rows of cages with 27 cages each in three back-to-back stairstep arrangements. Four birds were placed in each 30.5 cm wide X 45.7 cm deep cage with 46 cm height in front, 36 cm in back, and a flooring slope of 1 : 4.6. Pullets of the 3 genetic stocks from each of the 2 rearing environments were placed in each row. There were 12 stock-rearing environment combinations represented in pairs of adjacent cages. Those 2 adjacent cages containing the same combination were considered as an experiemental unit and units were randomly assigned to locations within each row of cages. Each genetic strain-rearing environment combination was represented twice in each row and those replications came from the 2 rearing units representing that combination. Therefore, the experimental design was a randomized complete block, with replicated units. The experimental design is shown in Table 3.

Laying-house cages allowed 348 cm^2 floor space and 7.6 cm feeder space per pullet. Water was supplied by 2.7 cm diameter water cups placed between adjacent cages. The birds were using the same type of watering system as used in the rearing environment. Lights were initially turned on daily from 06:00 to 22:00. Because of the failure of an automatic timer, when pullets were 30 weeks of age, the lights remained on for 24 hours daily for several weeks. It was then decided to continue 24 hour lighting until the end of the study. Because the water system pressure control was determined by pressure at the level of upper deck cages, water pressure was higher than recommanded for lower deck cages. This became apparent and the problem was corrected when pullets were weighed at one week posthousing (Table A-5). Further statistical evaluation (see later) indicated no carry-over effect on subsequent body weight and egg production traits.

The number of eggs laid was recorded on three consecutive days weekly, from 20 until 68 weeks of age, then converted to a seven-day basis for analysis. The total 48-week production period was divided into 12 twenty-eight-day periods. Hen-housed egg production was based on data collected from 20 to 68 weeks. Egg weight was measured during the fourth week of each period by bulk weighing of one or 2 day's eggs on the third day of collection from each experimental unit at 28-day intervals started at 23 weeks. Egg mass on a hen-housed basis, was calculated for each four-week period by multiplying egg weight by number of eggs, then dividing by the number of days for total hens housed. Eggs collected for weighing were also candled and evaluated according to the USDA standard for individual eggs as being large, medium, small, undergrades (rough shells and "body checks") and loss (cracked shells and blood spots) (USDA, 1975).

Hen-day rate of lay was determined from weekly egg records and number of birds surviving. Age of sexual maturity was estimated from the age when 50% hen-day rate was reached. Body weights were obtained at 19, 20, 50 and 67 weeks of age. Feather scores and nervouseness scores were obtained between 60 and 63 weeks of age and between 75 and 78 weeks of age.

Beginning at 60 weeks of age, all birds in lower-tier cages were scored for nervousness by 3 observers, working independently, using a modified scoring procedure based on Hansen's descriptions (Hansen, 1976). Birds were scored once each at 60, 61, 62 and 63 weeks, and scores were averaged within each experimental unit. The same procedure was repeated for hens in both upper and lower tiers starting at 75 weeks of age. The observer moved to face the division between 4-bird cages, raised both arms from the side to above the head, then lowered them slowly (within 5 second), and placed hands across the feed trough. Scores were based on responses over a 10-second period. The following scores were used: 0 = calm, no nervous or evasive action; 4 = extreme escape and avoidance behavior and continuing for the full 10 seconds. Birds showing intermediate level of nervous behaviors were scored by integers between 0 and 4.

Feather scores were obtained by the method described by Adams et al. (1978) after nervousness score were obtained on all cages. Pullets without feather damage were scored 9, and those with bare backs and wings were scored 1. The intermediate levels of feather loss and damage were scored by integers between 1 and 9.

Statistical analysis

Means from experimental units were used in analyzing all traits studied, using the ANOVA procedure in the statistical analysis system (SAS, 1982). It was assumed that genetic strain, rearing environment, and age were fixed effects. When multiple comparisons were involved, differences among treatment means were tested for significance by Duncan's multiple range test (Duncan, 1955).

The statistical model used in preliminary analysis for tier effects on body weight and body weight gain, and for tier effects on feather and nervousness scores at 75 weeks of age was:

$$Y_{ijkh} = u + T_i + e_{ih} + GS_j + RE_k + (GS \times RE)_{jk} + v_{ijkh}$$

where T = Tier of cages;

e_{ih} = error term (tier x block) used to test tier effects;

GS = genetic strains;

RE = rearing environments.

v_{ijkh} = error term used to test GS, RE and 2- and 3-way interactions.

The statistical model used to analyze age of sexual maturity, livability (which was transformed to arcsin $\sqrt{\text{percentage}}$), egg size and egg quality, feather and nervousness scores at 60 weeks of age was:

$$Y_{ijk} = u + GS_i + RE_j + (GS \times RE)_{ij} + e_{ijk}$$

where GS = genetic strains;

RE = rearing environments.

Repeated measures analyses of variance were applied for traits which were measured repeatedly. The statistical model was:

$$Y_{ijkh} = u + GS_i + RE_j + (GS \times RE)_{ij} + e_{ijk} + P_h + (P \times GS)_{ih} + (P \times RE)_{jh} + v_{ijkh}$$

where T = Tier of cages;

GS = genetic strains;

RE = rearing environments.

e_{ijk} = error term used to test GS and RE effects;

P_h = Period.

v_{ijkh} = error term used to test period and interactions involving period.

Table 3. Number of experimental units and hens per row of cages for comparing genetic strains and carry-over effects of rearing environments on traits during the laying phase.*

Genetic Strain	Cage reared			Floor reared			Total hens
	No. units**	No. hens /unit	No. hens /treatment	No. units**	No. hens /unit	No. hens /treatment	
B	2	8	16	2	8	16	32
H	2	8	16	2	8	16	32
N	2	8	16	2	8	16	32
Total hens	6	24	48	6	24	48	96

* Twelve rows of cages were used.

** Two adjacent 4-bird cages were considered as an experimental unit.

RESULTS

Rearing Phase

1. Effects of strain and tier in the cage rearing environment

Because of concern that tiers of cages might differ in their effects on pullets in the cage-rearing environment, preliminary analyses were carried out on data obtained from cages only. Body weight and body weight gain variances of individual pullets in upper and lower tiers of cages were tested for homogeneity with the results shown in Table A-1. Although differences were indicated as significant between body weight variances of pullets in upper and lower tiers for Strain B and Strain N at 2 and 0 weeks, respectively, those were due to sampling.

Chicks were not assigned to lower and upper tiers until 2 weeks old. The differences in body weight variances for tiers within Strain B from 5 to 11 weeks may be, at least in part, a carry-over effect of the initial sampling at 2 weeks of age, because the F ratio decreased gradually from 2 to 19 weeks. The only other difference in variance of body weights was within Strain N at 8 weeks of age. These results are interpreted as indicating that variation of body weight did not differ between lower and upper tiers within the genetic strains. In comparing body weight gain of pullets in upper and lower tiers after 2 weeks of age, 4 were larger than expected for upper-tier and 3 were larger than expected for lower-tier cages in within-strain, paired comparisons. Here again, it appears doubtful that tiers differed in their effects.

The body weight and body weight gain records of cage-reared birds classified by genetic strains are given in Table 4 and the analysis of variance results in Table A-2. There were significant differences for body weight and body weight gain among genetic strains at most ages from five to 19 weeks. Strain N gained the most in body weight from five to 19 weeks , but the strains did not differ in final body weight at 19 weeks.

Chicks reared in the lower tier had heavier body weights than those in the upper tier at 5, 8 and 11 weeks, Table 5, but no differences were detected subsequently. Chicks reared in the upper tier had a higher percentage total weight gain than those reared in the lower tier from 5 to 19 weeks. A genetic stock X tier interaction in body weight was present at 8 weeks and 19 weeks, and genetic stock X tier interactions were found for body weight gains from 17 to 19, 5 to 19 weeks, and percentage gain from 5 to 19 weeks of age (Table A-2 and Figure 1.)

2. Effects of strains and rearing environments

Variances of body weights and of body weight gains are presented for cage and floor-reared pullets on a strain-by-strain basis in Table A-3. Of the 48 pairwise comparisons, 16 were significant. Eight indicated greater variance for cage-reared and 8 indicated greater variance for floor-reared pullets. It is obvious that comparisons at different ages within strains are not entirely independent of each other. Overall, there is no convincing evidence of greater variability in body weight or weight gain in either rearing environment.

Mean body weights and weight gains for chicks of the three strains are shown in Table 6 and the analysis is presented in Table A-4. Strain differences in body weight were significant from hatching through 17 weeks of age. Strain

Table 4. Effect of genetic strains on mean body weight and body weight gain for cage-reared pullets.

Age (wk)	Genetic strain B	Genetic strain H	Genetic strain N	±SEM[1]
	A. Body weight, g			
5	279^{b}	303^{a}	267^{c}	1.95
8	518^{b}	572^{a}	504^{b}	3.68
11	786^{b}	840^{a}	804^{b}	4.43
14	969^{c}	1020^{a}	1008^{b}	4.76
17	1133^{b}	1175^{a}	1185^{a}	5.49
19	1220^{c}	1224^{b}	1277^{a}	6.48
	B. Body weight gain, g			
5- 8	239^{b}	269^{a}	237^{b}	2.24
8-11	268^{b}	268^{b}	380^{a}	2.24
11-14	183^{b}	177^{b}	203^{a}	1.88
14-17	164	157	178	2.32
17-19	88^{a}	48^{b}	92^{a}	2.96
5-19	941^{b}	921^{b}	1010^{a}	6.48
% gain 5-19	340^{b}	304^{c}	382^{a}	3.78

[1] ±SEM = Standard error of individual pullet body weights and weight gains within each age.

[a, b, c] Within age, strain means followed by different superscripts are significantly different ($P<0.05$).

Table 5. Effect of tiers on mean body weight and body weight gain (±SEM)[1] for cage-reared pullets.

Age (wk)	Tier: Upper	Tier: Lower	Upper - Lower
	A. Body weight, g		
5	276±2.91	289±2.47	-13 **
8	521±5.83	541±4.32	-20 **
11	800±6.69	820±5.70	-20 *
14	992±6.72	1006±6.71	14
17	1161±7.41	1167±8.11	-6
19	1242±8.97	1239±9.41	3
	B. Body weight gain, g		
5- 8	245±3.67	252±2.57	-7
8-11	279±3.09	278±3.25	1
11-14	192±2.57	185±2.73	7
14-17	169±2.99	163±3.53	6
17-19	81±4.39	71±3.94	10 *
5-19	965±8.86	949±9.50	16 **
% gain 5-19	354±5.25	330±4.47	24 **

[1] ±SEM = Standard error of individual pullet body weights and weight gains.

* P<0.05, ** P<0.01, *** P<0.001.

H was significantly heavier than the other stocks in body weight from two through 11 weeks. Strain N grew fastest from 8 to 14 weeks. The strains did not differ significantly in final body weight, total weight gain, or percentage total weight gain.

Cage-reared pullets were heavier at 5 and 11 weeks, and gained more from 2 to 5 and 17 to 19 weeks, Table 7. However, floor-pen reared pullets gained more ($P<.001$) than those in cages from 11 to 14. A genetic strain by environment interaction in body weight gain was present in one of the seven comparisons only (17-19 weeks). On the basis of samples of chick weights, no differences were found between rearing environments in body weight at the end of the rearing period, total weight gain, or percentage total weight gain. Nevertheless, when all pullets were weighed as placed in cages in the laying house at 19 weeks, cage-reared pullets were found to be significantly heavier than floor-reared pullets with body weights 1238 and 1206 grams, respectively.

Chi-square analyses failed to detect any significant effects of genetic stocks or rearing environments on livability (X^2=0.211). Overall survival to 19 weeks of age was 96.9%.

Table 6. Effect of genetic strains on mean body weight and body weight gain during the rearing period.

Age (wk)	Genetic strain B	H	N	±SEM[1]
	A. Body weight, g			
0	37^{b}	36^{c}	39^{a}	0.15
2	93^{b}	99^{a}	79^{c}	0.53
5	271^{b}	293^{a}	258^{c}	1.40
8	514^{b}	560^{a}	507^{b}	2.49
11	774^{c}	823^{a}	800^{b}	3.07
14	973^{b}	1018^{a}	1015^{a}	3.28
17	1138^{b}	1170^{b}	1193^{a}	3.81
19	1211	1229	1244	4.37
	B. Body weight gain, g			
2- 5	178^{b}	194^{a}	179^{b}	1.10
5- 8	243	267	249	1.54
8-11	260^{b}	263^{b}	393^{a}	1.65
11-14	199^{b}	194^{b}	214^{a}	1.57
14-17	165	153	179	1.78
17-19	73	58	51	2.29
0-19	1175	1193	1205	4.35
% gain 0-19	3227	3379	3083	16.33

[1] ±SEM = Standard error of individual pullet body weights and weight gains within each age.

[a, b, c] Within age, strain means followed by different superscripts are significantly different ($P<0.05$).

Table 7. Effect of rearing environments on mean body weight and body weight gain (±SEM)[1] during the rearing period.

	Rearing environment		
Age (wk)	Cage	Floor	Cage - Floor
	A. Body weight, g		
0	37±0.20	37±0.21	0
2	90±0.79	91±0.72	-1
5	283±1.95	265±1.85	18 ***
8	531±3.68	523±3.34	8
11	810±4.43	788±4.16	22 ***
14	999±4.76	1005±4.53	-6
17	1164±5.49	1170±5.31	-6
19	1240±6.48	1216±5.78	24
	B. Body weight gain, g		
2- 5	193± 1.45	175± 1.43	17 **
5- 8	248± 2.24	257± 2.09	-9
8-11	279± 2.24	266± 2.34	13
11-14	188± 1.88	217± 2.15	-29 ***
14-17	166± 2.32	165± 2.71	1
17-19	76± 2.96	46± 3.22	30 *
0-19	1203± 6.44	1179± 5.76	24
% gain 0-19	3231±22.23	3229±23.97	2

[1] ±SEM = Standard error of individual pullet body weights and weight gains.

* $P<0.05$, ** $P<0.01$, *** $P<0.001$.

Laying phase

1. Preliminary analyses of tier effects.

Because of the initial problem in the watering system, which affected lower-tier pullets and persisted for the first week only, preliminary analyses were carried out to determine whether tier should be considered as a main effect during the laying phase. Tables 8 and A-5 show that tiers significantly affected pullets' body weight at 20 weeks and weight gain from 19 to 20 weeks. Pullets in lower tier cages were lighter in weight at 20 weeks than those in the upper tier and lost slightly less than 2% in body weight, whereas those in the upper tier gained slightly more than 1% during the first week in laying-house cages. Analyses of subsequent body weights and weight gains failed to show any further deleterious effects on lower-tier birds for weight changes (Table 8) or egg-production traits (Table 9). Also, tier did not affect livability significantly over the laying period; hens in the upper tier had 92.0% and those in the lower tier 90.3% livability.

Nervousness and feather scores were obtained for hens in both tiers beginning at 75 weeks only, long after the initial problem with the watering system had been solved. Hens housed in the upper tier were more nervous and had less feather loss (Table 10). Further analyses of nervousness and feather scores (Table A-9) at 75 weeks, in which tier was included as a main effect, failed to indicate any tier by genetic stock or tier by rearing environment interactions.

On the base of the results indicated above, it was decided that tier would not be considered as a main effect in further analyses.

Table 8. Effect of tiers on mean body weight and body weight gain (±SEM)[1] during the laying period.

Age (wk)	Tier: Upper	Tier: Lower	Upper - Lower
	A. Body weight, g		
20	1241± 8.4	1200± 8.4	41 **
50	1607±11.3	1592±11.3	15
67	1554± 8.7	1561± 8.7	- 7
	B. Body weight gain, g		
19-20	16± 8.4	-20± 8.4	36 ***
20-50	383±12.1	373±12.0	10
50-67	-67±11.6	-28±11.6	-39 *
19-67	331±11.0	345±11.0	26
% gain 19-67	28± 1.1	29± 1.1	- 1

[1] ±SEM = Standard error of individual pullet body weights and weight gains.

* $P<0.05$, ** $P<0.01$, *** $P<0.001$.

Table 9. Performance of hens in upper and lower tiers of cages (20 to 68 weeks of age). *

Parameter	Lower	Upper	Lower - Upper
Hen-day egg production, %	77.3	76.2	1.1
Hen-housed egg production, %	69.8	69.0	0.8
Egg weight, g	60.8	60.8	0.0
Egg mass, g	42.7	42.3	0.4

* None of the means differed significantly (P>.05).

Table 10. Effects of tiers on nervousness and feahter scores at 75 weeks of age.

	Score [2]	
Tier	Nervousness	Feathering
Upper	1.26	4.71
Lower	1.16	3.92
±SEM [1]	0.07	0.1
Upper - Lower	0.10	0.79 ***

[1] ±SEM = Standard error of cage means.

[2] Higher nervousness score indicates more fearful behavior;
Higher feather score indicates less feather loss.

*** P<.001.

2. Effects of genetic strains

Comparisons of body weights and weight gains among strains are shown in Table 11 and the analyses in Table A-5. Strain N pullets had the heaviest body weights and Strain B the lightest body weights at 50 and 67 weeks of age. Strain N gained the most and Strain B gained the least in weight ($P<.05$) from 20 to 50 weeks. However, the percentage total weight gain did not differ among the three strains.

Strain means for age at sexual maturity, livability, hen-day rate of lay, hen-housed rate of lay, egg weight and egg mass are shown in Table 12 and analyses are presented in Table A-6. Significant differences among strains were found in all these traits.

Egg size and quality means presented in Table 13 and analyses in Table A-7 indicate that Strain B produced more large eggs than strains H and N. The percentage of undergrade eggs was greater for Strain N than for Strains B and H.

Pullets of Strain N were the most nervous at both 60 and 75 weeks old, and had the most feather damage and loss among the three strains at 60 (Table A-8) but not at 75 weeks of age (Table 14 and A-8). Hens of strain H were intermediate in nervousness, and had the best feather coverage at 75 weeks.

Genetic strains differed in livability of hens during the laying period (Table 12).

Table 11. Effect of genetic strains on average body weight and weight gain during the laying period.

Age (wk)	Genetic strain B	Genetic strain H	Genetic strain N	±SEM[1]
	A. Body weight, g			
20	1227	1215	1221	10.31
50	1554[c]	1603[b]	1644[a]	13.82
67	1518[c]	1556[b]	1599[a]	10.69
	B. Body weight gain, g			
19-20	20[a]	-4[ab]	-22[b]	10.32
20-50	348[b]	384[ab]	401[a]	14.80
50-67	-67	-29	-46	14.27
19-67	322	329	362	13.48
% gain 19-67	28	28	30	1.29

[1] ±SEM = Standard error of individual pullet body weights and weight gains within each age.

[a, b, c] Within age, strain means followed by different superscripts are significantly different ($P<0.05$).

Table 12. Effects of genetic strains on age at sexual maturity, livability and egg production traits.

Parameter	Genetic strain B	Genetic strain H	Genetic strain N	±SEM[1]
Sexual maturity (wk)	22.3^a	23.4^b	23.4^b	0.84
Livability (%)	96.1^a	89.3^b	88.0^b	1.54
Hen-day egg production, (%)	75.7^b	79.2^a	75.5^b	0.39
Hen-housed egg production, (%)	71.6^a	69.7^a	67.0^b	1.00
Egg weight, (g)	60.9^a	60.0^b	61.4^a	0.33
Egg mass, (g/hen/day)	43.9^a	42.1^b	41.5^b	1.00

[1] ±SEM = Standard error of cage means.

[a, b, c] Within age, strain means followed by different superscripts are significantly different.(P<.05).

Table 13. Effects of genetic strains on measures of egg size and quality.

%	Genetic strain B	Genetic strain H	Genetic strain N	±SEM[1]
Large	80.5^{a}	75.0^{b}	73.3^{b}	0.89
Medium	8.4^{b}	11.5^{a}	8.1^{b}	0.42
Small	5.5^{a}	6.0^{a}	5.0^{a}	0.42
Undergrades	5.2^{b}	6.0^{b}	11.6^{a}	0.39
Loss	1.0^{a}	0.3^{a}	1.7^{a}	0.12

[1] ±SEM = Standard error of cage means.

[a, b, c] Within age, strain means followed by different superscripts are significantly different.($P<.05$).

Table 14. Efects of genetic strains on nervousness and feather scores.

Strains	Nervousness 60 wk	Nervousness 75 wk	Feathering 60 wk	Feathering 75 wk
B	0.42^{c}	0.86^{c}	5.48^{a}	4.08^{b}
H	0.93^{b}	1.11^{b}	5.41^{a}	4.67^{a}
N	1.65^{a}	1.42^{a}	4.69^{b}	4.27^{b}
±SEM[1]	0.0900	0.0934	0.1300	0.1206

[1] ±SEM = Standard error of cage means.

[a, b, c] Within age, strain means followed by different superscripts are significantly different ($P<.05$).

3. Effects of rearing environments

Pullets reared in cages matured earlier, 22.9 vs. 23.1, than those from floor pens (Tables 15 and A-6). Differences in livability, hen-day rate of lay, hen-housed rate of lay, egg weight and egg mass were not influenced significantly by rearing environments.

Effects of rearing environments on egg size and quality are shown in Tables 16 and A-7. Pullets reared in floor pens laid more large eggs those reared in cages. Rearing environments did not affect percent medium, small, undergrades and loss eggs.

Table 17 shows the effects of rearing environments on body weight and body weight gains after pullets were moved into the laying house. Cage reared birds were heavier than floor reared birds (1238 vs. 1206 g). This result was obtained by weighing all the birds at the time when pullets were placed in the laying house at 19 weeks. Earlier, I failed to find a significant difference between the two rearing environments at the final body weight of the rearing phase, but that result was based on only 22% of all pullets being weighed. Mean body weights at 20, 50 and 67 weeks were essentially the same for pullets reared in either cages or floor-pen environments. However, pullets reared in floor pens gained more weight from 20 to 50 and from 19 to 67 weeks than did those reared in cages.

Rearing environment differences were not found for nervousness at 60 and 75 weeks of age (Tables 18, A 8-9). Feather score at 60 weeks of age was better for hens reared in cages, but at 75 weeks of age no difference between hens from the two rearing environments was evident.

Table 15. Performance of hens from different rearing environments (Mean±SEM, 20 to 68 weeks of age).

	Rearing environment		
Parameter	Cage	Floor	Cage - Floor
Sexual maturity (wk)	22.9±0.10	23.1±0.09	-0.2*
Livability (%)	90.5±1.30	91.8±1.18	-1.3
Hen-day egg production, %	77.3±0.33	76.2±0.36	1.1
Hen-housed egg production, %	69.9±0.56	69.0±0.60	0.9
Egg weight, g	60.8±0.17	60.8±0.16	0.0
Egg mass, g	42.7±0.37	42.3±0.39	0.4

* Means of the two rearing environments differ significantly (P<.05).

Table 16. Effects of rearing environments on measures of egg size and quality (Mean±SEM).

	Rearing environment		
%	Cage	Floor	Cage - Floor
Large	74.9±0.97	78.9±1.48	-4.0 *
Medium	9.9±0.61	8.9±0.59	1.0
Small	5.7±0.56	5.2±0.57	0.5
Undergrades	8.3±0.45	7.3±0.64	1.0
loss	1.3±0.17	1.4±0.18	-0.1

* Means of the two rearing environments differ significantly (P<.05).

Table 17. Effect of rearing environments on mean body weight and weight gain during the laying period.

Age (wk)	rearing environment: Cage	Floor	Cage - Floor
	A. Body weight, g		
19	1238± 4.54	1206±4.16	32 ***
20	1227± 7.91	1215±8.70	12
50	1582±14.12	1608±8.33	-26
67	1553± 8.78	1562±7.73	-9
	B. Body weight gain, g		
19-20	-11± 9.31	8± 9.86	-19
20-50	377±10.83	392±11.49	-15 **
50-67	-49±11.52	-45±13.49	-4
19-67	321±11.90	355± 8.76	-34 *
% gain 19-67	27± 1.12	30± 0.87	-3 *

* Means of the two rearing environments differ significantly (P<.05).
** P<0.01, *** P<0.001.

Table 18. Effects of rearing environments on nervousness and feather score.

	Nervousness		Feathering	
	60 wk	75 wk	60 wk	75 wk
Cage	1.01	1.19	5.42	4.36
Floor	0.98	1.07	4.96	4.33
Cage - Floor	0.03	0.12	0.46 *	0.03

* Means of the two rearing environments differ significantly (P<.05).

Livability from 19 to 67 weeks of age was not significantly affected by rearing environment, the mean percentage livability in laying house cages was 91%.

4. Effects of periods (ages).

Table 19 shows the effects of age on egg production traits. Analyses of variance are present in Table A-6. Birds reached peak hen-day and hen-housed egg production and had largest egg mass from 28 to 31 weeks of age, then declined gradually for the same traits until hens were 64-67 weeks of age. Egg weight increased from 50 grams at 20-23 weeks of age to 63 grams at 64-67 weeks of age.

5. Interactions of genetic strains and rearing environments.

Genetic strain by rearing environment interactions were found for body weights at 20 and 50 weeks and body weight gains from 19 to 20 and 20 to 50 weeks (Table A-5), and for percentage large and medium eggs (Tables 20 and A-7, Fig 2 and 3). No genetic strain by rearing environment interactions were found for any of the other egg production traits or for nervousness or feather scores.

Genetic strain by period (age) interactions were present for hen-day, hen-housed egg productions, egg weight, and egg mass (Figures 4-7).

A rearing environment by period (age) interaction was found for hen-housed rate of lay (Figure 8).

Table 19. Effect of period (age)on egg producton.[1]

Periods	Hen-day rate, %	Hen-housed rate, %	Egg weight g	Egg mass g/hen/day
20-23	74.7^{e}	27.6^{j}	49.6^{g}	13.7^{h}
24-27	85.6^{b}	83.6^{b}	55.1^{f}	46.0^{c}
28-31	87.1^{a}	85.6^{a}	59.5^{e}	50.8^{a}
32-35	84.2^{b}	82.0^{c}	60.5^{d}	49.4^{b}
36-39	80.7^{c}	78.0^{d}	61.7^{c}	48.3^{b}
40-43	77.1^{d}	73.9^{e}	63.2^{b}	46.7^{c}
44-47	72.8^{f}	69.4^{f}	64.1^{a}	44.7^{d}
48-51	72.5^{f}	68.7^{f}	64.5^{a}	44.2^{d}
52-55	72.3^{f}	68.0^{f}	63.5^{b}	43.0^{e}
56-59	74.9^{e}	69.7^{f}	63.2^{b}	44.1^{d}
60-63	71.6^{f}	66.3^{h}	60.9^{d}	40.3^{f}
64-67	66.2^{g}	60.5^{i}	63.3^{b}	38.5^{g}

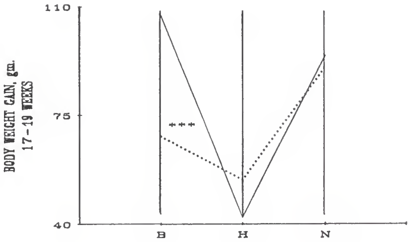
[1] Within colomn, means followed by different superscripts are significant different ($P<.05$).

Table 20. Genetic strain-rearing environment means for traits having interactions.

	Strain B			Strain H			Strain N		
	Cage		Floor	Cage		Floor	Cage		Floor
				A. Body weight, g					
Age, wk									
20	1210		1244	1231		1199	1240	***	1201
50	1543	**	1599	1614		1592	1656		1631
				B. Body weight Gain, g					
Age, wk									
19-20	-9	**	50	18	*	-26	-43	*	-1
20-50	324	***	405	400		367	374	*	429
				C. Egg size					
Size, %									
Large	77	**	84	73		77	75		72
Medium	10	**	7	12		11	7		9

* P<.05, ** P<.01, *** P<.001 for comparisons of cage vs. floor within strain and age.

Figure 1. Body weights and body weight gains of pullets kept in upper and lower tiers of cages for three strains of White Leghorn chicks during the rearing period. Solid line (________) indicates upper tier, and dotted line (........) indicates lower tier. Significant differences between pullets in upper and lower tiers within strains are indicated by asterisks (* $P<.05$, ** $P<.05$, *** $P<.001$).


BODY WEIGHT GAIN, gm.
17-19 WEEKS
110
75
40
+++
B
H
N

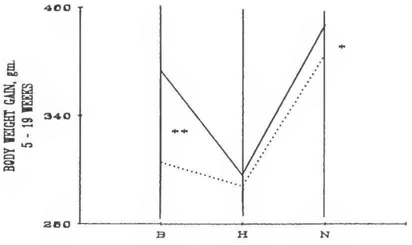
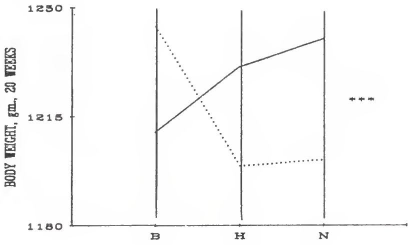
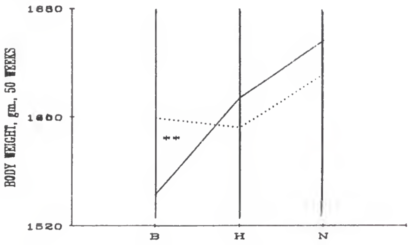
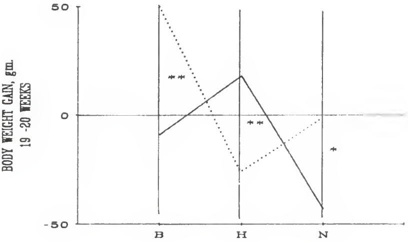

BODY WEIGHT GAIN, gm.
5 - 19 WEEKS
400
340
280
++
+
B
H
N

Figure 2. Body weights and body weight gains of pullets reared in cages and floor pens for three strains of White Lehgorn pullets during the laying period. Solid line (_______) indicates cage reared birds, and dotted line (........) indicates floor pen reared birds. Significant differences between rearing environments within strains are indicated by asterisks (* P<.05, ** P<.01, *** P<.001).


1250
1215
1180
BODY WEIGHT, gm., 20 WEEKS
B
H
N
***


1680
1600
1520
BODY WEIGHT, gm., 50 WEEKS
B
H
N
**


50
0
-50
BODY WEIGHT GAIN, gm.
19 -20 WEEKS
B
H
N
* *
* *
*

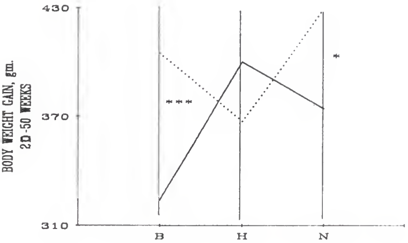
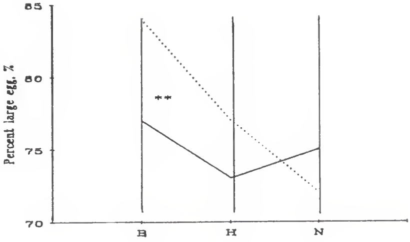

430
370
310
BODY WEIGHT GAIN, gm.
2D-50 WEEKS
B
H
N
* * *
*

Figure 3. Genetic strain by rearing environment interactions for percent large eggs and percent medium eggs. Solid line (_______) indicates cage reared pullets, and dotted line (........) indicates floor pen reared pullets. The asterisks (**) indicate a significant differences (P<.01) between rearing environments within strains.


85
80
75
70
Percent large egg, %
**
B
H
N

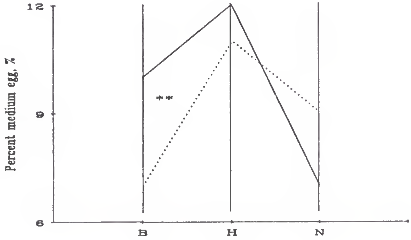

12
9
6
Percent medium egg, %
**
B
H
N

Figure 4. Effects of genetic strains and periods (ages) on hen-day egg production. Ages indicated are at the beginning of each 4-week period.

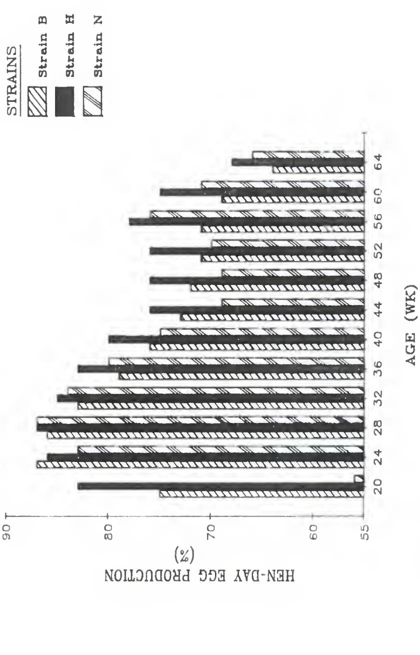

STRAINS
Strain B
Strain H
Strain N
HEN-DAY EGG PRODUCTION (%)
90
80
70
60
55
20
24
28
32
36
40
44
48
52
56
60
64
AGE (WK)

FIGURE 4.

Figure 5. Effects of genetic strains and periods (ages) on hen-housed egg production. Ages indicated are at the beginning of each 4-week period.

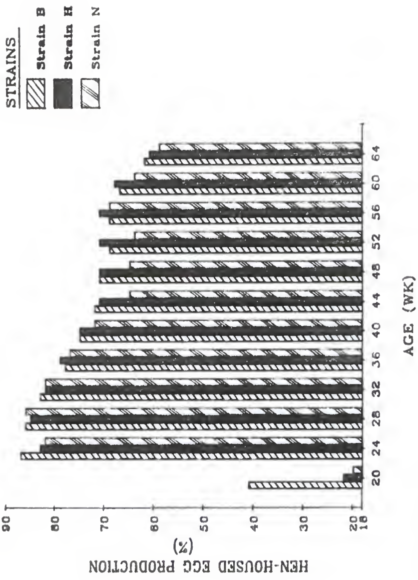

STRAINS
Strain B
Strain H
Strain N
HEN-HOUSED EGG PRODUCTION (%)
AGE (WK)
18 20 30 40 50 60 70 80 90
20 24 28 32 36 40 44 48 52 56 60 64

FIGURE 5.

Figure 6. Effects of genetic strains and periods (ages) on egg weight. Ages indicated are at the beginning of each 4-week period.

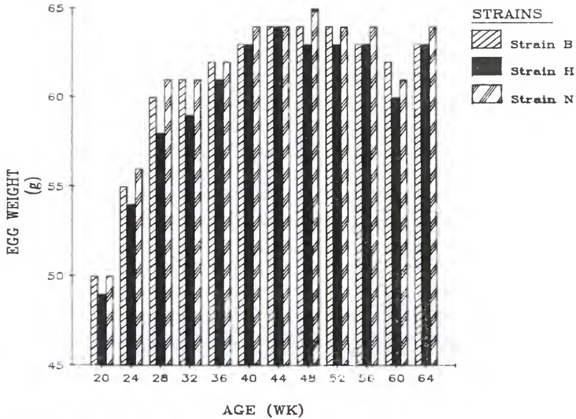

EGG WEIGHT
(g)
65
60
55
50
45
20
24
28
32
36
40
44
48
52
56
60
64
AGE (WK)
STRAINS
Strain B
Strain H
Strain N

FIGURE 6.

Figure 7. Effects of genetic strains and periods (ages) on egg mass. Ages indicated are at the beginning of each 4-week period.

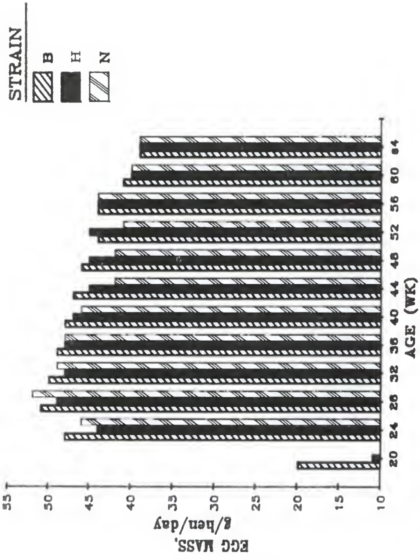

STRAIN
B
H
N
EGG MASS,
g/hen/day
55
50
45
40
35
30
25
20
15
10
20
24
28
32
36
40
44
48
52
56
60
64
AGE (WK)

FIGURE 7.

Figure 8. Effects of rearing environment and periods (ages) on hen-housed egg egg production. Ages indicated are at the beginning of each 4-week period.

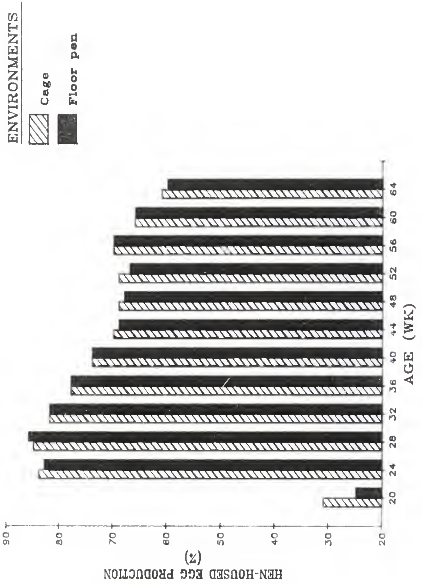

ENVIRONMENTS
Cage
Floor pen
HEN-HOUSED EGG PRODUCTION (%)
90
80
70
60
50
40
30
20
20
24
28
32
36
40
44
48
52
56
60
64
AGE (WK)

FIGURE 8.

DISCUSSION

Rearing phase

Poor husbandry conditions, such as increased population density, inadequate feeding and watering space, and social disturbances, causing increased social stress would be expected to cause a depression in mean performance level and increased individual variability associated with a skewed frequency distribution (McBride, 1962, 1968; Craig et al. 1969). In this experiment, evidence of differences in quality of environment of upper and lower tiers of cages was absent, based on the criteria of body weight and weight gain variation, and mean body weights and weight gains and incidence of mortality. In terms of body weight and body weight gain variation evidence was lacking that cage and floor-pen rearing environments differed in quality. However, cage-reared chicks had heavier body weights at 5, 11 and 19 weeks of age than did floor-pen reared chicks.

Laying phase

From the preliminary analyses, differences associated with tiers of cages were found for body weight at 20 weeks and body weight gain from 19 to 20 weeks of age. Those differences were apparently caused by greater difficulty in obtaining water by those birds housed in the lower tier. Following resolution of the watering problem, there was no apparent carry-over effects of tier on any of the other productivity traits tested. At 75 weeks of age, birds in the upper tier of cages were more nervous than those in the lower tier of cages. The later results support previous results obtained by Sefton (1976) and Jones (1985).

Strain differences were significant for sexual maturity, livability, hen-day egg production, hen-housed egg production, egg weight, egg mass, body weight, nervousness, feather loss, and percentage large, medium and undergrade eggs.

Strain B was less nervous than the other two strains and had better feather coverage at 60-63 weeks of age. A similar association between nervousness and feathering scores was reported earlier by Craig et al (1983) with different genetic strains. In the case of extreme nervousness and hysteria occuring under conditions of large group size in crowded cages, Elmslie et al (1966) and Hansen (1976) found extreme feather loss. However, Craig et al (1986) failed to obtain better performance of a less nervous strain of White Leghorns when kept at three densities and two group sizes in cages.

In the present study, pullets reared in cages weighed 3% more at housing, but no differences associated with rearing environments were found subsequenly for body weights, egg production traits, or nervousness. Although feather loss was less for cage- reared hens at 60-63 weeks of age, no difference was apparent at 75-78 weeks of age. The results of this study are similar to those of previous studies (Shupe and Quisenberry 1961, and Craig et al, unpublished) with egg-strain hens, in failing to find differences during the laying phase associated with cage and floor-pen rearing.

The genetic strain by rearing environment interactions for percent large eggs and percent medium eggs indicated that rearing environment effects were not consistant over the genetic strains for their effects on hen's egg size. Differences in body weight gain among strains after being placed in laying cages may be responsible. Strain B, reared in floor pens, gained more weight during the laying phase and had a higher percentage of large eggs than they did when reared in cages. This was not found in strains H and N.

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APPENDIX

Table A-1. Comparisons of variance of body weight and body weight gain of cage-reared pullets in lower-tier and upper-tier cages.

Age, wk	Strain B			Strain H			Strain N		
	Lower	Upper	F	Lower	Upper	F	Lower	Upper	F
A. Variance of body weight									
0	6	6	1.00	7	6	1.17	6	11	1.83*
2	36	81	2.25**	54	43	1.26	100	122	1.22
5	514	936	1.82*	536	483	1.11	618	798	1.29
8	1693	2948	1.74*	1360	1878	1.38	2134	3725	1.75*
11	2758	4725	1.71*	3580	3486	1.03	4298	6062	1.41
14	4191	5331	1.27	4914	4364	1.13	5306	5605	1.06
17	5792	7548	1.30	7380	6441	1.15	7910	5048	1.57
19	9712	10674	1.10	7709	8294	1.08	10300	8896	1.16
B. Variance of body weight gain									
0-2	39	67	1.72*	52	43	1.21	106	108	1.02
2-5	389	572	1.47	313	348	1.11	337	434	1.29
5-8	469	791	1.69*	548	660	1.20	989	2405	2.43**
8-11	802	642	1.25	1243	613	2.03+	971	1614	1.66
11-14	707	496	1.43	898	552	1.63	755	879	1.16
14-17	1719	948	1.81+	1428	928	1.54	1034	1219	1.18
17-19	2905	1480	1.96+	823	1548	1.88*	1159	1510	1.30
2-8	1517	2354	1.55	1062	1648	1.55	1814	3205	1.77*
0-19	9799	10547	1.08	7638	8382	1.10	10270	8633	1.19

* P<.05, ** P<.01 that upper tier variance is larger due to chance alone.

\+ P<.05, ++ P<.01 that lower tier variance is larger due to chance alone.

Table A-2. Analysis of variance of body weights and body weight gains for cage reared pullets.

Source of Variaton	df	Age (wk) 5	8	11	14	17	19
		A. Mean squares of body weight					
Genetic strain (GS)	2	26459.4**	101898.3***	59628.7**	55870.3*	61296.8**	78706.2**
Tier (T)	1	10439.2**	24555.8**	22497.2*	7333.3	2332.8	519.5
GS X T	2	980.5	4336.3*	4188.3	12168.7	6258.6	30441.9*
Error	6	495.9	580.3	1702.2	3923.0	3656.4	4673.5

* $P<.05$, ** $P<.01$.

Table A-2. (Continued)

Source of Variaton	df	Age (wk) 5-8	8-11	11-14	14-17	17-19	5-19	% 5-19
		A. Mean squares of body weights						
Genetic strain (GS)	2	25858**	27180**	14986**	8776	46436***	174571**	120967***
Tier (T)	1	2974	45	2731	2906	6378*	17041	35643**
GS X T	2	2755	943	865	497	13432**	39878**	11439**
Error	6	1219.8	1176.9	826.1	3739.8	593.7	2486.9	627.9

Table A-3. Comparisons of variance of body weight and body weight gain of pullets in cages and floor pens during the rearing period.

Age, wk	Strain B			Strain H			Strain N		
	Cage	Floor	F	Cage	Floor	F	Cage	Floor	F
				A. Variance of body weight					
0	6	6	1.17	7	6	1.67*	8	9	1.13
2	58	63	1.09	54	43	1.52*	110	46	2.39**
5	532	510	1.61*	536	483	1.40	737	628	1.17
8	2440	2065	1.18	1360	1878	1.60+	3153	2474	1.27
11	3754	3272	1.15	3580	3486	1.26	5418	3729	1.45*
14	4703	4240	1.11	4914	4364	1.02	5572	4692	1.19
17	6607	7230	1.10	7380	6441	1.06	6580	4930	1.33
19	10649	9919	1.07	7709	8294	1.06	9599	6191	1.55*
				B. Variance of body weight gain					
0–2	52	54	1.04	47	64	1.36	106	43	2.47**
2–5	578	403	1.43	340	460	1.35	412	458	1.11
5–8	626	1202	1.92++	598	946	1.58+	1772	866	2.05**
8–11	732	1158	1.58+	919	787	1.17	1274	1306	1.03
11–14	635	791	1.25	714	935	1.31	822	1482	1.80++
14–17	1352	1933	1.43	1170	1802	1.54+	1112	1073	1.04
17–19	2549	1728	1.48*	1216	1526	1.25	1320	2172	1.65+
2–8	2055	1753	1.17	1343	2094	1.56+	2721	2189	1.24
0–19	10632	9899	1.07	7989	7405	1.08	9462	6167	1.53

* $P<.05$, ** $P<.01$ that cage variance is larger due to chance alone.

\+ $P<.05$, ++ $P<.01$ that floor variance is larger due to chance alone.

Table A-4. Analyses of variance for body weight and body weight gains during the rearing period.

Source of variation	df	Age (wk)							
		Hatch	2	5	8	11	14	17	19
		A. Mean squares of body weights							
Genetic strain (GS)	2	14.9**	418.8***	1257.2***	3268.6***	2389.8***	2500.4*	3086.7*	1111.1
Rearing environment (RE)	1	1.4**	0.8	926.7**	218.0	1447.5**	105.4	95.0	1873.2
GS X RE	2	0.5*	1.5	1.2	217.3	166.8	79.2	194.0	1431.2
Error	6	0.1	8.4	33.4	95.9	42.6	98.5	367.6	425.9

* $P<.05$, ** $P<.01$.

Table A-4. (Continued)

Source of variation	df	Age (wk) 2-5	5-8	8-11	11-14	14-17	17-19	0-19	% 0-19
A. Mean squares of body weight gains									
Genetic strain (GS)	2	345*	588	1382**	465*	675	516	954	955
Rearing environ.(RE)	1	963**	246	542	2471***	3	2680*	1775	1775
GS X RE	2	2	193	13	37	35	2655*	1392	1392
Error	6	42	163	6	51	353	341	426	426

Table A-5. Analysis of variance for body weight and weight gain during the laying period.

Source of variation	df	Body weight 19 wk	20 wk	50 wk	67 wk
		Mean squares			
Tier (T)	1	150	57460**	8696	1603
Block (B)	5	2694	2876	9464	3674
Error A (T X B)[1]	5	2564	1313	2184	8432
Genetic strain (GS)	2	20173***	1726	96290***	77833***
Rearing environment (RE)	1	36656***	5372	7519	3221
GS X RE	2	21196***	19851*	50970**	2035
T X GS	2	749	5	12681	3185
T X RE	1	86	12553	24212	1528
T X GS X RE	2	1167	3687	14626	11429
Error B[2]	122	1350	5103	9169	5480

* P<.05, ** P<.01, *** P<.001

[1] Error term for testing mean squares of indicated above.

[2] Error term for testing mean squares of indicated above.

Table A-5. (Cont.)

Source of variation	df	19-20 wk	20-50 wk	50-67 wk	19-67 wk	% gain 19-67 wk
			B. Mean squares of body weight gains			
Tier (T)	1	46198**	4293	55853**	7403	83
Block (B)	5	3317	7918	8041	3774	35
Error A[1]	5	2202	5578	2053	14469	131
Genetic strain (GS)	2	21320*	34508*	16875	21965	105
Rearing environment (RE)	1	13086	73680**	619	41923*	344*
GS X RE	2	37000**	64200**	26430	14286	180
T X GS	2	4096	13229	13427	10	0.7
T X RE	1	22058*	34610	1576	3794	27
T X GS X RE	2	2117	10236	11759	2938	15
Error B[2]	122	5112	10510	9769	8726	80

* P<.05, ** P<.01, *** P<.001

1 Error term for testing mean squares indicated above.

2 Error term for testing mean squares indicated above.

Table A-6. Analyses of variance for age at sexual maturity, hen-day and hen-housed egg production, egg weight and egg mass.

Sourse of variation	df	Sexual maturity, wk	Liva-bility,%	Hen-day rate,%	Hen-housed rate, %	Egg weight g	Egg mass g/hen/day
		Mean squares					
Row	11	0.63	79	146	148	29	91
Genetic strain (GS)	2	20.27***	9.2***	1743***	3007***	323***	924**
Rearing environ (RE)	1	1.36*	69	7	293	0.02	65
GS X RE	2	0.09	118	219	287	34	65
Error A[1]	127	0.34	114	159***	379***	24***	168***
4-week periods (P)	11			5890***	33465***	2744***	15656***
P X GS	22			153**	553***	9***	161***
P X RE	11			36	126***	2	35
P X GS X RE	22			60	20	3	10
Error B[2]	1410-1518[3]			42	41	4	21

* P<.05, ** P<.01, *** P<.001

[1] Error term for testing mean squares of indicated above.

[2] Error term for testing mean squares of variables including period.

[3] Degrees of freedom vary because of missing value.

Table A-7. Analyses of variance for effect of genetic strain and rearing environment on percentage of marketable eggs by size, undergrade and egg loss.

Sourse of variation	df	Marketable eggs Large %	Medium %	Small %	Undergrades %	Egg loss %
		Mean squares				
Row	11	28.93	19.1	9.4	24.0	1.1
Genetic strain (GS)	2	698.5***	162.7***	30.9	582.5***	6.4
Rearing environ (RE)	1	247.0*	36.9	42.7	68.1	0.3
GS X RE	2	292.4**	83.1*	15.4	61.5	1.0
Error	127	42.2	17.9	16.3	25.1	2.3

* P<.05, ** P<.01, *** P<.001

Table A-8. Analysis of variance for nervousness and feather scores at 60 weeks of age.

Source of variation	d.f.	Nervousness	Feathering
		------------- Mean squares	-------------
Row	5	0.35***	4.87*
Genetic stock (GS)	2	4.43***	18.38***
Rearing environment (RE)	1	0.01	15.59**
GS X RE	2	0.07	0.07
Error	71	0.08	1.62

* P<.05, ** P<.01, *** P<.001.

Table A-9. Analysis of variance for nervousness and feather scores at 75 weeks of age.

Source of variation	d.f.	Nervousness	Feathering
		------------- Mean squares ------------	
Tier (T)	1	1.410	9.57**
Block (BLK)	5	0.162	0.55
T X BLK[1]	5	0.381	0.36
Genetic stocks (GS)	2	3.806***	4.40***
Rearing environ (RE)	1	0.502	0.03
GS X RE	2	0.004	1.03
T X GS	2	0.120	0.28
T X RE	1	0.063	1.34
T X GS X RE	2	0.632	0.649
Error	122	0.340	0.280

* P<.05, ** P<.01, *** P<.001.

[1] Block is defined by a set of upper and lower tiers of cages.

SOME EFFECTS OF CAGE AND FLOOR REARING ON COMMERCIAL WHITE LEGHORN PULLETS DURING GROWTH AND THE FIRST YEAR OF EGG PRODUCTION.

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AN ABSTRACT OF A MASTER'S THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

College of Agriculture

Department of Animal Sciences and Industry
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Three commercial White Leghorn Stocks were compared for growing performance when reared in cages and floor-pens during the rearing period and egg production traits, livability, nervousness, and feather loss during the laying period.

Differences in quality of environment of cage and floor-pen rearing were not found, based on the criteria of body weight and body weight gain variation, mean body weight and body weight gain, and mortality during the rearing period.

Strain differences were found for sexual maturity, livability, hen-day egg production, hen-housed egg production, egg weight, egg mass, body weight, nervousness, feather score, and percentage large, medium and undergrade eggs. The strain which was less nervous had better feather coverage at 60 weeks of age.

Cage rearing and floor rearing were not associated with differences in terms of laying performance and well-being of the birds as judged by egg production traits, nervousness and feathering at later ages. Interactions between genetic strain and rearing environment were generally absent for egg production traits and for nervousness and feathering scores but were present for body weight and percentage large and medium eggs.