EFFECTS OF TYPE OF REARING DIET, CAGE SHAPE, TYPE OF CAGE PARTITION, AND FEED TROUGH PARTITIONS ON THE PRODUCTIVITY AND BEHAVIOR OF LAYERS

By

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INTRODUCTION

Management systems, such as the conventional step-down protein dietary regimen or the step-up protein dietary regimen, and high density cages have attracted attention because of their potential for reducing costs associated with egg production. These systems have resulted in the concern of researchers over problems of pullet growth and maturity associated with dietary regimens and the well being of birds in high density cages.

Traditionally, pullets have been fed a step-down protein dietary regimen during the growing phase. If problems of over weight birds arose, some type of feed deprivation has commonly been used. Leeson and Summers (1978) questioned the step-down protein regimen when they found that birds, allowed feed free choice, preferred a reverse, or a step-up protein dietary regimen. They reported that the advantages of this system were lower feed costs and a nonstressful means of feed restriction, which resulted in a better developed bird at maturity.

High density cage houses may place hens in stressful situations, possibly adversely affecting production or behavior. Reverse cages, which are longer than deep and allow more feeder space for the bird, were reported by Bell (1972) to reduce the stress of this environment. This arrangement has been shown to reduce the adverse effects of high bird density on layers. Recently, the behavior of the hen has been examined in the hopes of learning how the hen reacts to her environment or its alteration.

Two experiments were conducted to: 1) study the effects of feeding a step-down protein feeding regimen vs. a high and a low energy step-up feeding regimen during the growing phase on the performance of egg-type pullets and 2) examine the effects of rearing diets, cage shape, type of cage wall partition and feed trough partitions on the subsequent performance and behavior of the hens.

REVIEW OF LITERATURE

Effect of Pullet Grower Diet. A common practice in the commercial poultry industry is to feed decreasing levels of protein to growing pullets. Blaylock (1956) determined that reducing protein from 18% to 12% by 16 weeks of age had no effect on maturity or production of the hen. Berg and Bearse (1958) confirmed these findings and went one step further, stating that protein levels for pullets could drop below 12% after 16 weeks without affecting body weight, maturity, or production. The effects of six different step-down protein programs on 20-week body weights and subsequent production parameters of pullets were reported by Douglas et al. (1985). They found that low protein levels significantly restricted body growth when protein levels fell below the 15 to 14% levels at 18 to 20 weeks of age, but by 28 weeks there was no difference in body weights. None of the treatments had any significant effect on egg production, egg weight or feed conversion.

Lillie and Denton (1966) and Kim and McGinnins (1976) concluded from their research that a diet containing 12% protein throughout the rearing period was adequate for egg production, egg weight and feed conversion. However, even though differences were not significant, the lower protein levels delayed maturity and lowered body weight at the onset of production. Fuller and Chaney (1974) delayed maturity in two groups of White Leghorn pullets by restricting their energy intake. By delaying maturity, the number of small and double yolk eggs was reduced when production began. In addition, body weights were not different for either the control group or the pullets on restricted energy.

The use of decreasing protein levels (step-down feeding system) during the growing period of egg-type pullets was questioned by Leeson and Summers (1978). They found that hens in cages could select their own diet when given a split diet of a concentrated energy feed and a concentrated protein feed. They compared the production of the hens on the split diet with hens on a conventional diet and found that the hens on the split diet had higher production. Because of this Summers and Leeson (1978) allowed pullets to select their own diet. Two pens of 20 pullets were allocated to either a conventional step-down diet or a split diet consisting of a concentrated energy feed and a concentrated protein feed. The split diets were fed in separate feeders. They reported that pullets given a dietary choice, consumed increasing amounts of protein as they matured (step-up protein) which is the reverse of the current basis for feeding step-down protein diets. Their step-up protein diets resulted in pullets with almost linear growth and reduced body weight. Leeson and Summers (1979) compared a step-down protein diet: 0 to 8 weeks, 18% crude protein (CP), 3049 kcal/kg metabolizable energy (ME); 8 to 12 weeks, 15% CP, 2992 ME; 12 to 20 weeks, 13% CP, 2952 ME and a step-up protein diet: 0 to 12 weeks, 12% CP, 3080 ME; 12 to 16 weeks, 16% CP, 2974 ME; 16 to 20 weeks, 19% CP, 2972 ME. They found that birds reared on step-up protein diets were significantly lighter, consumed less protein and were less successful in meeting their necessary energy requirements from 0 to 20 weeks of age than birds fed step-down protein diets. Egg production was comparable for both groups. The birds reared on step-up protein diets produced smaller eggs which was attributed to their smaller body weight at 20 weeks of age. In a subsequent study, Leeson and Summers (1984) confirmed that the step-up protein diets caused reduced body weight, egg size and egg production. At that time, they also used varying energy levels, but found that this change had no effect on feed consumption.

Bish et al. (1984) modified step-up protein diets by beginning all chicks on an 18% CP starter. At intervals of 1, 2, and 3 weeks, separate groups were put on a 12% CP rationto begin the step-up program. They found that all treatments caused pullets with lighter body weights than those reared on a step-down protein diet, but not as severe a restriction in body weight as reported by Leeson and Summers (1979). Therefore, egg production and egg size for the birds were not as severely restricted and feed conversion was improved compared to pullets reared on step-down protein diets.

Adaptation to Environments "Settling In". The housing of a floor-reared pullet in a laying cage is a drastic change in environment. During this "settling in" stage, the pullet has to adapt to a new physical environment of a cage with different styles of feeders and waterers. Along with a different physical environment, the pullet also has to adapt to a new social environment consisting of strange cage mates.

Information is limited on the behavior of pullets during the first few days following housing in cages when they are settling into a new physical and social environment. Murchison (1936) examined the time function in the establishment of social hierarchies of the domestic fowl. He determined that group sizes of 2, 3, 4, 5 and 6 individuals in pens would need 15, 19, 22, 26 and 32 weeks, respectively, to establish a linear hierarchy structure. Guhl (1958) determined that flocks which were assembled immediately after hatching developed a social structure in 8-10 weeks utilizing the behavior which facilitates social attraction and interaction. Social interaction for groups of six adult males were highest when initially assembled in pens, and generally declined and plateaued in 10 days (Williams et al., 1977). Their data indicated that the time needed to integrate into a social group involved much less time than Murchison (1936) originally proposed. Development of the social behaviors of assembled small flocks, where all are strangers, occurs in a period of time when aggression levels are highest. Guhl (1953) determined, that during this initial period after housing, pecks per bird were highest initially, then dropped off sharply within the following week. During this time, they are competing for resources, such as feed, water and territory. He also determined that hens introduced later into the flock had reduced feed consumption, body weight and egg production until they had been assimulated into the flock. Also, Duncan et al. (1978) found that when they released new male chickens into a feral flock, the males lost condition initially and did not regain full condition or integrate with the flock for approximately 12 weeks. Introduction of a strange bird to a small flock of socially adapted birds has drastic effects on productivity of the new bird and increases the activity of the other birds within the group. Syme et al. (1984) determined that birds work out a social structure in which they will discriminate between individuals and associate to a greater degree with lower or equally ranked birds within the group. This allows the birds to acquire their essential needs without attack or threats from higher ranked individuals.

The social rank of hens in multiple-bird cages was reported by Cunningham and Van Tienhoven (1984) to decrease egg production of the low ranking birds. This effect was reduced by changing the management techniques used in the layer house. The management changes made included deep vs. shallow cages, the type of feeding program used, and ad libitum vs. restricted feeding. There were no significant rank effects among birds of different ranks in 5 bird cages.

Effect of Cage Shape. The use of the reverse cage system was first introduced by Bell (1972). He reported that birds had significantly ($P<.05$) less mortality, produced more eggs with fewer loss eggs, and had better feed conversion when housed in 45.7 x 30.5 cm reverse cages vs. 30.5 x 45.7 cm deep cages. Feed consumption for both groups was not different.

Lee and Bolton (1976) housed medium- and light-weight hens in deep cages (40.5 x 40.5 cm) or shallow cages (61.0 x 30.5 cm). They kept performance records over weekly periods throughout the year and found that egg numbers were significantly higher in the shallow cages for medium-weight hens and for light-weight hens during weeks 18-30. The number of loss eggs between 60-70 weeks was lower for hens housed in shallow cages than for hens in deep cages, but was significant only in the light-weight birds. Both strains consumed significantly less (4%) feed in shallow cages. This experiment may have confounding factors of shape by density since shallow cages were 220 cm^2 larger. Hughes and Black (1976) found the same results as Lee and Bolton and concluded that the advantage of the shallow cage is that accessability to the feed trough is greater. A similar study by Hughes and Black (1977), comparing hens in 40.6 x 45.7 cm deep cages and 61.0 x 30.5 cm shallow cages, showed higher bird activity levels in the deep than the shallow cages. They also determined that the higher production in shallow cages was achieved even though birds in shallow cages consumed less feed during the production period. Three factors were presented by them to explain their results; 1) reduced activity levels, 2) a more leisurely eating pattern, and 3) a better feather coat; all contributing to the more efficient utilization of the feed consumed.

Hill and Hunt (1978) determined that hens in shallow cages, either 20.3 cm or 30.5 cm deep and 15.2 cm wide, had significantly increased feed consumption, ending body weights and egg weight when compared to birds in deep cages. They found that birds in the shallow cages were significantly (P<.01) less nervous, had more egg cracking, inferior egg production, higher feed conversion and lower net egg income than birds in the deep cages. These results were substantiated in a subsequent study (Hill and Hunt, 1980). They reported that body weights in the reverse cages could be controlled by restricting feeder space, with an additional benefit being significantly reduced mortality, comparable to that of hens in the deep cages. However, for the second time, they found that net income favored the deep cage.

Better hen-day production was found by Baiao and Campos (1979) for hens in reverse cages, as well as better livability. The other production criteria were found to be similar for hens in both deep and shallow cages.

Carey, et al. (1981) determined that hens in standard cages laid eggs at a greater rate, ate more feed and had a better feed conversion than the hens in reverse cages. Hens in reverse cages had lighter ending body weights, consumed less feed and had lower egg production than hens in standard cages Carey (1982).

Two trials were conducted by Muir (1976) to compare hens in deep and shallow cages with half the cages 35.6 cm high and the other half 30.5 cm high. He found that height had an effect on live weight at the end of trial 1 with the reverse cage having the heaviest birds in both high and low cages. The chickens in high cages were the heaviest in both the shallow and reverse cages. No significant differences in the other parameters were apparent. In trial 2, the birds in reverse cages with low tops laid significantly more eggs and had better feed conversion than those in deep cages with high or low tops and shallow cages with high tops. These results supported the work done by Bell (1972).

Swanson and Bell (1977) compared the performance of hens in three different cages, two conventional (30.5 x 40.6 cm and 30.5 x 45.7 cm) and one reverse (45.7 x 30.5 cm). Performance favored the reverse cage, however, the results were not always significant possibly because of the confounding effect of the different conventional cage shapes they used. They found that the reverse cage had the advantage in hen-housed production and feed efficiency along with an improved net egg income.

Reverse cages had no advantage over conventional cages in a light and air controlled building (Martin et al., 1981). This contradicted previous and subsequent research work done in this area.

Cunningham and Ostrander (1981) found that pullets housed in deep cages laid fewer eggs, had smaller body weights, used less total feed, had smaller eggs, and laid less egg mass and fewer large eggs than their counterparts in shallow cages. There were no differences found between the other parameters observed.

Cage shape did not have significant effects on production parameters, except for egg size which was larger for hens in the reverse cage (Cunningham, 1981). He noted that there was a trend for the hens in shallow cages to feed more frequently and consume greater quantities of feed than those in deep cages. He also noted that hens in shallow cages initiated fewer aggressive acts, though not significantly less, than hens in deep cages.

Ouart and Adams (1982) found that cage shape had no effect on egg production or any of the other production parameters they measured. They did find that the added feeder space of the shallow cage increased body weight gain even though it did not affect feed conversion or consumption.

Cunningham (1982a) found that birds in shallow cages (60.9 x 31.8 cm) on full feed consumed significantly ($P<.05$) more feed, with a greater weight gain during their productive life, than those in deep cages (38.1 x 50.8 cm). He also reported that egg production, egg weight and egg mass were greater for hens in shallow cages than for those in deep cages. Because of the increased feed consumption, shallow cage costs were higher, thus reducing total income over that of deep cages. Cunningham (1982b) confirmed his earlier results of higher egg production, heavier eggs, higher egg income and greater body weights for birds in shallow cages, but deep cages had lower pullet and feed costs per bird. The other parameters studied were not different between the two cage types. Birds in shallow cages were found to have higher egg production, greater egg mass, more large plus size eggs, greater body weight gains and greater feed consumption than birds in deep cages (Cunningham and Ostrander, 1982), supporting previous work on standard and reverse cages.

Adams and Craig (1985) conducted a survey of research reports where performance of hens in exactly reversed and not exactly reverse cages were examined. The survey indicated that hens in shallow cages had significantly ($P<.01$) higher egg production, averaging 5.8 eggs more per hen than those in deep cages.

Effect of Bird Density. Sefton (1976) studied the effects of bird density on production of hens. He approached this by two methods: 1) varying bird numbers without reducing area per bird, and 2) changing bird numbers and reducing area per bird. He determined that area per bird as well as number of birds per cage had a significant effect on production. Similar results with bird numbers ranging from 2 to 7 birds per cage at densities of 17.2 to 32.3 birds per m^2 were reported by Martin et al. (1976). They found that most production criteria were depressed at densities over 22 birds per m^2.

Al-Rawi et al. (1976) looked at the effects of group size on egg production. They found that group size negatively affected hen-day production, hen-housed production and mortality. Other production criteria showed no significant changes. Swanson and Bell (1977) found that feed efficiency and egg income were also depressed at higher densities.

Hill and Hunt (1978) determined that bird density adversely affected egg mass, egg production, and mortality. High density also increased the feed intake per bird and feed conversion, making crowded birds less economical. These changes in feed consumption and conversion were attributed to the increased activities of the birds in higher density environments.

Hen-day production declined from 78.0% to 78.1% and 75.2%, respectively, as density increased from 5 to 6 to 7 hens per cage (Cunningham and Ostrander, 1981). Hen-housed production and egg mass were also reduced significantly. The cause of this may have been the decrease in total feed consumed per bird and reduced feed efficiency. In a subsequent study, Cunningham (1982b) determined that as density increased from 4 to 6 birds per cage, hen-day production declined from 76.9 to 73.7%, while egg mass declined along with production. He discerned that total feed usage increased, yet feed conversion also improved as density increased. Cunningham and Ostrander (1982) tested the effects of density on production parameters in laying hens. They determined that increased density depressed egg production, egg mass, feed conversion, weight gains and resulted in higher mortality.

Ouart and Adams (1982) reported that increasing density from 3 to 4 birds per cage adversely affected production in one experiment. Production was 3.5% greater in the lower density cages. In a second experiment, birds housed at 3 birds per cage produced at 77.9% compared to 72.5% for 4 birds per cage.

The relationship between densities of 516, 387 and 310 cm^2 per bird to production and feed consumption was examined by Roush et al. (1984). Production was found to be depressed as density increased, hens at 516 cm^2/ bird laying at 77.9% vs. 76.3 and 71.0%, respectively, for hens at 387 and 310 cm^2/ bird. Feed conversion and feed to produce a dozen eggs was increased along with the amount of total feed consumed.

In a survey of research work done between 1971 and 1983, Adams and Craig (1985) found that decreasing floor area per hen from 387 cm^2 (medium density) to 310 cm^2 (high density) significantly reduced eggs per hen housed by 16.6.

A density of 310 cm^2 decreased feed consumption while reducing feed efficiency by 68 g feed/doz. eggs. In comparing hens kept at 516 cm^2 (low density) vs. 387 cm^2 (medium density), similar results occurred but differences were not as large.

Effect of Cage Partition. Preliminary work by Adams (1983) on the effects of wire vs. solid cage partitions on performance of layers showed no significant differences between the two for production parameters. However, hens in cages with solid partitions tended to have lower egg production. He also reported that differences in feed consumption of 112 g/hen/day for hens in wire-sided cages vs. 114 g/hen/day for hens in solid-sided cages was not significant, but favored the solid-sided cage.

Ramos (1985) confirmed the initial finding of Adams and concluded that production parameters were not influenced by solid vs. wire-sided cages. Mortality tended to be higher in both deep and shallow cages with solid partitions. He attributed this to the fact that many birds got their toes caught under the solid partitions which caused excessive bleeding or made it impossible for the hens to reach the feeder.

Effect of Bird Feathering. Adams et al. (1978) investigated feathering of mixed groups of hens and cocks kept in cages at various densities. Feather scores of the hens was determined by comparing the hens with pictures of hens which had been scored from 1 to 9, with 1 having the most exposed skin and 9 having the least. They determined that the larger the group size, the lower the feather score. This was altered significantly ($P<.01$) by placing partitions in the cage with small openings to allow the hens to move from side to side thus dividing the group in half. They also observed that hens with lowest feather scores tended to be the most fearful.

Feather pecking was minimized by keeping the upper beaks of the hens trimmed (Hill and Hunt 1978). As a result, most of the feather wear came from rubbing against the wire partitions or against each other, or scrambling over one another.

Ouart and Adams (1982) conducted two experiments where they looked at feathering using the Adams' et al. (1978) scoring system. They found the birds housed four/cage had lower average feather scores 7.1, vs. 7.4 than those housed three/cage. Along with this, they felt that nervousness and feather damage may be related indicating a possible relationship between feather score and nervousness.

VanSkike (1982) found that cage shape had an effect on feather score. Hens in the deep cages had the lowest score (least feathers) while those in the shallow cages had the highest scores. The other parameters that he examined did not effect the feather score.

Effect of Feed Trough Partitions. The social structure in a group of hens develops at a young age. Guhl (1953) found that social hierarchies developed in flocks of strangers in a relatively short time. He stated that the birds at the high end of the hierarchy had priority for food, water and other limited resources, leaving birds of low rank without sufficient resources to maintain production or possibly life. Aggressive acts of high ranking birds against low ranking birds was the cause forcing the low ranking birds away from resources, mainly feed. Al-Rawi and Craig (1975) and Al-Rawi et al. (1976) determined that agonistic acts occurred more frequently when the birds were feeding, with more being pecks than threats.

Bouissou (1970) reviewed studies involving social hierarchies of domestic cattle. She found that after social orders were established, they lead to a relatively balanced group with low levels of interaction. However, even with these conditions, animals of low rank were at a disadvantage, especially in relation to feeding time, which could have detrimental effects on productivity. She conducted an experiment utilizing feed trough partitions, to allow low ranking animals to feed for longer time periods without interference from superiors within the herd. She found that partitions which protected just the head, allowed the subordinate animal to feed without interference, thus effectively reducing the dominant animal's effect.

Meunier-Salaun and Faure (1984) conducted an experiment where they divided feeding space of 75 cm^2 into different spatial arrangements. Areas were devised as follows: one (75 cm^2) area, three (25 cm^2) areas adjacent to one another, three (25 cm^2) areas 10 cm apart, three (25 cm^2) areas 20cm apart and three (25 cm^2) areas 40 cm apart. Birds fed the same amount of time with the different feeder arangements. But, as spacings increased, feeding bouts became longer. Interestingly, the hens associated more at the wider feeder spacings. It was more likly to find two birds eating out of the same opening. This indicated that social facilitation occurred and had an important role in feeding behavior. Aggression was relatively constant over the different feeder arangements. Partitioning of the feeder was reported by Huon et al. (1986) to inhibit the feeding time and feeding bouts, which resulted in a reduction in feed consumption.

Further work in this area by Mankovich and Banks (1982) involved the use of space by hens within a small flock. They determined that high ranking birds predominantly occupied the space around the feeder, while the lower ranking birds centered their activity around the perch area. This set up territories for the various birds, reducing somewhat the availability of food for the lower ranking birds.

MATERIALS AND METHODS

Experiment 1.

Rearing Phase. Approximately 1800 dayold chicks of a commercial strain (Hyline W-77) were obtained from a local hatchery on January 12, 1984. The chicks were wingbanded and randomly assigned to 15 pens (5 pens of 120 chicks each per dietary regimen) in a curtain-sided, naturally ventilated brooding-rearing house. Supplemental heat was provided by natural gas fired brooders.

Chicks on both the step-up protein dietary regimens were fed a 12% crude protein (CP) diet from 0 through 12 weeks, a 16% CP energy level diet from 13 through 16 weeks, and an 18% CP energy level diet from 17 weeks to housing. The difference in the two step-up protein regimens was the energy levels of the 12% CP starter diets; 2713 and 3071 kcal ME/kg, respectively, for the step-up protein low (SUPL) and step-up protein high (SUPH) energy diets. Chicks on the step-down protein regimen (SDP) were fed diets containing 21% CP - 2823 kcal ME/kg from 0 through 6 weeks, 18% CP - 2864 kcal ME/kg from 7 through 12 weeks, and 16% CP - 3001 kcal ME/kg from 13 weeks to housing. All diets were fed *ad libitum*. Composition of the diets are shown in the appendix, Table A-1 through A-7.

Chicks were beak trimmed at 7 days of age and retrimmed at housing. They were vaccinated for the following diseases: Marek's at dayold; Newcastle and bronchitis at 10 days; Newcastle at 5 weeks; bronchitis at 7 weeks; fowlpox and avian encephalomyelitis at 12 weeks; and Newcastle and bronchitis at 16 weeks. Body weight was determined by weighing a 25 bird sample from each pen at 4, 8, 12, 16 and 18 weeks.

Laying Phase. At 18 weeks of age, the pullets were housed three or four birds per 30.5 x 45.7-cm deep or 45.7 x 30.5-cm shallow cage located in two center rows of double-deck cages in a curtain-sided, naturally ventilated house. Half of the cages had 2.6 x 5.1-cm wire and half 10 guage solid metal side and back partitions. The metal was fastened to the wire cage partitions with rivets. The solid metal back partitions had five 2.5-cm holes to facilitate air movement. Floor area per bird was 468 and 348 cm^2 in the three and four bird cages, respectively. The KSU 18% CP, 2671 kcal ME/kg layer ration was fed *ad libitum* during the laying period (appendix, Table A-8). The photoperiod was 15 hours per day. A summary of the treatments is shown in Table 1.

Performance data were collected from 20 to 68 weeks of age and were summarized by 28-day periods. Egg production data were collected 3 days per week and converted to 7 day values. Egg quality data, evaluated according to USDA standards, were based on all eggs laid during 3 days of the last week of each 28-day period.

Table 1. Summary of treatments, Exp. 1

Diet[1] no.	Den.[2]	Type of cage wall	No. of cages Deep	Shallow	No. birds
SDP	3	wire	5	4	27
SDP	4	"	5	4	36
SDP	3	solid metal	5	4	27
SDP	4	" "	5	4	36
SUPH	3	wire	5	4	27
SUPH	4	"	5	4	36
SUPH	3	solid metal	5	4	27
SUPH	4	" "	5	4	36
SUPL	3	wire	5	4	27
SUPL	4	"	5	4	36
SUPL	3	solid metal	5	4	27
SUPL	4	" "	5	4	36

[1]Diets: SDP = Step-down protein; SUPH = Step-up protein, high energy; SUPL = Step-up protein, low energy.
[2]Density: 3 = 3♀♀/ cage ; 4 = 4♀♀/ cage.

Observation of "settling in" behavior was made on the birds in each of three adjacent shallow and three adjacent deep cages to determine the adaptation of the pullets to the cage environment. Adjacent cages were used to facilitate data collection by video recorders. The pullets in these cages were randomly selected from different rearing pens within the same rearing treatment. They were marked with different colored dyes for identification when placed in the cages.

Settling in behavior was observed during days 1 to 5 and 7 post housing. The birds were exposed to 15 hours of light per day during filming. Observation equipment was two Panasonic Model NV-8050 Time Lapse-recorders with built in time-date display and two Panasonic video cameras, Model WV-3150.

The tapes were viewed utilizing a recorder and a large screen monitor. The behaviors that were evaluated, which were presented by Anderson et al. (1985), included standing, otherwise inactive (ST); crouching, off feet (CR); preening (PR); moving, walking, running, and flying (MOV); feeding and pecking movements at the feed (FE); drinking (DR); comfort movements such as stretching and feather fluffing (COM); pecking inedible objects other than feathers (PI); feather pecking (FP); and other behaviors (NA). Tabulation and summarization of the data were accomplished with the use of a computer. A scanning technique was used when viewing the tapes. Filming was done using the 24 hour mode on the recorder. Viewing was done at 12 times the normal speed (2 hour mode). In the scanning technique, a 3 min (180 sec) actual time period was viewed in 15 sec (180 sec /12 x normal recorded speed = 15 sec per viewing period). Within this 15 sec period, each chicken was observed one time and one behavior recorded. The chickens were viewed in the same order in each period. The identification colors indicated the order; white first, green second, red third and black fourth. The tapes were viewed in a random order by two trained observers to avoid any biases.

The hens that were used for the settling in observations and hens in an additional set of three adjacent shallow and deep cages were observed at 27 weeks (peak production) and 56 weeks (post-peak production) to determine the effect of feed trough partitions on agonistic and feeding behaviors. The feed trough partitions were made of 1.2-cm hardware cloth extending from the bottom of the feed trough to the top of the cage. There were four equal sized feed trough areas per cage which enabled the hens to have visual but not physical contact with each other while feeding. Each feed trough area was identified by number beginning at one on the right side and proceeding to four on the left side. There were four treatment combinations with feed trough partitions in place: shallow cage-no partitions; shallow cage-partitions; deep cage-no partitions; and deep cage-partitions. Feed consumption records for the birds in all treatments were started 1 week after the partitions were installed and continued for 1 month. Recordings of the birds' behavior were made the last 10 days of this period after which the barriers were removed.

The treatments were paired in all possible combinations and randomly assigned a recording date between 8/16 to 8/26/84 for observations at peak production and

2/18 to 2/28/85 for post-peak observations. Recordings were made every other day to allow for movement of equipment between treatments. The equipment and viewing techniques were described previously. The behaviors observed were feeding area one (FP1); feeding area two (FP2); feeding area three (FP3); feeding area four (FP4); drinking (DR); intra-cage aggression (INC); inter-cage aggression (BEC); and other behaviors (O).

Feather cover scores of the hens were recorded at 65 weeks of age using the system of Adams et al. (1978).

Experiment 2.

Rearing Phase. Approximately 1900 dayold chicks of a commercial strain (Babcock B-300V) were obtained from a local hatchery on January 18, 1985. The chicks were handled as described in Experiment 1 except that a sample of 25 dayold chicks was selected from each pen and weighed.

Statistical Analysis. The primary method was the standard analysis of variance. Pen (treatment) was used as the estimate of experimental error in the analysis of pullet rearing data in both experiments. Means were separated via Duncan's Multiple Range Test (Duncan, 1955) for Experiment 1 and Least Significant Differences (LSD) for Experiment 2. The means for egg production, egg quality, settling in, and type of partition were separated using the LSD method. Feeding location preference data for birds in cages with partitions in the feed trough, were analyzed by the Chi Square method.

RESULTS AND DISCUSSION

Effect of Rearing Diets on Performance.

Experiment 1. The means for body weight and feed consumption from 0 - 19 weeks are shown in Table 2.

Table 2. Effect of rearing diets on average body weight and total feed consumption, Exp. 1

Treatments	Avg body weight (g)					Feed cons.
Age (wk)	4	8	12	16	19	(g/hen)
SDP[1]	271^{a}[2]	688^{a}	980^{a}	1306^{a}	1391^{a}	7504^{a}
SUPH	148^{b}	381^{c}	719^{c}	1101^{b}	1218^{c}	6030^{b}
SUPL	151^{b}	423^{b}	795^{b}	1103^{b}	1259^{b}	7026^{a}

[1]SDP = Step-down protein diets.
SUPH = Step-up protein diets, high energy.
SUPL = Step-up protein diets, low energy.
[2]Different superscripts within columns denote significant difference at P<.05.

Pullets grown on the step-down protein diet (SDP) had significantly (P<.05) heavier body weights at 4, 8, 12, 16 and 19 weeks of age than those grown on either SUPH or SUPL diets. The SUPH fed pullets were the lightest in weight, weighing significantly (P<.05) less at 8, 12 and 19 weeks than those fed the other two dietary regimens. These results are supported by the work of Leeson and Summers (1978) who reported birds on SUP diets weighed significantly less at 20 weeks of age than birds reared on

SDP diets. The differences in body weight were the most extreme between the birds fed the SDP and those fed the SUPH diets. Leeson and Summers (1984) reported that pullets raised on SUP diets were lighter and consumed lower levels of protein and energy than birds fed SDP diets. Feed consumption (Table 2) for birds fed the SDP, SUPH, and SUPL diets was 7504, 6030, and 7026 g, respectively, showing that only birds reared on the SUPH diets consumed significantly (P<.05) less feed. Savage (1977) calculated the total nutrient needs of growing a White Leghorn pullet to 20 weeks to be 1020 g of crude protein, a minimum of 18,600 kcal ME and 63 g of calcium. His data suggest that the calculated consumption of 925.2 g of crude protein and 18,230 kcal ME of energy per pullet reared on the SUPH diets severely restricted their growth and development, resulting in lighter body weights. Whereas the estimated energy, protein and calcium consumption of the birds reared on the SDP and SUPL diets was in excess of Savage's (1977) recommendations. This suggests that the SUPH diets were inadequate for adequate growth and development, but the SDP and SUPL diets were adequate, producing birds of comparable body weight.

Experiment 2. The means for body weight and feed consumption are shown in Table 3. Pullets grown on the SDP diets were significantly (P<.05) heavier throughout the growing period than those fed the SUPH and SUPL diets.

Table 3. Effect of rearing diets on average body weight and total feed consumption, Exp. 2

Treatments Age (wk)	4	Avg body weight (g) 8	12	16	19	Feed cons. (g/hen)
SDP[1]	210^{a2}	493^{a}	882^{a}	1127^{a}	1318^{a}	9817^{a}
SUPH	157^{b}	370^{b}	690^{c}	1019^{c}	1199^{b}	7705^{b}
SUPL	153^{b}	385^{b}	731^{b}	1056^{b}	1211^{b}	8829^{b}

[1]SDP = Step-down protein diets.
SUPH = Step-up protein diets, high energy.
SUPL = Step-up protein diets, low energy.
[2]Different superscripts within columns denote significant difference at P<.05.

These data suggest that the SUPH fed pullets exhibited compensatory weight gain after 16 weeks as their 19 week body weight was not significantly different than that of the SUPL fed birds. The SUPH fed pullets consumed the least amount of feed, however, their consumption was only significantly (P<.05) different from that of SDP fed pullets (7705 vs. 9817 g). Feed consumption was considerably higher in this experiment than in Experiment 1. This difference may have been due to the different feeding methods or the different strains used in this experiment which appeared to result in more feed usage.

Effect of Rearing Diets on Layer Performance (Exp. 1).

Age at sexual maturity for hens raised on the SDP diet was significantly ($P<.05$) earlier than for those on the SUPH or SUPL diets, 22.5 vs. 24.6 and 24.1 weeks, respectively (Table 4). Leeson and Summers (1979) found that hens reared on (SUP) diets reached maturity at 23.57 weeks vs. 22.43 weeks for those on (SDP) diets, which supports my results.

Table 4. Age at sexual maturity, eggs produced, mortality, body weight gain and feed conversion of hens fed SDP, SUPH or SUPL diets, Exp. 1

Trt.	Age at sexual maturity (wk)[1]	Eggs prod.[2]	Mortality %	Body wt gain %[3]	g egg/ g feed
SDP	22.5^{a}[4]	217^{a}	13.5^{a}	32.3^{a}	.340^{b}
SUPH	24.6^{c}	229^{ab}	8.2^{a}	47.5^{b}	.336^{a}
SUPL	24.1^{b}	231^{b}	7.5^{a}	44.7^{b}	.344^{b}

[1]Age at which 50% production was attained.
[2]Eggs produced = number in 3 days x 7/3.
[3]Body weight gain = ending weight - beginning weight/ beginning weight x 100.
[4]Different superscripts within columns denote significant difference at $P<.05$.

This delay in maturity seems to be related to the body weight, since the data in Table 3 show that those pullets grown on the SUPH or SUPL diets were significantly ($P<.05$) lighter at housing (19 weeks) and matured the latest.

Data in Table 4 show the hens which were raised on the SDP diets produced significantly fewer eggs (217) than the hens raised on the SUPL diets (231), but not significantly more than those on the SUPH diets (229 eggs). Bish (1984) reported that hens reared on SDP protein diets produced fewer and larger eggs, than those on the SUP protein diets. There were no significant differences in mortality among the rearing treatments, however, hens reared on the SDP diets had higher mortality than either the SUPH or SUPL fed hens. Hens reared on the SUPH diets had the greatest overall body weight gain (Table 4), 47.5%, while hens on the SDP or SUPL diets gained 32.3 and 44.7%, respectively. The SDP reared birds were significantly (P<.05) heavier at housing (19 weeks) than either the SUPH or SUPL reared birds. The SUPH reared birds were the lightest at housing, thus had the most weight to gain.

Hens which were reared on the SUPH diets had significantly poorer feed conversion (.336 g egg/g feed) when compared to birds grown on SDP or SUPL diets, .340 and .344 g egg/g feed, respectively (Table 4). This may have been because the SUPH fed hens, who were the lightest weight at housing, diverted nutrients into body growth at the expense of egg production, resulting in a lower feed conversion.

The data in Table 5 show that altered energy levels or a high protein prestarter in the SUP diets used throughout the rearing period also improved total egg mass, but resulted in the production of significantly more medium sized eggs. I utilized different energy levels to increase

Table 5. Total egg mass, egg quality, feather score of hens reared on either SDP, SUPH or SUPL diets, Exp. 1

Trt.	Egg Mass g egg/hen	Lg	Med	Sm	Crack	UG	Loss	Feather score[1]
		%						
SDP	11064^{a}[2]	76.7^{b}	18.6^{a}	1.6^{a}	1.9^{a}	3.0^{a}	1.5^{b}	5.1^{a}
SUPH	12294^{b}	66.9^{a}	23.7^{b}	3.2^{a}	1.9^{a}	3.1^{a}	1.3^{ab}	5.4^{a}
SUPL	12330^{b}	70.1^{ab}	20.4^{ab}	3.2^{a}	2.5^{a}	3.4^{a}	0.5^{a}	5.3^{a}

[1]Higher feather score = better feather cover (1-9).
[2]Different superscripts within columns denote significant difference at $P<.05$.

initial feed consumption whereas Bish (1984) used an 18% crude protein prestarter diet for either 1, 2 or 3 weeks before placing the chicks on SUP diets. Using different energy levels in this study may have resulted in differences in composition between birds reared on SDP vs. SUPH and SUPL diets. The SDP diets could have caused an increase in percentage of body fat, as noted by Leeson and Summers (1978), resulting in lower productivity. Mbugua et al. (1985) showed that feed restriction improved body composition, lowered the percentage of body fat resulting in improved egg production. However, the restriction process of feed deprivation may stress the bird, causing it to overeat when feed is available. This would reduce nutrient availability and further restrict the bird's growth. Improved body composition may result without stress being placed on the bird with the use of SUPH and SUPL diets. This may result in better utilization of the nutrients available to the bird.

The egg quality data in Table 5 show that hens reared on the SDP diets produced significantly more large eggs, 76.7 vs. 66.9%, than the hens reared on the SUPH diets. Hens reared on the SUPL diets produced 70.1% large eggs which was significantly (P<.05) less than that of the hens reared on the SDP diets. These results indicate that the SDP fed hens that had the heaviest body weight at housing produced the highest percentage of large eggs, but the lowest amount of total egg mass (SDP = 11064, SUPH = 12294, SUPL = 12330 g/hen). These results favor the lighter weight hens reared on the SUPH and SUPL diets. Rearing diet had no significant effect on the subsequent feather score of the hens.

Effect of Density. Age at sexual maturity was not significantly affected by bird density. But bird density adversely affected most other production parameters as shown in Table 6.

Table 6. Effect of bird density, cage shape and type of cage partition on age at maturity, eggs produced, mortality, body weight gain and feed conversion

Trt.	Age at sexual maturity (wk)	Eggs prod.[1]	Mortality (%)	Body wt gain %[2]	g egg/ g feed
Density:					
3 hens	23.7	238***	6.9*	42.0	.362*
4 hens	23.7	217	12.5	41.0	.384
Shape:					
Deep	23.9	230	6.1**	40.6	.352*
Shallow	23.5	222	13.3	42.3	.400
Partition:					
Wire	23.7	228	10.2	40.5	.341
Solid	23.7	224	9.3	42.5	.340

*(P<.05) **(P<.01) ***(P<.001)

1 Eggs produced = 3 day collection * 7/3.

2 Body weight gain = ending weight - beginning weight /beginning * 100.

Four hens per cage laid significantly (P<.001) fewer eggs (217 vs. 238) and had significantly (P<.05) higher mortality (12.5 vs. 6.9%) than three per cage. Significant depression of most production parameters was also found by Sefton (1976) and Al-Rawi et al. (1976). There was no significant difference between percent body weight gain for hens housed three or four/cage. Feed conversion for four hens per cage was significantly (P<.05) better, .384 vs. .362 g egg/g feed, than for three. This contradicts the results presented by Swanson and Bell (1977) who reported feed conversion was depressed at higher bird densities. It may be that the hens at the lower density in this study spent more time playing with the feed, resulting in more feed wastage. Cunningham and Ostrander (1981) and Adams and Craig (1985) reported that decreasing floor area significantly depressed egg production and depressed feed efficiency.

The data in Table 7 show that the percentage of undergrades produced was significantly (P<.01) greater for hens housed four/cage than three/cage (4.3 vs. 2.0%). This may have been caused by hens damaging the eggs after lay. The average feather score for four hens/cage was significantly (P<.001) lower, 4.7 vs. 5.8, than for three hens/cage. Hughes and Black (1977), Adams et al. (1978) and Ramos (1985) reported that four hens/cage had significantly poorer feather cover than three/cage. Craig et al. (1983) found latency to feeding, a test of fearfulness, to be much greater for hens with poor feather scores which indicates a relationship between feather score and fearfulness.

Effect of Cage Shape. The shape of the cage had no significant effect on the age at sexual maturity of the hens, Table 6, confirming a report by Ramos (1985) in which hens housed either four or three/cage matured at 160 and 162 days, respectively. This study shows that hens in deep cages produced more eggs per bird, though not significantly more, than those in shallow cages, 230 vs. 222. In contrast, Lee and Bolton (1976) reported their shallow caged hens produced significantly more eggs. As shown in Table 6, mortality was significantly ($P<.01$) affected by cage shape with the shallow caged hens having higher mortality than the deep caged hens (13.3 vs. 6.1%). Contrary to this, Baiao and Campos (1979) and Bell (1972) found that livability was better in shallow than deep cages. Body weight gains were similar for both densities. Even with lower production, the hens in shallow cages had significantly ($P<.05$) better feed efficency, .400 vs. .352 g egg/g feed, than those in deep cages (Table 6). This may have resulted from less bird activity and work to gain position for feed as suggested by Hill and Hunt (1978). Egg mass, egg quality, and feather scores were not significantly affected by cage shape, Table 7.

Table 7. Effect of bird density, cage shape and type of cage partition on egg mass, egg quality and feather score

Trt.	Egg mass g egg/hen	Lg	Med	Sm %	Crack	UG	Loss	Feather score[1]
Density:								
3 Hens	12832	73.9	21.2	2.4	2.0	2.0**	0.9	5.8***
4 Hens	11195	68.6	20.6	3.0	2.2	4.3	1.4	4.7
Shape:								
Deep	11987	71.1	22.0	3.0	2.3	2.6	1.3	5.2
Shallow	11805	71.4	19.8	2.4	1.9	3.8	0.9	5.3
Partition:								
Wire	12138	71.5	21.7	2.9	2.0	3.6	0.9	5.1
Solid	11655	71.0	20.0	2.5	2.2	2.7	1.3	5.4

*(P<.05) **(P<.01) ***(P<.001).

[1]Higher feather score = better feather cover (1-9).

Effect of cage side partition. The type of cage partition did not have a significant effect on the production parameters shown in Table 6. These findings are supported by previous work conducted by Adams (1983) and Ramos (1985). They found only slight and nonsignificant advantages for egg production and feed conversion of hens housed in cages with solid partitions compared to those in cages with wire partitions. However, my study indicates that hens in cages with wire partitions had a nonsignificant advantage in eggs produced, 228 vs. 224, for those in cages with solid partitions. Data in Table 7 show that type of cage side partition had no effect on egg quality data. Ramos (1985) obtained similar results.

A significant (P<.05) interaction of bird density by type of cage side partition for feather score was observed. Data in Table 8 show that birds housed four/cage with

Table 8. Means for bird density by cage partition interaction for feather scores

Bird density - Partition	Feather Score[1]
3 birds/cage - wire	5.80[a]
3 birds/cage - solid	5.73[a]
4 birds/cage - wire	4.32[c]
4 birds/cage - solid	5.15[b]

[1]Higher number indicates better feather cover.
[abc]Superscript denotes significant difference (P<.05).

solid partitions had significantly ($P<.05$) higher feather score than four birds housed in cages with wire partitions. This indicates that cages with solid sides caused less feather damage at the higher bird density possibly because of the reduced abrasion. Birds housed at three/cage in cages with wire or solid partitions had feather scores which were not significantly different, but, both had significantly ($P<.05$) better feather scores than birds housed at four/cage. However, as Craig et al. (1983) and Ouart and Adams (1982) stated, loss of feathers may increase nervousness in the hens. With an increase in nervousness, the increase inactivity could have caused the increase in loss eggs and the significant increase in undergrades for the hens housed at four/cage.

There was a significant ($P<.05$) cage shape by cage partition interaction (Table 9) for feather scores.

Table 9. Means for cage shape by cage partition interaction for feather scores

Cage shape - partition	Feather Score[1]
Deep cage - wire	5.20^{ab}
Deep cage - solid	5.15^{ab}
Shallow cage - wire	4.92^{b}
Shallow cage - solid	5.72^{a}

[1]Higher number indicates better feather cover.
[ab]Superscript denotes significant difference ($P<.05$).

The birds in shallow cages with solid sides had significantly (P<.05) higher feather scores than birds in shallow cages with wire sides. This seems to indicate that hens in deep cages lost more feathers due to bird to bird abrasion than bird to cage partition abrasion. Hens in shallow cages lost feathers due to wire cage partition abrasion which was significantly (P<.05) reduced with solid metal partitions.

Adaptation to the Environment "Settling In" Behavior. Crouching was the predominant activity on days 1 and 2 post-housing as shown in Table 10 but the frequency declined throughout the 7 day period (Figure 2). This suggests that crouching may have been a display of fearfulness to the new environment as Duncan (1980) suggested that crouching is related to anti-predator behavior. This implies that a bird may display a significant increase in crouching when placed in a new environment or a fearful situation. As birds adapted to the new environment in this study, crouching activity declined in frequency and other activities increased.

The birds in deep cages spent significantly (P<.05) more periods standing than those in the shallow cages. This may have been a result of competition for available feeder space. The data show that birds housed in either deep or shallow cages fed a similar number of periods throughout the settling in period. Therefore, the greater standing activity of the deep caged birds may have been due to the constant changing of places at the feed trough, which must take place for all birds to feed at a rate similar to that of the birds in shallow cages. Birds in shallow cages exhibited significantly ($P<.05$) less moving activity since all could feed simultaneously, unlike the deep caged hens. Few aggressive acts were observed during the "settling in" stage when the pullets were adapting to their new environment in the cage with strangers. The only recorded aggressive activity occurred in the deep cages but incidence was too infrequent to analyze. This agrees with Cunningham (1981) who reported that birds in shallow cages initiated fewer aggressive acts than those in deep cages. The birds in deep and shallow cages showed no other significant activity differences.

The day post housing had a significant effect on all the activities observed. Williams et al. (1977) found that social interactions were high when the pullets were initially housed, then leveled off within 10 days. Data in Table 10 show the same general trend, except that the patterns of behavior were changed. Standing activity, as shown in Fig. 1, was the highest on day 1, declined during day 2, rose on days 3 and 4, then was not significantly different on days 5 and 7.

Table 10. Effect of cage shape and days post-housing on "settling in" behaviors

Trt.	Stand	Crouch	Preen	Feed	Comfort Activity[2]	PI[1]	FP[1]	Move
Shape:								
Deep	4.55*	6.39*	2.47	4.01	0.02	0.55	0.35	1.00*
Shallow	2.83	8.77	1.99	3.99	0.01	0.67	0.27	0.64
Day:								
1	4.13^{a}[3]	8.95^{a}	1.20^{d}	3.59^{cd}	0.03^{b}	0.42^{b}	0.37^{a}	0.82^{a}
2	2.99^{c}	8.53^{a}	2.03^{c}	4.18^{abc}	<.01^{c}	0.75^{a}	0.23^{ab}	0.83^{a}
3	3.45^{bc}	7.49^{b}	2.51^{ab}	3.77^{bcd}	0.00^{c}	0.72^{a}	0.13^{b}	0.78^{a}
4	4.06^{ab}	7.16^{bc}	2.61^{a}	3.54^{d}	0.07^{a}	0.41^{b}	0.39^{a}	0.96^{a}
5	3.63^{abc}	6.85^{bc}	2.74^{a}	4.36^{ab}	<.01^{c}	0.62^{ab}	0.37^{a}	0.76^{a}
7	3.88^{ab}	6.50^{c}	2.29^{bc}	4.57^{a}	0.00^{c}	0.74^{a}	0.37^{a}	0.77^{a}

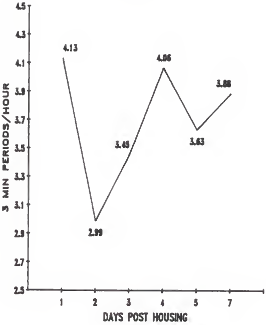
* ($P<.05$).
[1]PI = pecking inedible objects; FP = feather pecking.
[2]Activity= number of 3 minute periods/hr behavior was observed.
[3]Different superscripts within columns denote significant difference at $P<.05$.

Figure 2 shows that crouching activity had a linear trend downward as days post housing increased. This suggests that if crouching is considered a fear related activity, it may be a good indicator of adaptation since the birds became less fearful and increased other activities during this period.

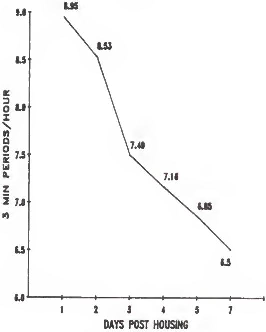
Preening activity as shown in Fig. 3 began at a low level during day 1 post housing, increased to day 5, then declined. This trend may indicate that preening is an alternative activity to crouching until the time period when the other activities normalize.

Syme (1974) felt that feather pecking, a type of social grooming with no injury intent, may be a form of recognition between birds. Feather pecking data shown in Fig. 4, display a development pattern opposite of preening, being high initially, when familiarity would have been low, declining to day 3, then rising to day 4, and not being significantly different from days 5 and 7. The plateau in feather pecking at days 4 - 7 post housing may indicate the point at which the birds became socially adapted to each other. Comfort activity displayed no significant trends in development. Pecking of inedible objects (PI) had a pattern of development illustrated in Fig. 5 and seemed to be related to that of feeding and feather pecking. An increase in PI occurred as feather

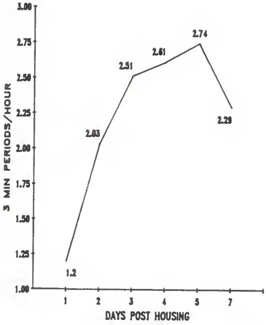
SETTLING IN BEHAVIOR
STANDING
FIG. 1



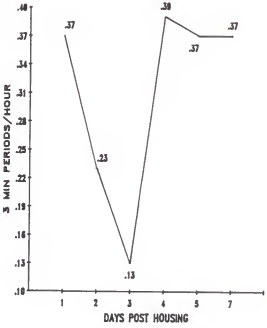
SETTLING IN BEHAVIOR
CROUCHING
FIG. 2



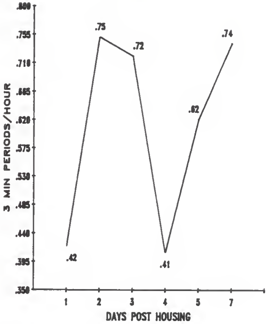
SETTLING IN BEHAVIOR
PREENING
FIG. 3



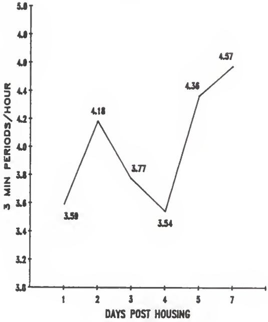
SETTLING IN BEHAVIOR
FEATHER PECKING
FIG. 4



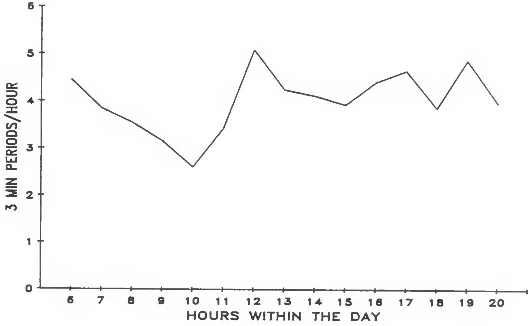
SETTLING IN BEHAVIOR
PECKING INEDIBLE OBJECT
FIG. 5



SETTLING IN BEHAVIOR
FEEDING
FIG. 6



SETTLING IN BEHAVIOR
FEEDING
FIG. 7



pecking decreased.

Feeding activity data in Fig. 6 shows that feeding activity was lowest on day 1, possibly from unfamiliarity with the environment. But feeding activity significantly increased the following day, most likely because of increasing hunger. The number of periods of feeding activity declined during days 3 and 4 then plateaued which seems to indicate adaptation to their environment. Guhl (1953) was of the opinion that aggression occurs when birds are competing for resources of feed, water and space. This may have been the reason for changes in feeding activity however, little aggression was observed. Recent studies by Banks et. al (1979) and Craig and Ramos (1986) and review articles by Syme (1974) and Craig (1986) raise questions about the acceptance of such general assumptions. The diurnal feeding pattern shown in Fig. 7 for the birds in both deep and shallow cages was similar. Feeding activity was at high levels initially after lights on (0600 hour) and just prior to lights off (2000 hour). Feeding was at the lowest level at 1000 hour in this experiment. At approximately (1130 hour), the birds were fed causing a significant ($P<.05$) rise in periods of feeding activity which peaked at (1200 hour) then declined the next 2 hours and increased 4 hours prior to lights out. This diurnal pattern suggests the distorted U-shaped pattern described by Hughes and Black (1977). The high feeding activity levels initially after lights on and prior to lights off, with a significant increase in feeding activity at feeding time, correspond with their work. Both patterns were disrupted at feeding time which caused a significant rise in activity forming two U shaped patterns, one in the morning and the other in the afternoon.

This study indicates that frequencies of most behaviors (Table 10) ceased to change significantly after day 3 post housing. These data suggest a much shorter time span than Guhl (1953) and Williams et al. (1977) who found that activities stabilized within 10 days post-housing. Murchison (1936) determined that a group size of four birds would need 22 weeks maximum in which to stabilize to a linear hierarchy. My data appear to disagree with this research in that the hens settled into a pattern at 4 days. My observations were concerned with stabilization of behaviors and not the establishment of discernable social hierarchies. Syme et al. (1984) felt that the birds learn to discriminate between the other birds of different ranks, thus reducing the number of periods of high social interaction. Since all birds were strangers when brought together in this study, reduced performance of the birds did not occur as described by Duncan et al. (1978). My results favor those of Adams (1974) who reported that introducing strange hens in the cage had no significant effect on productivity of hens housed four/cage.

Effects of Feed Trough Partitions. Cage shape had no significant effect on eggs per day but did increase feed consumption in deep cages as shown in Table 11. Feed

Table 11. Effect of cage shape, feed trough partition and age on total feed consumption, feed consumption/day, egg production/day and feed conversion[1]

Treatment	Kg feed/ day	Eggs/ day	Eggs/kg feed	Feed cons (kg)
Shape:				
Deep	0.46**	3.57	7.83	13.07**
Shallow	0.45	3.73	8.43	12.63
Partition:				
With	0.46	3.47	7.61*	13.04**
Without	0.45	3.83	8.65	12.66
Age:				
27	0.41**	3.89	9.47**	
56	0.50	3.40	6.79	

*(P<.10) **(P<.05).
[1]All data calculated on a per cage basis.

efficiency was significantly depressed with the presence of partitions, 7.61 vs. 8.65 eggs/kg feed for feeders with or without partitions, respectively. Feed consumption, expressed as kg/day/cage or total consumption, was significantly (P<.05) affected by cage shape, deep caged hens consuming more than shallow caged hens(.46 and 13.07 vs. .45 and 12.63 kg). Feeding behavior data in Table 12

Table 12. Total periods of feeding, drinking, aggression and alternative behaviors for hens with and without feed trough partitions

Treatment	Total feed periods[1]	Drink[1]	Aggression within cage[1]	Aggression between cages[1]	Alternative behaviors[1]
Shape:					
Deep	6.64***	1.48	0.02**	<.01	11.86***
Shallow	8.23	1.40	0.01	<.01	10.36
Partition:					
Partition	7.52	1.52	0.02*	<.01	11.27
No Partition	7.35	1.36	0.01	<.01	10.95
Age:					
27 weeks	8.27*	1.92*	0.02*	<.01	9.79
56 weeks	6.61	0.95	0.01	<.01	12.43*

*(P<.05) **(P<.01) ***(P<.001).

[1]All behaviors represent number of 3 minute periods/hour.

show that birds in deep cages spent significantly ($P<.001$) fewer periods per hour feeding than birds in shallow cages. This seems to indicate total feed consumption is not related to time spent at the feeder in an ad-libitum situation. The birds in deep cages also spent significantly ($P<.001$) more time performing alternative behaviors than those in shallow cages. Which was altered by the presence of feed trough partitions which reduced the number of alternative behaviors performed. Feed consumption (Table 11) was significantly ($P<.05$) increased (13.04 vs. 12.66 kg/cage) by the presence of partitions. It is not known if the insertion of the partitions at 27 and 56 weeks of age caused the decline of production.

Partitions in the feed trough, as suggested by Bouissou (1970) from her work with dairy cattle, increased time at the feeder, possibly increasing feed consumption of the lower ranking animals. Birds in cages with feed trough partitions did not feed significantly more than birds in cages without partitions (Table 12). This may indicate that vertical wires, which make up the front of the cage, acted as a feed trough partition. Bouissou (1970) found that even a single bar dividing the feed trough of dairy cattle increased feeding time. As shown in Table 11, even though feeding periods were not significantly different, the total amount of feed consumed per hen was significantly

(P<.05) increased with partitions, 13.04 vs. 12.66 kg/cage without partitions, respectively. Aggression was significantly different for cages with and without partitions. This seems to indicate that partitions in deep cages may obstruct access to the feed trough by some birds causing increased aggression. In this study a cage type by feed trough partition interaction for total feeding periods shown in Table 13, supports Bouissou's (1970) results, but only in deep cages where there was not sufficient space for all birds to feed simultaneously, thus reducing the possible benefits of partitions within the feed trough.

Table 13. Cage shape by feed trough partition interaction for means of total feeding periods

Cage shape - feed trough partition	Total periods feeding
Deep - partition	6.23[a1]
Deep - no partition	7.05[b]
Shallow - partition	8.48[c]
Shallow - no partition	7.99[c]

[1]Different superscripts within columns denote significant difference at (P<.05).

The age of the birds caused significant (P<.05) differences in feed consumption/day and eggs/kg feed, possibly due to a decline in egg production as the birds aged (Table 11). The young birds (27 wk.) approaching peak production consumed significantly ($P<.05$) less feed/day than at 56 weeks. This was probably caused by the smaller body capacity of the younger birds. Aggression within the cage (Table 12) was significantly ($P<.05$) higher at 27 weeks than 56 weeks (.02 vs. .01). The significant difference in total feed consumption/day may be the result of differences in the body size at 27 vs. 56 weeks of age.

Data from a randomly selected sample of hens show that hens in cages with feed trough partitions fed significantly ($P<.05$) more periods at certain positions at the feed trough (Table 14). This indicated that the hens had a preference for feeding position, suggesting a type of territorial behavior even though defense of this area (aggression) was not observed. This pattern was similar for hens kept in either deep or shallow cages with changes in this pattern occurring with age. Hens number 544 and 2662 had similar preferences at both 27 and 56 weeks of age though not identical. Hen 544 preferred position four at both ages but had no preference against a position at 56 weeks. Hen 2662 preferred position three and had a preference against feeding at position one at both ages. The other hens showed no pattern similarity between ages and hen 551 reversed its feeding position preference. As these data show, preference for feeding position does not remain constant. This expounds the idea that social structure is in a state of flux during the productive life of the hen.

Table 14. Preference for feeding location of hens in cages with feed trough partitions

Feeding position[1]	Age 27 week 1	2	3	4	56 weeks 1	2	3	4
Deep cage:								
544[2]	10[b3]	19	34[a]	37[a]	24	18	20	38[a]
551	36[a]	28	16[b]	20	26	8[b]	29	37[a]
563	38[a]	20	27	15[b]	15[b]	26	20	39[a]
Shallow cage:								
2653	16[b]	33[a]	42[a]	8[b]	27	27	13[b]	32
2662	18[b]	28	33[a]	20	6[b]	37[a]	41[a]	16[b]
2672	14[b]	44[a]	23	19	5[b]	27	23	45[a]

[1]Feeding position = location of specified space at feed trough beginning on the right for pos. 1 then progressing to the left side to pos. 4.
[2]Numbers of randomly selected hens.
[3]Numbers represent percentage of periods spent at positions.
[a]Superscript indicates significance (P<.05) greater than mean of 25% calculated by Chi square analysis.
[b]Superscript indicates significance (P<.05) less than mean of 25% calculated by Chi square analysis.

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APPENDIX

Table A-1. KSU chick starter ration, fed 0 - 6 weeks of age

Ingredients	Amount per 100kg
Yellow corn	27.50
Sorghum grain	27.50
Soybean meal (44%)	34.60
Alfalfa meal (17%)	5.00
Distillers solubles	2.00
Limestone	1.50
DiCal	1.00
Salt	0.25
KSU premix	0.50
Trace mineral mix	0.05
Choline cloride	0.01
DL - Methionine	0.05
Amprol	0.05

Calculated analysis:

Crude protein	20.89%
ME (kcal/kg)	2823.
Calcium	0.96%
Phosphorus	0.59%
Methionine	0.38%

Table A-2. KSU pullet grower ration, fed 7 - 12 weeks of age

Ingredients	Amounts per 100 kg
Yellow corn	28.60
Sorghum grain	28.50
Wheat shorts	10.00
Soybean meal (44%)	24.50
Alfalfa meal (17%)	5.00
Limestone	1.00
DiCal	1.50
Salt	0.25
KSU premix	0.50
Trace mineral mix	0.05
Choline cloride	0.01
DL - Methionine	0.05
Amprol	0.05

Calculated analysis:

Crude protein	17.90%
ME (kcal/kg)	2864.
Calcium	0.85%
Phosphorus	0.65%
Methionine	0.33%

Table A-3. KSU pullet finisher ration, fed 13 - 20 weeks of age

Ingredients	Amounts per 100 kg
Yellow corn	30.70
Sorghum grain	30.70
Ground oats	12.73
Animal fat	1.00
Soybean meal (44%)	21.00
Limestone	0.75
DiCal	2.00
Salt	0.50
KSU premix	0.50
Trace mineral mix	0.05
DL - Methionine	0.02
Amprol	0.05

Calculated analysis:

Crude protein	15.87%
ME (kcal/kg)	3001.
Calcium	0.80%
Phosphorus	0.73%
Methionine	0.27%

Table A-4. KSU experimental high energy step-up protein starter ration, fed 0 - 12 weeks of age

Ingredients	Amounts per 100 kg
Yellow corn	39.40
Sorghum grain	39.40
Ground oats	5.00
Soybean meal (44%)	11.60
Limestone	1.30
DiCal	2.50
Salt	0.20
KSU premix	0.50
Trace mineral mix	0.05
Amprol	0.05

Calculated analysis:

Crude protein	12.50%
ME (kcal/kg)	3071.
Calcium	1.09%
Phosphorus	0.78%
Methionine	0.21%

Table A-5. KSU experimental low energy step-up protein starter ration, fed 0 - 12 weeks of age

Ingredients	Amounts per 100 kg
Yellow corn	15.00
Ground oats	67.00
Wheat middlings	9.80
Soybean meal (44%)	4.00
Limestone	1.70
DiCal	1.50
Salt	0.25
KSU premix	0.50
Trace mineral mix	0.05
Amprol	0.02

Calculate analysis:

Crude protein	12.25%
ME (kcal/kg)	2713.
Calcium	1.03%
Phosphorus	0.62%
Methionine	0.20%

Table A-6. KSU experimental step-up protein grower ration, fed 13-16 weeks of age

Ingredients	Amounts per 100 kg
Yellow corn	30.70
Sorghum grain	30.70
Ground oats	12.73
Animal fat	1.00
Soybean meal (44%)	21.00
Limestone	0.75
DiCal	2.00
Salt	0.50
KSU premix	0.50
Trace mineral mix	0.05
DL - Methionine	0.02
Amprol	0.05

Calculated analysis:

Crude protein	15.87%
ME (kcal/kg)	3001.
Calcium	0.80%
Phosphorus	0.73%
Methionine	0.27%

Table A-7. KSU experimental step-up protein finishing ration, fed 17 - 20 weeks of age

Ingredients	Amount per 100 kg
Yellow corn	33.17
Sorghum grain	30.00
Ground oats	2.00
Animal fat	1.00
Soybean meal (44%)	30.00
Limestone	0.75
DiCal	2.00
Salt	0.50
KSU premix	0.50
Trace mineral mix	0.05
DL - Methionine	0.02

Calculated analysis:

Crude protein	18.47%
ME (kcal/kg)	2991.
Calcium	0.81%
Phosphorus	0.75%
Methionine	0.31%

Table A-8. KSU layer ration, fed during egg production period

Ingredients	Amounts per 100 kg
Yellow corn	29.49
Sorghum grain	29.49
Soybean meal (44%)	28.49
Alfalfa meal (17%)	2.49
Limestone	3.34
Oyster shell	3.34
DiCal	2.50
Salt	0.24
KSU premix	0.50
Trace mineral mix	0.05
DL - Methionine	0.07

Calculated analysis:

Crude protein	18.54
ME (kcal/kg)	2671.
Calcium	3.21
Phosphorus	0.81
Methionine	0.38

Table A-9. Analysis of variance for average body weight and total feed consumption, Exp. 1

Source of variation	df	Body weight -MS-	Total feed consumption -MS-
Treatment (T)	2	33191196.97***	2827646.67**
Error pen (T)	12	221831.22	284186.67
Period (P)	4	315529063.45***	
TxP	8	793569.06***	
Error	48	62970.97	

(P<.01) *(P<.001)

Table A-10. Analysis of variance for average body weight and total feed consumption, Exp. 2

Source of variation	df	Body weight -MS-	Total feed consumption -MS-
Treatment (T)	2	10143151.57***	111668948.44**
Error pen (T)	12	146986.85	1524143.87
Period (P)	4	444747852.55***	
TxP	8	345498.61***	
Error	48	35316.68	

(P<.01) *(P<.001)

Table A-11. Analysis of variance for effect of rearing diets, bird density, cage shape and type of cage partition on age at sexual maturity, eggs produced, mortality, body weight gains and feed conversion

Source of variation	df	Age at sexual maturity (wks) -MS-	Eggs produced -MS-	Mortality % -MS-	Body wt gain % -MS-	Feed conversion[1] -MS-
Ration (R)	2	48.60***	38.93	4.43	1559.99***	3536095.98***
Density (D)	1	0.01	903.84***	9.25*	17.21	1272836.85*
Shape (S)	1	3.61	29.67	15.45**	51.66	1367294.94*
Wall (W)	1	0.19	8.44	0.26	76.88	411306.98
RxD	2	1.17	4.28	1.82	57.97	1593915.88**
RxS	2	1.23	21.60	1.91	16.34	1127812.12*
DxS	1	0.43	28.84	2.72	1.47	2180022.92**
RxW	2	0.06	9.73	0.07	49.51	307901.82
DxW	1	0.19	5.78	4.11	254.53	94341.96
SxW	1	0.08	0.11	0.02	20.81	448429.50
RxDxS	2	4.03	18.54	0.52	55.49	1024190.09*
RxDxW	2	2.33*	28.17	1.33	139.03	53748.22
RxSxW	2	2.89	6.01	0.68	42.61	355757.38
DxSxW	1	3.06	1.44	5.80	27.39	733543.40
Error	98	1.04	16.03	1.94	108.74	244371.81

*(P<.05) **(P<.01) ***(P<.001)

[1] Feed conversion = g egg/g feed.

Table A-12. Analysis of variance for effect of rearing diets, bird density, cage shape and type of cage partition on egg mass, egg quality and feather score

Source of variation	df	Egg mass[1] -MS-	%Lg -MS-	%Med -MS-	%Sm -MS-	%Crack -MS-	%UG -MS-	%Loss -MS-	Feather score[2] -MS-
Ration (R)	2	152640368.89*	558.79*	165.69*	20.75	3.05	1.02	6.64	59.04
Density (D)	1	710756390.73***	495.45	6.47	6.13	0.19	99.93**	3.93	1922.00***
Shape (S)	1	7290201.13	2.33	82.87	6.26	1.63	20.40	2.69	37.55
Wall (W)	1	51423372.11	3.05	52.73	2.99	0.61	17.17	2.37	256.89
RxD	2	96022366.57	7.15	26.58	2.18	2.13	9.68	4.92	59.37
RxS	2	36953951.25	3.20	26.82	19.67	11.74	0.27	9.15	39.18
DxS	1	55057831.08	257.81	68.93	0.98	0.49	35.31	6.98	18.00
RxW	2	3134546.83	402.96	80.97	1.95	2.59	10.41	1.05	191.77
DxW	1	19226482.36	20.51	36.90	1.87	7.27	1.23	2.19	373.55*
SxW	1	16576031.55	62.83	85.46	67.74*	0.28	8.59	1.79	320.89*
RxDxS	2	86818888.07	279.19	85.71	12.71	0.71	2.42	4.25	52.79
RxDxW	2	142550735.78*	90.79	88.05	31.75	1.27	8.52	2.08	260.93*
RxSxW	2	721108.33	147.09	0.97	4.03	1.95	0.16	3.81	81.35
DxSxW	1	124469852.97	13.11	123.28	28.29	2.76	11.70	2.57	162.00
Error	98	3794789.30	166.73	42.70	10.00	3.95	11.96	2.76	70.45

*(P<.05) **(P<.01) ***(P<.001)

[1] Egg mass = g egg/hen.

[2] Higher feather score = better feather cover.

Table A-13. Analysis of variance for effect of cage shape and days post-housing on "settling in" behaviors

Source of variation	df	Stand -MS-	Crouch -MS-	Preen -MS-	Feed -MS-	Comfort -MS-	PI[1] -MS-	FP[1] -MS-	Moving -MS-
Shape	1	399.50**	760.45**	31.90	0.08	<.01	1.78	0.77	17.52*
Error Cage (Shape)	4	12.03	21.60	5.44	35.07	<.01	0.33	2.26	1.08
Day	5	16.33*	83.75***	28.54***	16.49*	0.06***	2.23**	0.99	0.47
ShapexDay	5	12.80*	21.05**	7.11***	14.07*	0.02**	3.36***	2.05**	2.60*
Error CagexDay(Shape)	20	4.27	5.47	0.92	4.05	<.01	0.50	0.41	0.85

*(P<.05) **(P<.01) ***(P<.001)

[1]PI = pecking inedible object; FP = feather pecking.

Table A-14. Analysis of variance for feed consumption, feed consumption/day, egg production/day, and feed conversion for hens with or without feed trough partitions

Source of variation	df	Feed/day (kg) -MS-	Eggs/day -MS-	Feed conversion -MS-	Feed consumption -MS-
Shape (S)	1	$<.01^{**}$	0.16	2.17	1.19^{*}
Partition (P)	1	$<.01$	0.78	6.34	0.84^{*}
Age (A)	1	$.05^{***}$	1.48	43.02^{***}	192.61^{***}
SxP	1	$<.01$	0.93	2.53	0.39
SxA	1	$<.01$	0.42	1.21	0.24
PxA	1	$<.01^{*}$	0.01	1.22	1.09^{*}
SxPxA	1	$<.01$	0.31	2.07	0.31
Error	16	$<.01$	0.36	1.55	0.15

$^{*}(P<.05)$ $^{**}(P<.01)$ $^{***}(P<.001)$

Table A-15. Analysis of variance for total periods feeding, drinking, aggression within cage, aggression between cages, and alternative behaviors in cages with or without feed trough partitions

Source of variation	df	Total feed periods -MS-	Drinking -MS-	Aggression within cages -MS-	Aggression between cages -MS-	Alternative behavior -MS-
Shape (S)	1	15.23***	0.04	<.01**	<.01	13.58***
Partition (P)	1	0.17	0.16	<.01*	<.01	0.64
Age (A)	1	16.51***	5.64***	<.01**	<.01	41.91***
SxP	1	2.62*	<.01	<.01	<.01	2.35
SxA	1	0.02	0.07	<.01***	<.01	0.03
PxA	1	0.01	0.02	<.01	<.01	0.31
SxPxA	1	1.18	0.09	<.01**	<.01	0.53
Error	16	0.53	0.05	<.01	<.01	0.66

*(P<.05) **(P<.01) ***(P<.001)

EFFECTS OF TYPE OF REARING DIET, CAGE SHAPE, TYPE OF CAGE PARTITION, ANDFEED TROUGH PARTITION ON THE PRODUCTIVITY AND BEHAVIOR OF LAYERS

by

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AN ABSTRACT OF A MASTER'S THESIS

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1987

Two experiments studied the effects of step-down protein (SDP) diets vs. step-up protein high energy (SUPH) diets and step-up proteinlow energy (SUPL) diets on growth and feed consumption of commercial strains of SCWL pullets.

In Experiment 1, pullets reared on the SDP diets were significantly (P<.05) heavier throughout the rearing period and at housing at 19 weeks (1391g) than birds reared on either the SUPH (1218g) or SUPL diets (1259g). Birds reared on the SUPH diets were the lightest at housing and consumed the least amount of feed (6030g). Birds fed the SDP and SUPL diets consumed significantly more feed than bird fed the SUPH diets but were not significantly different from each other (7504 vs. 7026g).

Birds reared on the SDP diets in Experiment 2 were significantly (P<.05) heavier at 19 weeks than birds reared on the SUPH or SUPL diets, 1318g vs. 1198 and 1210g, respectively. The SUPH and SUPL fed birds were not significantly different for body weight. This indicated that birds fed the SUPH diets displayed compensatory growth during the last weeks of the growing period. Feed consumption was not significantly different between the SUPH and SUPL fed birds (7705 vs. 8829g). However, both had significantly lower feed consumption than birds reared on SDP diets (9817g).

Data were recorded on the effects of rearing dietary regimens, bird density, cage shape and type of cage partitions on performance and behavior in Experiment 1. Birds reared on the SDP diets reached sexual maturity significantly (P<.05) earlier than birds reared on either the SUPH or SUPL diets, 22.5 vs. 24.6 and 24.1 weeks, respectively. The SDP reared birds also produced significantly fewer eggs with a lower total egg mass. However, their percentage of large eggs was significantly greater 76.7 vs. 66.9 or 70.1% than for SUPH or SUDL reared birds.

Increasing bird density from 3 to 4 hens/cage adversely affected production (238 vs. 217 eggs), mortality (6.9 vs. 12.5%), feed conversion (.362 vs. .384 g egg/ g feed), percentage of undergrades (2.0 vs. 4.3) and feather score (5.8 vs. 4.7). Hens in shallow cages had significantly higher feed conversion (.400 vs. .352 g egg/g feed) and lower mortality (6.1 vs. 13.3%) than those in deep cages. The type of cage wall partition had no significant effect on any of the production parameters measured.

During the settling in period it was found that activity patterns changed significantly during the first 4 days post-housing but not during days 5 to 7.

Feed trough partitions had no significant effect on eggs/day and egg production. Feed conversion was significantly ($P<.10$) depressed with feed trough partitions (7.61 vs. 8.65 eggs/ kg feed) than without partitions. A cage shape by feed trough partition interaction showed that partitions increased feeding activity in the shallow cages, where all birds could feed simultaneously, but not in the deep cages. Hens were found to have a significant ($P<.05$) preference in feeding position when the feed trough was partitioned, however, this preference in position was not the same at different ages.