Effects of Bird Age, Density, and Molt on Behavioral Profiles of Two Commercial Layer Strains in Cages[1]

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ABSTRACT Two commercial strains, Hy-Line W-36 and DeKalb XL, were moved to a laying house at 18 wk of age. They were housed 6 hens / layer cage at 2 densities (361 and 482 cm^2/bird) with 2 replications each per strain / density combination. The high-density treatment contained 24 hens / replication and the low-density treatment contained 18 hens / replication for a total of 168 hens. Production parameters were measured during the first egg production cycle, the molt period, and the first 4 wk of the second lay cycle (20 to 68 wk of age). Behavioral observations were taken during 2 consecutive d at 26, 34, 43, 51, 62, 64, and 68 wk of age to examine behavioral patterns. Modified Hansen's tests were conducted concurrently to provide indication of the fearfulness levels of hens at the various stages of production. The production characteristics were similar for both strains. The hens kept at the higher density had lower ($P < 0.01$) hen-day production and ($P < 0.05$) daily egg mass. Appetitive behaviors were not affected by strain or density but were affected by the age of the hen and by molting. During the molt, feeding and drinking behavioral acts were fewer ($P < 0.05$) at 0.018 and 0.013 acts per bird / min, respectively, and standing behavior was highest. The results indicated that the frequencies of pecking inedible objects during the molt period were similar to the frequencies at 26 and 34 wk. Hens performed more acts of standing, and crouching and had lower frequency of movement during the molt. Those kept at a low density performed more movement acts. Feather pecking decreased as hens aged and increased when they molted but was not affected by strain or density. The frequency of aggression and submissive acts was significantly lower during the molt period. Behaviors were affected by strain, density, bird age, and molting; however, the patterns and number of aggressive acts did not increase to compromise the welfare status of the hens. Behaviors during the molt appeared consistent with mechanisms for conservation of body reserves.

(*Key words*: chicken, laying hen, molt, behavior, fearfulness)

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INTRODUCTION

The molting of commercial layers has been under increased scrutiny as a common husbandry practice. This practice has been characterized as stressful (Beuving and Vonder, 1978) and frustrating (Duncan and Wood-Gush, 1971) that negatively affects the welfare of the hen due to the initial period of fasting to cease egg production (C. Akin, 2000, PETA, Norfolk, VA, personal communication). The ethogram or behavioral profile of domesticated hens includes a repertoire of behaviors including feeding, drinking, comfort, social, reproductive, and antipredator behaviors (Duncan, 1980). Agonistic behaviors such as aggression, escape and avoidance, and submission, and their relationship to stress within an animal are of particular interest as potential indicators of welfare during molting. Since the early behavioral studies and the determination of a peck order in chicks by Schjelderup-Ebbe (1922), it has been suggested that social hierarchy be used in elucidating factors involved in production aspects and bird welfare. Guhl (1956) and Craig et al. (1986) suggested these hierarchies may be formed as a result of the interaction of learned generalizations, social bonds, and hormonal sensitivities among other factors with subordinate hens having a poorer welfare status. However, the cage environment alters normal behavior patterns and may increase the incidence of stereotyped behaviors that have been suggested to negatively influence the welfare of hens.

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Abbreviation Key: AE = avoid and escape behavior; AG = aggressive acts; CORT = corticosterone; CM = comfort movement; CR = crouching behavior; DK = Dekalb XL; DR = drinking; FD = feeding; FP = feather pecking; HDP = hen-day production; HY = Hy-Line W-36; MHT = modified Hansen's test score; MV = movement; PI = pecking inedible objects; PR = preening; ST = standing; SUB = submissive act.

Webster (2000) indicated that no apparent harm and debilitation to hens were observed when they were deprived of feed for the initiation of a molt. He indicated that fasted hens adapt to the environmental change relatively quickly. Anderson et al. (1989) indicated that behavioral patterns change significantly after hens are placed in cages, suggesting a process of adaptation to management practices and physical and social environments. This adaptation process ultimately lowers the number of negative social interactions between hens, which may reduce stress and enhance welfare. Low frequency of certain behaviors supports the findings of Craig (1992) who implied that the restriction of movement in layer cages might produce unforeseen behavioral changes. He indicated that birds might display a more limited repertoire of behaviors in cages than in other environments.

Other behavioral measures investigated that are related to welfare have concentrated on stress or fearfulness responses of the hen. Jones (1987) found tests such as tonic immobility and exposure to a novel stimulus useful in determining underlying states of fear. However, in a study by Okpokho and Craig (1986), fearfulness tests such as escape or avoidance and tonic immobility indicated no significant effects due to the rearing environment, age, or habituation on fear levels. Anderson and Adams (1991, 1992) reported a number of different behaviors as environmental settings changed that did not elicit detrimental effects on production or fear responses. However, significant fearfulness at peak production (34 wk) vs. postpeak production (54 wk) was found (Anderson and Adams, 1992).

Al-Rawi and Craig (1975) found that increasing density from 2,884 cm^2 to 412 cm^2 in multiple-bird cages with populations ranging from 4 to 28 hens / cage to be effective in reducing the number of agonistic behaviors and that the frequency of pecking subsides due to the fear of being pecked by a superior. They indicated that exposing chickens to high density and multiple-bird cages might not have detrimental physiological effects on an individual bird's welfare. Siegel (1960) and Mashaly et al. (1984) indicated that increased density for hens in the production environment was indeed stressful by their indicators. Siegel (1960) indicated that birds kept in pens at higher densities of 0.4 ft^2 and populations of 30 birds / pen had heavier adrenals and lighter bursas than hens provided 1.0 ft^2/bird with 12 birds / pen. Marshaly et al. (1984) indicated that 5 hens housed at 310 cm^2 had higher corticosterone (CORT) levels than 3 or 4 hens housed at 516 and 387 cm^2, respectively. The work by Davis et al. (2000) does not support this hypothesis by showing that hens kept at a higher density and a constant population of 6 hens had no significant effect on indicators of stress. They showed that CORT levels and heterophil:lymphocyte ratios were no different between densities of 361 and 482 cm^2.

In another study, genetic strains differing in escape and avoidance activity were exposed to various densities and group sizes (Okpokho et al., 1987). Higher densities appear to cause decreases in performance characteristics such as livability, egg mass, and BW while also increasing the levels of nervousness and feather loss.

It appears that some birds have a greater ability to adapt to high density environments and larger cage populations. Craig (1992) suggested that at least some of the differences in behaviors observed among different strains under the same environmental conditions must be a result of their genetic makeup. Craig (1992) further suggested that genetics may be responsible for behaviors that have an adverse effect on hen productivity levels in multiple-bird cages. Hence, if pullets were selectively caged based on performance data and agonistic activities then adaptation to particular environments might be greatly improved from one generation to the next for particular genetic strains.

Sefton (1976) found that, although negative relationships between fearfulness and egg production as well as between fearfulness and livability exist for hens kept at 460 and 575 cm^2 or housed 2 to 3 hens / cage, no particular patterns were observed when all density and hen populations were compared. Okpokho et al. (1987) also found strains that were different in escape and avoidance behaviors differed in nervousness and feather loss. They also showed that feather loss appears to accompany those birds that are more fearful. Craig et al. (1986) found that increased group size is also accompanied by increased feather loss. Hens in single-bird cages had significantly reduced fearfulness levels, whereas hens in 4- and 6-bird cages had similar fearfulness levels.

The correlation of these behavioral indices should aid in solidifying, at least in some part, previous notions about the effects strain, density, and molting, as they relate to poultry behavior, have on hen welfare in laying operations. This study attempts to elucidate behavioral responses of poultry housed at 2 different densities and how these densities may reflect upon behavior as an indicator of the well-being of a hen. Therefore, the objectives of this study were to determine the effects of strain, density, bird age, and molt on behavioral profiles and fearfulness of commercial laying hens as potential indicators of welfare.

MATERIALS AND METHODS

Two commercial strains of laying hens, Hy-Line W-36 (HY) and DeKalb XL (DK), were reared separately as pullet flocks in an enclosed, environmentally controlled brood-grow house with 3 banks of trideck cages (310 cm^2 per bird). During the pullet phase, we used a step-down lighting program with flourescent lights beginning at 23L:1D at 1 d of age and ending at 15L:9D at 18 wk of age. Temperatures were maintained at 26.7 ± 3°C during the pullet and laying phases. At 18 wk of age, the hens were transferred to an enclosed, mechanically ventilated layer house. The 2 strains were housed 6 hens / cage in quaddeck layer cages at 2 densities (361 and 482 cm^2 per bird) with 2 replications for each strain and density combination. The high density replicates contained four 61 × 35.5-cm cages (24 hens per replicate), and the low density replicates contained three 81 × 35.5-cm cages (18 hens per replicate). Production parameters for each replicate were measured biweekly during the first egg production cycle, a molt period, and the first 4 wk of the second cycle (20 to 68 wk of age). The hens were exposed to a step-up lighting program, using fluorescent lights as the light source, to 16.5L:7.5D at 36 wk of age. The birds were fully fed a layer ration until 63 wk of age when the molt was induced by feed withdrawal for 14 d. When the molt period was initiated at 63 wk, the day length was reduced to 8L:16D for 2 wk, which resulted in approximately 30% reduction in average body weight. Full feeding was then resumed at 65 wk of age, and the day length was increased to 14.5L:9.5D and then increased by 1 h / wk to 16.5L:7.5D at 67 wk. The husbandry and research protocols were in accordance with the Institutional Animal Care and Use Committee approval.

Behavioral observations were taken during 2 consecutive d at 26, 34, 43, 51, 62, 64 (observed on d 3 and 4 after fast initiated) and at 68 wk of age to examine daily behavioral patterns utilizing the modified scanning technique developed by Anderson and Adams (1991). During observation periods, the observer was dressed in caretaker attire and stood 1.5 m from the front of the cage within the replicate to minimize potential impact on hen behavior. If hens showed signs of behavior disruption, the observer began the observations after the hens resumed their normal activity. Each cage was then observed for two 5-min periods at approximately 50-min intervals beginning at lights on (0500 h), midday (1200 h), and evening (1800 h). Within each 5-min period, the behavioral acts independent of cage mates, standing (ST), crouching (CR), preening (PR), moving (MV), feeding (FD), drinking (DR), comfort movements (CM), and pecking inedible objects (PI), were recorded. The behaviors performed by each hen, within the cage being observed, at the moment of observation were recorded once per minute during the 5-min observation period. On each day of observation, 1 cage containing 6 hens in each of the replicates representing the strain × density treatment was randomly selected as the starting point, and from that point the cage in each of the replicates were observed in ascending or descending replicate order on that day. These observation times were selected based upon Anderson et al. (1989) who reported that a diurnal pattern of feeding and other activities occurred during the daylight period and these periods generally reflected the activity levels in the birds. In addition, social acts, those requiring the interaction of 2 hens, aggression (AG), avoidance and escape behavior (AE), peck neighbor, stand on, submissive acts (SUB), stood upon, pecked by neighbor, and feather pecking (FP), which did not illicit an AE behavioral response, were recorded as they occurred during each 5-min observational period. The descriptions and definitions for the 16 behaviors observed were based on the definitions of Na-Lampang (1989) and Hurnik et al. (1995). The definition for FD was modified to include feeding actions in the feed trough where feed is normally present, in order to accommodate the fasting period when no feed is present in the trough. The Hansen's test (Hansen, 1976) as modified by Jin and Craig (1988) was utilized to evaluate fear-related behavior. The modified Hansen's test (MHT) consisted of the observer moving in front of the cage, then raising an arm from the side to above the head, then lowering the arm to the feed trough, and placing the hand across the feeder. Scores are based upon a 10-s response period. The fear-related behavior testing began when the hens were 20 wk of age and was evaluated across 8 hen ages in this portion of the research project. The level of fearfulness in the MHT ranged from 0 (no response) to 4 (severe AE).

Statistical Analysis

The experimental design used for the production study was a completely randomized design using a 2 × 2 factorial for 2 strains, the HY and the DK, 2 densities, and 2 replicates of each strain × density combination for a total of 168 hens. The production data were analyzed using the replicate means and the SAS general linear models procedure (SAS Institute, 1996). Means of the main effects that were significantly different were separated using Duncan's multiple range test.

The split-plot design used for the behavior study utilized 7 hen ages as the repeated measure. The treatment combinations were randomized within the house using the 2 × 2 factorial for strain and densities as above. Observations were made from cages within the same replicates throughout the experiment that maintained a constant hen population. The analysis is based upon the cage data expressed as behavioral acts / bird / min.

The analysis used for the behavioral act counts that were independent of cage mates, ST, CR, PR, MV, FD, DR, CM, and PI were analyzed using the mixed procedure (SAS Institute, 1996) for split-plot designs with the between-replicate factor being the strain × density and the within-replicate factor being bird age. The error term for the whole plot was replicate (strain × density) and the subplot used the residual error. Behavioral count data were transformed using the square root transformation, then tested for distribution normality and homogeneity of the variance. The strain and density effects were separated with the use of the estimate statement, within the SAS mixed procedure (SAS Institute, 1996), to estimate the linear function of the parameters. Means separation for the transformed data that were significantly different was accomplished using the least square means, which was applied to the untransformed means for reporting.

The behavior data associated with social acts, those requiring the interaction of 2 hens, AG, AE, peck neighbor, stand on, SUB, stood upon, pecked by neighbor, and FP, were found to be non-normal count data. They were analyzed using the SAS GENMOD procedure for Poisson regression analysis with a log link function. This allowed for a split-plot analysis with separation of the main effects of the treatment (strain × density) and age. The strain and density effect were separated using the contrast statement within the GENMOD procedure. The general linear

TABLE 1. Effect of strain and density on feed consumption, productivity, and mortality

Source	Feed consumption (kg/100 ♂/d)	Feed conversion (g egg/g feed)	Hen-day production (%)	Daily egg mass (g egg/d)	Total mortality (%)
Strain					
Hy-Line W-36	10.9	0.41	80.0	47.2	1.4
Dekalb XL	11.9	0.40	79.7	48.7	15.3
Pooled SE	0.3	0.01	0.5	0.7	5.2
Density					
361 cm^2/bird	11.1	0.40	77.4	46.1	8.3
482 cm^2/bird	11.7	0.41	82.3**	49.7*	8.3
Pooled SE	0.3	0.01	0.5	0.7	5.2

*Means within each column for strain and density are significantly different ($P < 0.05$).

**Means within each column for strain and density are significantly different ($P < 0.01$).

model procedure was run to get the means separation by the least square means when there was a significant age effect as indicated by the GENMOD analysis. Analysis of the transformed data was applied to the untransformed means for reporting.

The MHT was a split-plot design using 8 hen ages as the repeated measure. The same 2 × 2 factorial involving 2 strains, (HY and DK), and 2 densities were analyzed using the mixed procedure (SAS Institute, 1996) for split-plot designs with the between-replicate factor being the strain × density and the within-replicate factor being bird age. The error term for the whole plot was replicate (strain × density) and the sub-plot used the residual error. The univariate procedure was utilized to test for normality of the square root transformed data set by examining the distribution of the residuals, which indicated that the transformed MHT scores were normally distributed. The strain and density effects were separated with the use of the estimate statement, within the SAS mixed procedure (SAS Institute, 1996), to estimate the linear function of the parameters. Means separation for the transformed data that were significantly different was accomplished using the least square means, which was applied to the untransformed means for reporting.

RESULTS AND DISCUSSION

As previously found by Anderson (1994) and Anderson and Adams (1991), hen strain did not affect feed consumption, feed conversion, hen-day production (HDP), daily egg mass, or mortality in this experiment (Table 1). There were no significant interactions between strain, density, and age in this study. However, cage density impacted the percentage HDP, which was greater ($P < 0.01$) for hens provided a density of 482 cm^2/bird (82.3%) than for hens provided a density of 361 cm^2/bird (77.4%). This density effect resulted in an increased ($P < 0.05$) production of daily egg mass in the hens housed at the low density. There were no interactions between strain and density for any of the production criteria measured. These responses are similar to those achieved by Okpokho et al. (1987). The production factors of HDP and mortality have been used as indicators of hen welfare. There was no difference in mortality between the 2 densities; however, HDP was improved in the low-density environment. Thus it appears that the 482 cm^2/bird density was more beneficial because egg productivity was better.

The appetitive behavior frequencies were similar for both strains and densities and, surprisingly, there were no significant interactions between strain, density, and age in this study (Table 2). FD acts decreased ($P < 0.05$) as the hens aged whereas DR remained at a relatively constant frequency throughout the production period. During the molting period with the absence of feed, the frequency of FD and DR acts were the lowest for any time during the entire production period. The hens were without feed during this period in order to initiate the molt and DR frequency decreased with the feed intake of the hens. PI appears to be a behavior that is a component of both exploratory and foraging behavior and may be facilitated by social facilitation (Keeling and Hurnik, 1996). Another component of the changes in PI patterns may be related to stereotyped behavior (Savory and Mann, 1999) in response to the feeding program, cage environment, or deprivation. Therefore the motivation should be factored into the interpretation. In this study PI was the highest at 26 wk and during the molt, and significantly higher ($P < 0.05$) than at 43, 51, 62 and 68 wk in the first and second cycle. The decreases in PI in the later periods of the first cycle and the early periods in the second cycle would suggest that stereotyped PI behavior is not a component of these changes, because the hens were on an ad libitum feeding program which diminishes PI activity (Savory and Mann, 1999). The 26-wk-old birds appeared that they were still interacting with a new environment. PI appears to be associated with exploratory behavior as described by Anderson et al. (1989). As the hens settle into the cage environment, this exploratory behavior diminishes. The PI frequency at 34 wk of age may be associated with peak production and the foraging motivation during this period with the hen working to meet a high nutrient demand. The frequencies of PI associated with the molt would indicate a foraging motivation and would increase in the absence of feed. During the ages when the hen's PI was highest (26 and 64 wk) there may have been 2 different motivations driving the behavior of the hen. This does not appear to indicate a stereotyped behavior. During the molt period

TABLE 2. Effect of strain, density, and bird age on appetitive behaviors

Source	Feed	Drinking	Pecking inedible objects
	(Acts/bird/min)		
Strain			
Hy-Line W-36	0.171	0.030	0.009
Dekalb XL	0.141	0.030	0.009
Pooled SE	0.019	0.003	0.002
Density			
361 cm^2/bird	0.161	0.031	0.009
482 cm^2/bird	0.151	0.030	0.009
Pooled SE	0.019	0.003	0.002
Bird age (wk)			
26	0.208^{a}	0.034^{a}	0.014^{a}
34	0.196^{ab}	0.038^{a}	0.010^{ab}
43	0.186^{ab}	0.030^{a}	0.007^{bc}
51	0.167^{bc}	0.030^{a}	0.009^{b}
62	0.177^{ab}	0.029^{a}	0.004^{bc}
64, molt	0.018^{d}	0.013^{b}	0.015^{a}
68	0.139^{c}	0.038^{a}	0.002^{c}
Pooled SE	0.014	0.005	0.002

[a–d]Means within each column for strain, density, and age without a common letter are significantly different ($P < 0.05$).

the hen is seeking food due to hunger; subsequently, the frequency of PI would increase as a component of foraging for feed during fasts. Keys et al. (1950) described this instinctive response in humans and it has been described in other species as well.

The behavior frequencies for ST, CR, PR, MV, and CM were similar between the strains, as shown in Table 3. The hens in the low-density cage expended more ($P < 0.05$) time MV within the cage while the behavior frequencies for ST, CR, PR, and CM were similar. This may be a function of space and the ability of hens to move within the cage with less interference from other hens. The frequency of ST increased during the production period and was higher ($P < 0.05$) during the molt than during any other period of the hen's production cycle studied (Table 3). This may be an anticipatory or filling behavior in that the hen is waiting for the feed to be placed in the feeder, as previous experience would have dictated. The mean frequency of CR acts increased ($P < 0.05$) as the hens aged from 26 to 34 wk, then plateaued from 34 to 68 wk of age. Anderson et al. (1989) found that birds in less crowded and deeper cages spent less time crouching. This study does not support the supposition that CR frequency may be a good indication of bird welfare at specific densities. The behavioral responses of fearfulness and crouching that have been associated with higher fear and stress situations due to their relationship to antipredator behavior (Duncan, 1980) and increased movement (Anderson

TABLE 3. Effect of strain, density, and bird age on standing, crouching preening movement, and comfort behaviors

Source	Standing	Crouching	Preen	Movement	Comfort movements
	(Acts/bird/min)				
Strain					
Hy-Line W-36	0.206	0.038	0.024	0.018	0.002
Dekalb XL	0.223	0.039	0.030	0.024	0.002
Pooled SE	0.025	0.008	0.003	0.004	0.001
Density					
361 cm^2/bird	0.215	0.038	0.030	0.014	0.002
482 cm^2/bird	0.214	0.040	0.024	0.028*	0.003
Pooled SE	0.025	0.008	0.003	0.004	0.001
Bird age (wk)					
26	0.165^{a}	0.017^{b}	0.022^{b}	0.029^{ab}	0.003
34	0.159^{a}	0.036^{a}	0.025^{b}	0.031^{a}	0.003
43	0.187^{a}	0.044^{a}	0.023^{b}	0.020^{bc}	0.002
51	0.185^{a}	0.058^{a}	0.024^{b}	0.023^{abc}	0.003
62	0.196^{a}	0.046^{a}	0.026^{b}	0.020^{bc}	0.002
64, molt	0.377^{c}	0.039^{a}	0.029^{b}	0.009^{d}	0.001
68	0.233^{b}	0.032^{ab}	0.042^{a}	0.014^{d}	0.001
Pooled SE	0.017	0.008	0.004	0.003	0.001

[a–d]Means within each column for strain, density, and age without a common letter are significantly different ($P < 0.05$).

*Means within each column for strain and density are significantly different ($P < 0.05$)

TABLE 4. Effect of strain and density on social feather pecking, aggressive, and submissive behaviors summarized over the production period

Source	Feather pecking	Aggression	Stand on	Submission	Stood upon	Avoid / escape	Pecked neighbor	Pecked by neighbor
	(Acts / bird / min)							
Strain								
Hy-Line W-36	0.093	0.109**	0.012	0.031	0.012	0.026	0.026	0.031
Dekalb XL	0.236	0.061	0.031	0.029	0.036	0.021	0.048	0.017
Pooled SE	0.033	0.019	0.007	0.009	0.008	0.008	0.011	0.009
Density								
361 cm^2 / bird	0.169	0.083	0.017	0.024	0.021	0.021	0.052	0.021
482 cm^2 / bird	0.160	0.088	0.026	0.036	0.026	0.026	0.021	0.026
Pooled SE	0.033	0.019	0.007	0.009	0.008	0.008	0.011	0.009
Bird age (wk)								
26	0.275^{ab}	0.150^{Y}	0.042	0.042^{ab}	0.050	0.008^{B}	0.092	0.100
34	0.308^{a}	0.083^{Y}	0.025	0.050^{a}	0.025	0.033^{AB}	0.050	0.033
43	0.117^{bc}	0.108^{Y}	0.008	0.033^{ab}	0.017	0.008^{B}	0.033	0.000
51	0.008^{c}	0.092^{Y}	0.017	0.017^{ab}	0.017	0.067^{A}	0.000	0.008
62	0.025^{c}	0.092^{Y}	0.017	0.025^{ab}	0.017	0.017^{B}	0.033	0.017
64, molt	0.358^{a}	0.000^{Z}	0.042	0.000^{b}	0.042	0.000^{B}	0.025	0.008
68	0.058^{c}	0.075^{Y}	0.000	0.042^{ab}	0.000	0.033^{AB}	0.025	0.000
Pooled SE	0.061	0.035	0.012	0.014	0.014	0.014	0.019	0.016

[a–c]Means within each column for age without a common letter are significantly different ($P < 0.05$).

[A,B]Means within each column for age without a common letter are significantly different ($P < 0.01$).

[Y,Z]Means within each column for age without a common letter are significantly different ($P < 0.001$).

**Means within each column for strain and density are significantly different ($P < 0.01$).

et al., 1989) could also impact other behavior patterns. PR was highest ($P < 0.05$) immediately post-molt. This observation is in association with the growth of a new feather coat that occurs during the period following molt. The amount of hen MV may be dependent upon the age of the hens and stereotyped pacing associated with egg laying (Craig and Muir, 1998) as the hen's reproductive status changes. The frequency of MV acts was highest during the early stages of the production cycle (26 to 34 wk) when egg production is high. Although increased movement (pacing within the cage) may be related to frustration in nest site selection in a cage, it may also be related to foraging behavior (Campbell et al., 1966) during this same time period when nutrients are in high demand to support reproduction. MV then declined to the lowest number of acts during the molting period and postmolt (64 and 68 wk of age). When placed in context with the duration and termination of the MV behavior at the feeder, water, and PI, which occurred more during the absence of feed, the relationship to frustration and the associated negative responses is not apparent. CM acts were not affected by strain, density, or hen age.

Feather pecking, lacking of any response from the hen being pecked, appears to be gentle in nature and a component of social recognition or grooming in chickens (Kjaer and Vestergaard, 1999) as indicated by the age and the frequencies of FP (Table 4). FP was highest during the early periods 26 and 34 wk and during the molt at 64 wk, which may be the result of social facilitation during periods of PR of feathers in young hens and PR associated with feather push out during the molt period. Prior to molt at 51 and 62 wk and after molt at 68 wk, FP was at its lowest frequencies. These results do not support the theory that stereotypic behaviors were formed since Kjaer and Vestergaard (1999) indicated that stereotypic behaviors would remain at a higher level throughout the production period. These results appear to indicate a period of social recognition at 26 and 34 wks followed by decreasing frequencies. FP is highest during the molt period (64 wk), which has been shown to result in feather and skin damage (Kjaer and Vestergaard, 1999). However, under the conditions in this study, feather damage, feather pulling, and skin damage were not observed. In this study, during the molt (64 wk) 2 motivational systems may be at work: social facilitation of cage mates to groom stimulated by the preening of the new feathers (Keeling and Hurnik, 1996) and displaced feeding behavior (Kjaer and Vestergaard, 1999). Differentiation of which motivational system was the initiator could not be determined, but probability would indicate that both possibly played a role. The strain and density had no significant impact on FP. The HY hens were significantly more aggressive than were the DK hens. However, the associated behaviors of SUB and AE were not influenced. This may indicate the existence of AG between hens of equal social status where the AG would not result in SUB or AE from the target hen. Observation of SUB and AE behaviors provide some insight into the social structure of the number of socially equivalent hens in the group. The behavioral interactions between hens of equal social status would help explain the lack of a subordinate hen response of SUB or AE. However, the hens may be responding in this manner for other reasons such as to threats with pecks. The molt resulted in reduced frequencies of AG ($P < 0.001$), SUB ($P < 0.05$), and AE ($P < 0.01$); in all 3 cases the observed frequency for these 3 behaviors were zero. The levels of aggression in this study support the findings of Webster (2000) where aggression was not observed at all after the first day of feed withdrawal. In this study the AG behavior frequency pattern as observed on d 3 and 4 were not

TABLE 5. Effect of strain, density and hen age on modified Hansen's test scores

	Modified Hansen's scores
Strain	
Hy-Line W-36	2.08
Dekalb XL	2.37
Pooled SE	0.27
Density	
361 cm^2/bird	2.16
482 cm^2/bird	2.29
Pooled SE	0.27
Bird age (wk)	
20	1.36^{Z}
26	1.69^{Y}
34	2.46^{VW}
43	2.56^{UV}
51	2.13^{X}
62	2.64^{UV}
64, molt	2.79^{U}
68	2.22^{WX}
Pooled SE	0.16

$^{U–Z}$Means within each column for strain density, and age without a common letter are significantly different ($P < 0.001$).

indicative of frustration as was indicated by Duncan and Wood-Gush (1971). They postulated that frustration might actually be manifested as a result of the fast to initiate the molt. The differences in AG found by Duncan and Wood-Gush (1971) and in this study may be related to the time of observation after the fast period started which differed. In this study observations were made during d 3 and 4 after the initiation of the fast as compared to Duncan and Wood-Gush (1971) who observed AG the first day after the fast was initiated. Interactions between hens in adjoining cages, peck neighbor and pecked by neighbor, were not affected by strain, density, or bird age.

Fearfulness, as measured by the MHT, was not influenced by the strain of the laying hen as shown in Table 5. In addition, density had no effect on the fearfulness level of the hens in this study, which is contrary to the findings of Hansen (1976) and Cunningham and Gvaryhu (1987). These researchers determined that highly dense populations were a primary factor in evoking nervousness or hysteria of layers and decreases in hen-day egg production and feather covering. In this study, age of the hen had a greater impact on the fearfulness score. As the hens aged, the level of fearfulness increased ($P < 0.001$) from a low of 1.36 at 20 wk of age to a high of 2.79 at 64 wk of age that coincided with the molt period. Postmolt, the fearfulness levels declined to the premolt levels.

Although there appeared to be no effects of certain behaviors on egg production, behaviors did change over time. MHT scores increased as the hens aged (Table 5), which is contradictory to the previous findings of Anderson and Adams (1991) where hens became less fearful as they aged. The increased MHT scores corresponded with increased CORT levels and heterophil:lymphocyte ratios (Davis et al., 2000) which may indicate increased stress with age and molting. In this study fearfulness increased as production levels increased and then dropped slightly during the post-peak production period. Molting did cause a rise in fearfulness, with a peak in MHT score during the initial stages of molting at 64 wk of age. The increased fearfulness during the first cycle may be the result of greater feather loss in the present study than was described by Anderson and Adams (1991). However, the increases in fearfulness during the molt may also have been associated with the fast and the associated feather loss that accelerated in a molt, whereas the activity levels associated with fasting hens were shown to decline at the concurrent time that observations were made in this study, which is supported by the study of Webster (2000). However, Webster (2000) indicated that hens appeared less fearful during the fast. There does not appear to be an interaction of molting with feather loss, which subsequently increases the fear response. On the contrary, the theory of feather loss appears to be supported by the drop in post-molt fearfulness scores after the hens have grown their new feathers (68 wk).

The shifting of behavioral patterns in this study appears to relate to hens adjusting to age, environmental conditions, and social interactions within the group. Davis et al. (2000) indicated that elevations in CORT coincided with peak egg production and are similar to levels found during the molt. Physiologically, this level of CORT production during peak egg production and molt promotes a gluconeogenic stimulus in support of the hen's physiological needs, i.e., the demand for protein and energy to support egg production and body maintenance, respectively. The behavior frequency patterns shown herein changed in ways that were more consistent with physiological need. Based on these findings, the egg industry should be aware of several factors affecting behavioral patterns. First, the process of aging appears to elicit changes in FD, DR, PI, ST, CR, PR, and MV behaviors and fearfulness levels. Behavioral patterns change over time and do not appear to be good indicators of the long-term welfare of the hens but may rather be an indicator of adaptation to a given environment or the lack thereof. The process of adaptation is supported by behavior patterns that change under the management conditions imposed on the hens. Reduced frequency of MV and increased CR may be more related to conservation of energy needed to support production. Furthermore, Beuving and Vonder (1977) found that plasma CORT increased about 1 h before oviposition in caged hens, then declined after oviposition. Therefore, one should expect higher CORT levels in high producing hens. The behavior patterns during the molt period do not indicate frustration due to lack of feed, and the drop in overt aggression on the part of the hens as such would therefore not be a contributor to increases in the fearfulness score or the physiological fear response of elevated CORT. Furthermore, strain and density do not appear to cause negative behavioral responses or increases in stress levels in hens based on CORT levels and heterophile-lymphocyte ratios, as indicated by Davis et al. (2000) in studies involving this same flock.

Since there were no interactions between strain, density, or age, it appears that hen age, rather than strain and density appears to have the greatest impact on behavior and the fear indicator. Molting also impacts the behavior of the hen as was apparent in the behavioral changes which occurred at 64 wk of age. It appears that molting was the trigger for these changes rather than age because the behavior frequencies returned to pre-molt levels in most cases, whereas if age were the trigger for the behavior changes alone, the return to pre-molt levels would not have been expected by 68 wk. However, the effects of aging are naturally unavoidable, and the current interest in the size of cages used, density, and molting are valid concerns for the bird's welfare. The bird's welfare is also a concern for the commercial egg industry, because a detrimental effect on the bird's welfare reduces productivity and therefore income to the producer. This study indicates that cage densities do not cause significant differences in behavior frequency patterns, aggression, or fearfulness. In fact, neither one of these different densities appears to produce behavioral effects that are indicative of impaired welfare or stress. However, cage density has been shown to depress productivity, which may indicate a higher level of stress at higher densities. The changes in behavior observed in this study can, in accordance with current research and beliefs, be interpreted as potential indicators of a reduction in welfare status. However, the question arises whether the transient nature of the behavior frequency patterns observed during this study actually do have a long-term negative impact on hen welfare. The findings in this study suggest that molting results in no long-term negative behavioral impacts with a number of documented beneficial effects. In fact PI (Table 2), CR, which has a dominance behavior relationship (Fischer, 1975), and PR (Table 3) behaviors are similar during the molt and during peak egg production at 34 wk. This supports the findings of Webster (2000) who indicated that fasting resulted in no harm or debilitation to the hens during a molt. It is apparent in this study that laying hens quickly adapt to the absence of feed with no overt aggression. Duncan and Wood-Gush (1971) maintained a high expectation of feed from the hens throughout their experiment, and yet in successive trials, when access to feed was thwarted, aggression decreased. This study suggests that the lack of feed during the molt or the lack of access to feed does not elicit overt aggressive behavior. In fact, fasting in itself elicits no increase in aggression.

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