Group Selection for Adaptation to Multiple-Hen Cages: Beak-Related Mortality, Feathering, and Body Weight Responses[1,2]

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ABSTRACT The hypothesis was tested that selection on the basis of family means for increased survival and hen-housed egg production, when sisters with intact beaks were kept together in multiple-bird cages, would cause adaptive changes in behavior. Specifically, it was posited that beak-inflicted injuries causing cannibalistic mortality and feather loss and damage would be reduced. Body weight effects were not predicted, but were examined. Three stocks were compared; the Selected (S), representing the seventh generation of selection, the Randombred Control (C) from which S was derived, and a commercial stock (X), known to be highly productive and beak-trimmed by commercial producers. Pullets were placed in single-bird (1H) as well as in 12-hen (12H) cages using a completely randomized block experimental design.

Mortality from beak-inflicted injuries differed among stocks in total hens lost ($P < 0.005$). Of 576 per stock in 12H cages 287, 128, and 46 replacements were used from 17 to 44 wk in X, C, and S, respectively, to maintain group size. The C and S hens also differed from 44 to 59 wk and 17 to 59 wk. X hens were not included in comparisons of mortality beyond 44 wk. Relative incidence of mortality caused by vent-cloacal injuries differed with X > C = S ($P < 0.005$ for X vs C and S). For cages with ≥ 1 cannibalistic death, X had twice ($P < 0.025$) and C 1.6 times ($P < 0.10$) as many with repeated losses as S.

Means and variances of feather scores were different for 1H vs 12H cages, ages, and genetic stocks. Greater variances were observed in 12H cages and among older birds. Within 1H units, genetic stocks did not differ in general, but in 12H cages X and C were always more variable than S. In 12H cages, mean feather scores and body weights were decreased and S hens had better feathering than either C or X. The evidence supported the hypothesis.

(*Key words*: adaptation, cages, cannibalistic mortality, feathering, body weight)

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INTRODUCTION

In a recent review, Craig and Swanson (1994) indicated how public concerns relating to the well-being of hens kept in cages have increased, especially in Western Europe, during the last three decades. Illustrating the depth of such concerns is the governmentally decreed phasing out of cage housing in Sweden and Switzerland. Nevertheless, Craig and Swanson (1994) suggest that cages should provide a relatively benign environment if excessive crowding and group size are avoided, cages are constructed to avoid entrapment and injuries, and genetic stocks are used in which aggressiveness, competitive behavior, psychological need for nests, fearfulness, and behavioral vices exist at low levels.

Among the more important behavioral problems of laying hens are those associated with the use of the beak, including aggressive pecking and the associated inability of low-status hens to obtain sufficient amenities (including feed), and feather and cannibalistic pecking. Although feather and cannibalistic pecking are usually minimized by beak trimming, that practice is questionable because recent evidence indicates that pain or increased sensitivity to painful stimuli associated with it persist for at least a few weeks or months (Breward and Gentle, 1985; Duncan *et al.*, 1989; Craig and Lee, 1990; Gentle *et al.*, 1990).

Selection to modify behaviors associated with well-being are likely to succeed (Guhl *et al.*, 1960; Craig *et al.*, 1965; Mills *et al.*, 1985; Craig and Muir, 1989, 1993). However, selection on behavioral traits requires a large input of specialized technical observation and may not assure desired increases in productivity traits. An alternative is to select on the basis of family means for productivity when hens are kept separately by families (possible in multiple-hen cages) on the assumption that families that are productive also possess desirable behavioral characteristics that would be selected as correlated responses.

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Muir (1996), after considering experimental evidence then available and theoretical considerations of Griffing (1967, 1976), began a selection study in 1982 based on group selection. Sire family means of egg production and survival, obtained from groups of intact-beak sisters kept separately from other families in multiple-hen cages, served as the criteria of selection.

This paper involves data on the incidence of mortality from beak-inflicted injuries, on feathering, and on body weights of intact-beak hens of three genetic stocks kept in 12-hen cages. Of primary interest were comparisons between the stock selected by Muir (1996) and its unselected control. Additional comparisons were provided by including a commercial stock in which beak trimming is recommended. Also, comparisons of feathering and body weights were obtained on hens of the three stocks in single- and multiple-bird cages.

MATERIALS AND METHODS

Genetic Stocks

Stocks of White Leghorn-type chickens used were: the unselected North Central Randombred Control (C); the seventh generation of a selected stock (S) derived from C, and a sample of the commercial DeKalb Delta[3] (X). Strain C was originated by crossing six commercial stocks in all possible combinations beginning in 1971 and has been maintained subsequently with random mating and without conscious selection (Garwood *et al.*, 1980). Strain S was initiated by sampling C and has been selected since 1982 on the basis of "family" or "group" performance for survival and egg production when hens were kept in 9- and 12-bird cages by sire families as described by Muir (1996). The X strain was chosen on the basis of being highly productive, readily available, and a strain for which beak trimming is recommended.

Rearing Procedures

Chicks for the present study were hatched June 16, 1993. They received numbered wing-bands in both wings, were vaccinated for Marek's disease, and were then placed in groups of 16, with others of their own strain and sex, in 61 × 91 cm wire cages. Initial temperature, at chick level, was 32 C and was decreased weekly for 4 wk until 21 C was obtained. Lights were on continuously for the first 48 h after housing and subsequently for 8 h/d. Light meter readings of 4 lx were obtained at chick level. Vaccinations against bronchitis and Newcastle disease were done at 2 and 16 wk and avian encephalomyelitis at 12 wk. Birds consumed rations *ad libitum* that were identical to and fed at the same ages as during Generations 1 through 6 (Muir, 1996).

Layer House Environment and Procedures

Four adjacent rooms were used in an environmentally modified house that excluded natural lighting and provided forced ventilation, supplemental heating, and evaporative cooling. Extreme "outside" thermal conditions could thus be avoided. Overhead lights were on daily from 0700 until 1900 h initially. Lights were increased by 15 min/wk (always beginning at 0700 h) until a 16-h day was achieved and then held constant for that photoperiod for the remainder of the study. Light meter readings taken at six locations in the aisle along each row and at the height of each deck of cages indicated mean readings of 30, 17, 14, and 11 lx from top to bottom decks, respectively. In addition, cages in lower decks were shaded to varying degrees by cages above them. Thus, about 25, 50, and 75% of the cage area was shaded in second, third, and fourth deck cages, respectively.

Each room contained eight rows of wire cages designed for laying hens. Cages were in four tiers in overlapping, stair-step-like arrangements on both sides that met at the top deck over a droppings pit. Each row of cages contained six sets of four 30.5 cm wide × 35.6 cm deep 1H cages and six 122 cm wide × 35.6 cm deep 12H cages. Cages were 43 cm high and ceilings were parallel with floors from the front to 20 cm deep; they then sloped downward until reaching the back of the cages 13 cm above floor level. The sloping section at the back of the ceiling and the backs of cages were covered by plastic to divert droppings from cages above. Top deck cages did not have plastic covers.

Experimental units consisted of four consecutive 1H cages and each 12H cage. Floor area per hen was available at 1,085 and 362 cm^2 in 1H and 12H cages, respectively. One-fourth of the feeder trough was covered in front of each 12H cage so that 30.5 and 7.6 cm feeder space was available per hen in 1H and 12H cages. Floor and feeder space allowances in 12H cages were roughly comparable to that provided for hens in multiple-bird caging of commercial hens in the US and 1H cage space allowances were generous by the same standard. Nipple waterers were placed in cut-out spaces at the top of partitions between adjoining cages and about 9 cm from the front of cages. Thus, each 1H and 12H cage had nipples on both sides and 12H cages had an additional three water nipples mounted on the top of the cage at 30.5-cm intervals.

Because 12H cages were produced by removing three partitions separating original cages of 1H size, structural considerations required that not more than two 12H cages should be adjacent. A further limitation was that automatic feed-sensing devices were located at one end of each row and 12H cages were placed at those locations so that feeders would fill adequately. Within those limitations, locations of 1H and 12H experimental units were randomized within each row. Each of the three genetic stocks was assigned randomly to two 1H and two 12H experimental units within each row. Therefore, within each row there were replicated units for each stock in each cage size, resulting in a randomized complete block experimental design.

[3]DEKALB Poultry Research, Inc., DeKalb, IL 60115.

Pullets were moved from rearing cages into the layer house when they were 17 wk old. (To simplify terminology, females in the layer house are referred to as hens.) Twelve females of a single strain were used to fill each crate used to transport pullets between rearing and layer houses. Three birds from each of four rearing cages were placed in each crate and then distributed randomly into three 1H units or into a single 12H unit. Therefore, it was likely that at least one neighbor would be a stranger in 1H units and each hen was placed with two familiar and 9 strange birds in each 12H unit. Two rooms were filled on 1 d and the two others were filled 3 d later.

Mortality from Cannibalistic Pecking

All hens were observed daily from 17 to 59 wk of age. Dead birds were removed and classified as to apparent cause of mortality. Clear evidence was present nearly always when "cannibalistic" deaths occurred because of beak-inflicted injuries in which tissue was missing (apparently consumed), hemorrhage occurred, and frequently openings into the body cavity or the vagina or uterus were present. Nevertheless, a few deaths were probably recorded as due to unknown causes when an exposed and injured cloaca had been withdrawn back into the body cavity. When beak-inflicted injuries were serious enough that survival was unlikely, birds were euthanatized by cervical dislocation and counted as dead from cannibalistic pecking. Deaths from beak-inflicted injuries were classified as being caused primarily by pecking in the vent-cloacal or "other" regions. A small percentage of beak-inflicted, i.e., cannibalistic, deaths were classified as involving "both" regions when the primary cause was uncertain.

Because it was deemed essential to maintain experimental units with the number of hens intended, dead birds were replaced during early hours of the photoperiod either on the day of death or the following day if they died after the period of inspection. Replacement birds were obtained from top-deck cages (Deck 1) containing the same genetic stock and initial group size as the dead bird. Therefore, only Decks 2, 3, and 4 (numbered from the top down) contained experimental units. Ordinarily, once replacement females had begun to be withdrawn from a unit, others from the same unit were used until it was empty. Additional females of the C and X strains remained available from rearing cages after all layer house cages were filled. Therefore, replacement cages in Deck 1 that were depleted were refilled as needed from the rearing house for about two months following initial housing. After refilling, cages were not used for replacements until other cages on Deck 1 were depleted.

Because of heavy mortality from cannibalistic pecking in C and X stocks in 12H cages, it was necessary to begin using replacement birds (after Deck 1 cages were emptied) from Deck 4 at 44 wk. Strain X was represented fully in Deck 3 for only a few weeks after 44 wk of age; after that Deck 3 hens were used to replace dead birds of the X stock in Deck 2. Therefore, X was excluded from further comparisons of mortality that continued until 59 wk of age. Mortality data from 17 to 44 wk (Period 1) involved all strains in Decks 2, 3, and 4; data from 44 to 59 wk (Period 2) involved stocks C and S in Decks 2 and 3. In addition, data for C and S stocks in Decks 2 and 3 were combined from Periods 1 and 2 (Total Period) for a longer-term comparison.

Feather Scores and Body Weights

Feather scores and body weights were obtained on individual hens of all strains in Decks 2 and 3 at 40 wk and in Deck 2 only at 59 wk of age. Separate scores were assigned for the combined back and wing region (B-W), the front of the neck and lower body in front of the legs (F) and the lower rear body behind the legs (R). Also a combined feather score (FS) was computed, using the mean of the three component scores. The same person (JVC) did all scoring. Feather scores ranged from 0 through 9 and approximated tenths of area that would be covered in a fully feathered hen (0 = 0 to 9%, 1 = 10 to 19%, . . . , 9 = 90 to 100%). Feather scores were reduced if feathers were damaged, as follows; slight damage: score reduced by 1; moderate damage: score reduced by 2; severe damage: score reduced by 3. Negative scores were not given; 0 was the lowest possible score.

Statistical Analyses

Mortality from all causes in 1H units was low, e.g., amounting to only six, three, and six females for the C, S, and X strains, respectively, over Period 1. Therefore, deaths in 1H cages were not analyzed. Mortality for 12H units was analyzed by chi-square. Separate analyses were done for number of cannibalized hens and number of cages with ≥ 1 cannibalized hens.

Within-experimental-unit means and variances were computed for feather scores and body weights. These were used as units of measure in subsequent analyses. Because variances for feather scores and body weights exhibited heterogeneity, it was decided to analyze by chi-square. Medians were calculated for each trait, and experimental units were classified simply in terms of being greater than or less than or equal to the median. Chi-square values were then used to determine whether genetic stock, group size, and age effects were significant. Because mean feather scores and body weights were nearly always larger in 1H units and variances among hens within units were nearly always larger in 12H units, medians were found to lie between 1H and 12H treatments. Therefore, within-group-size chi-square values were used for testing age and genetic stock effects.

Because not all decks were present at all ages, deck effects could confound age effects. Therefore, when comparing age effects, only those decks represented at all ages were included in the analysis. However, genetic stocks and birds per cage (1H vs 12H) effects are unbiased by deck effects because the same genetic stocks and cage sizes were present within each row.

RESULTS

Mortality from Cannibalistic Pecking

Deck Effects. A chi-square test for deck effects was carried out for total cannibalistic deaths during Period 1, with data pooled over genetic stocks and rooms. Significant differences were present among decks and for all paired combinations of decks. Numbers dead were 158, 194, and 109 for Decks 2, 3, and 4, respectively. Because Deck 4 birds were used as replacements for C and S strain hens dying of injuries during Period 2, C and S strains were compared over Decks 2 and 3 only for Period 2 and for the total period.

Total Hens Dead. Numbers of hens dead in 12H cages because of cannibalistic pecking are shown for each of the three genetic stocks in Table 1. During Period 1, 287, 128, and 46 females were replaced to maintain the constant group size of 12 hens per cage in X, C, and S strain cages, respectively. Differences among the stocks were found ($P < 0.005$), and all pairs of stocks differed significantly. Differences among the three stocks accumulated steadily (Figure 1). Strain X birds began to differentiate more rapidly from C and S after 20 wk and C strain birds from S about midway between 20 and 30 wk of age. C and S strain females differed in incidence of beak-related deaths during Period 2 (80 vs 24; $P < 0.005$) and for the total period (188 vs 64; $P < 0.005$), Table 1.

Strains X, C, and S differed in incidence of cannibalistic deaths associated with different regions of the body ($P < 0.005$) during Period 1. Strain X females had significantly more vent-cloacal injuries than either C or S strain females, and the latter two strains did not differ from each other. Frequencies of mortality because of vent-cloacal pickouts amounted to 91, 70, and 64% in the X, C, and S strains, respectively.

Cages with Mortality. Cages were classified as having either 0 or ≥ 1 death from cannibalistic pecking, and the incidence of cages with losses over all three decks was 32, 27, and 20 for the X, C, and S strains, respectively, during Period 1 (Table 1). Chi-square testing indicated one or more differences ($P < 0.05$) among strains. Pairwise comparisons indicated a significant difference between X and S only. Comparisons for cages on Decks 2 and 3 only during this period failed to detect a significant difference among the stocks, although a difference between C and S strain cages ($P < 0.01$) was detected for the same set of cages during Period 2. Over the total period, i.e., from 17 to 59 wk, no significant difference was found between the C and S strains. Examination of Figure 2 indicates how the differences in number of cages with mortality accumulated. Additional cages became involved with the passage of time, although the rate of increase diminished towards the end of the study.

Repeated Cannibalistic Deaths within Cages. Genetic stocks were compared for cages having at least

TABLE 1. Effects of genetic stock and age on deaths of hens from cannibalistic pecking when kept in 12-hen cages

	Period 1: 17 to 44 wk		Period 2: 44 to 59 wk	Total: 17 to 59 wk
Variable	Deck 2+3+4	Deck 2+3	Deck 2+3	Deck 2+3
	Total hens dead from cannibalistic pecking[2]			
Genetic stock[1]				
X	287	205	. . .	. . .
C	128	108	80	188
S	46	40	24	64
Probability				
All stocks	***	***	***	***
X vs C	***	***	. . .	. . .
X vs S	***	***	. . .	. . .
C vs S	***	***	***	***
	Cages with ≥ 1 dead from cannibalistic pecking[3]			
Genetic stock[1]				
X	32	19	. . .	. . .
C	27	18	23	26
S	20	14	12	21
Probability				
All stocks	*	NS	**	NS
X vs C	NS	. . .	. . .	. . .
X vs S	*	. . .	. . .	. . .
C vs S	NS	. . .	**	. . .

[1]X = DeKalb Delta; C = North Central Randombred Control; S = Selected, derived from C by seven generations of selection.

[2]Females per stock on Decks 2+3+4 = 576, on Decks 2+3 = 384.

[3]Cages per stock on Decks 2+3+4 = 48, on Decks 2+3 = 32.

*$P < 0.05$.

**$P < 0.01$.

***$P < 0.005$.

one cannibalistic death and it was shown that strains differed in the frequency of repeated cannibalistic events ($P < 0.005$). Pairwise comparisons failed to suggest any difference between hens in cages containing X and C stocks, but in S cages repeated cannibalistic deaths were less likely than in X cages (45 vs 88%; $P < 0.025$) and a difference of borderline significance was suggested in comparing cages of S and C females (45 vs 74%; $P < 0.10$).

Feathering and Body Weights

Preliminary ANOVA for deck effects at 40 wk failed to indicate significance for any of the feather scores or for body weights. Therefore, deck effects would not confound comparisons between results obtained at 40 and 59 wk of age.

Treatment Effects on Variability. Because feather scores and body weights were obtained on all hens in Decks 2 and 3 at 40 wk and in Deck 2 at 59 wk, it was possible to compare variances among individuals within experimental units for the different treatments. Feather score variances for the B-W, F, and R areas, and the mean scores of those regions (FS) were tested for differences among group sizes (1H vs 12H), ages, and genetic stocks. Differences in variability were found to be either significant or very highly significant ($P < 0.05$ to < 0.001) for group sizes, ages, and genetic stocks.

Greater variances of feather scores and body weights were present ($P < 0.001$) in 12H units (see median variances, Table 2). Because of heterogeneity of variances between 1H and 12H units, further comparisons of variances for ages and genetic stocks were conducted within group size classifications, Table 2. Within the 1H environment, heterogeneity was absent between ages and among genetic stocks with two exceptions; older hens were more variable for R feather scores, and S hens were less variable for the mean of all regions (FS) than were hens of either X or C. Within 12H cages a very different picture emerged. Feather scores and body weight variances were greater at 59 than at 40 wk in all cases, and X, and X and C strain birds were significantly more variable in feather scores than in the S strain for the R and FS regions, respectively. Genetic stocks within 12H cages did not differ in variances of body weights.

Treatment Effects on Means. Medians for feather scores and body weights are shown within the 1H and 12H categories, Table 3. Also shown are percentages of experimental units classified as being greater than the median. Number of females per cage had significant effects ($P < 0.001$) on all measures of feathering and on body weight; median values were always greater for 1H cages.

Chi-square analyses for age and genetic stock effects within the 1H and 12H units indicated age effects within both for feather scores but not for body weights. Feather

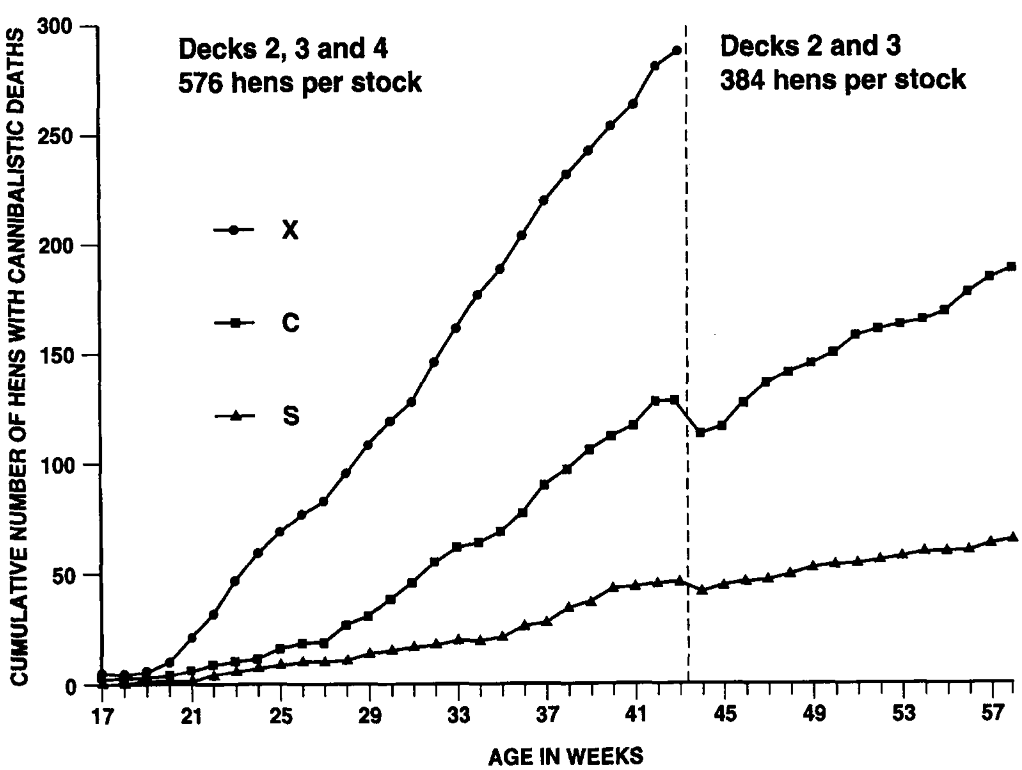

FIGURE 1. Weekly cumulative numbers of hens dead from cannibalistic pecking which were replaced to maintain a constant group size of 12 hens per cage in genetic stocks DeKalb Delta (X), North Central Randombred Control (C), and seventh generation of Selected (S) in Decks 2, 3, and 4 from 17 to 44 wk of age and of genetic stocks C and S in Decks 2 and 3 from 44 to 59 wk of age.

scores were significantly better at 40 than at 59 wk with only one exception (B-W feather scores in 1H cages). Genetic stock differences were not detected for feather scores in 1H cages or for body weights in either 1H or 12H cages. However, large and significant stock differences were detected for feather scores in 12H cages; S hens had significantly better feathering in all body regions than either X or C hens, and C hens were better than X hens in two of four measures.

DISCUSSION

Mortality from Cannibalistic Pecking

Mortality from cannibalistic pecking differed among decks. A nonlinear situation occurred; 12H cages in Deck 2, the highest of the three experimental decks, had intermediate losses, those in the middle the greatest and those in the bottom deck the least. Because dim lighting has been observed to be generally beneficial in reducing mortality from cannibalistic pecking (Gentle, 1986), it could be argued that losses were least in the lowest deck because lighting intensity was lowest and shadows most prevalent there. However, the nonlinear relationship of light intensity and mortality indicates that that influence alone cannot account for the results obtained.

Genetic stock influenced the number of hens dying of beak-inflicted injuries in multiple-hen cages during the egg production period. Why the commercial stock had the highest incidence is unknown, but its losses in the absence of beak-trimming were very large. The S strain benefitted greatly, in terms of reduced deaths, from family selection for survival and egg production. Kuo *et al.* (1991) reached a similar conclusion when samples of the S and C stocks were compared after four generations of selection. Although comparisons between that study and the present one confound many variables it appears that additional gains in reducing cannibalistic deaths may have occurred: during Generation 4, intact-beak S hens had 59% as much cannibalism as C to 40 wk of age whereas in Generation 7 it was 36 and 34% as much to 44 and 59 wk of age, respectively.

Craig and Muir (1993) presented evidence that an initial death from cannibalistic pecking within a cage increased the probability of further losses within the cage. In the present experiment, it was learned that the likelihood of further beak-inflicted deaths within a cage, following the first, differed among the stocks. Strain X hens had twice as many with additional losses from this cause as did S, and C had about 1.6 times higher incidence of cages with repeated losses. In view of the differences among stocks in repeated losses within cages, it is not surprising that differences among the stocks for number of cages with ≥ 1 cannibalistic loss were less likely to be significant than if total hens lost was the criterion.

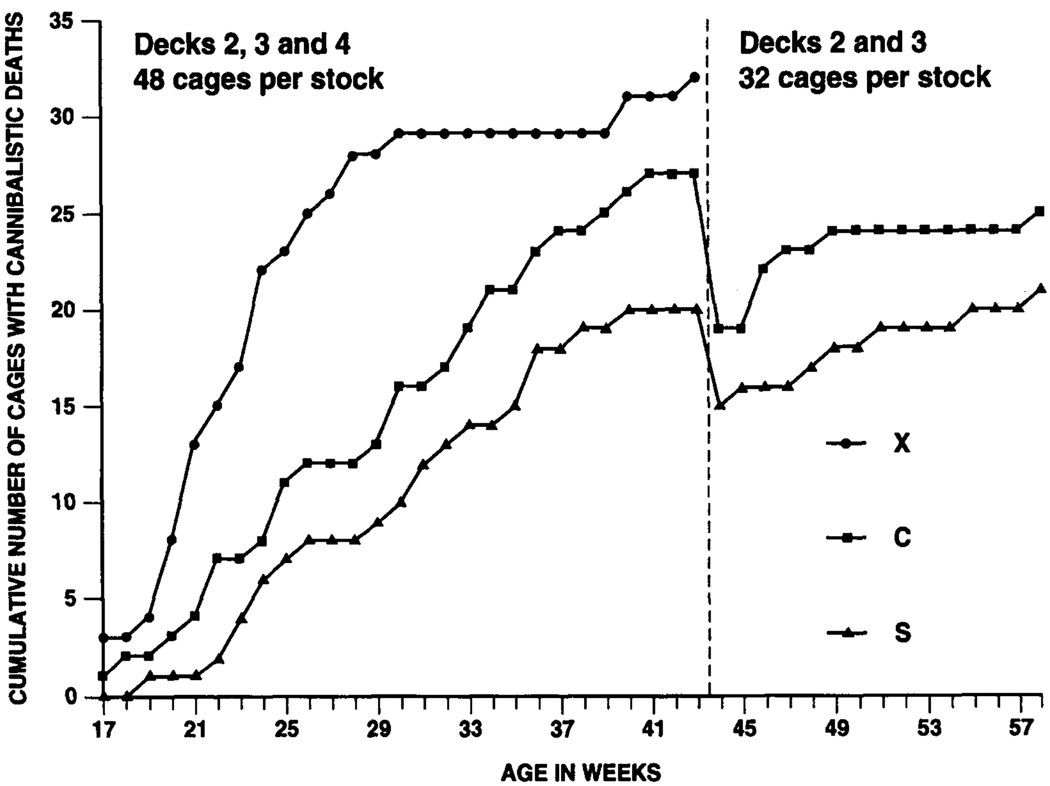

FIGURE 2. Weekly cumulative numbers of cages in which ≥ 1 hen(s) dead from cannibalistic pecking in which hens were replaced to maintain a constant group size of 12 per cage in genetic stocks DeKalb Delta (X), North Central Randombred Control (C) and seventh generation of Selected (S) in Decks 2, 3, and 4 from 17 to 44 wk and of genetic stocks C and S in Decks 2 and 3 from 44 to 59 wk of age.

Beak-inflicted injuries causing death differed among stocks in terms of regions involved. Although S hens were less likely to die from cannibalistic pecking than C hens, they did not differ in relative incidence of vent-cloacal involvement (about two thirds average for the two stocks). However, for hens dying of cannibalistic pecking, the vent-cloacal region was attacked with fatal results in more than 90% of strain X hens. The very high incidence of deaths from vent-cloacal injuries of intact-beak X hens in this study does not agree with the relative incidence found in a different commercial stock in an earlier study. In that experiment, losses from injuries in regions other than vent-cloacal were moderately greater to 44 wk (Craig, 1992).

Feathering

As pointed out by McBride (1960, 1962, 1968), social behavior causing stress is likely not only to depress mean performance but should also increase variability within flocks subjected to greater stress. Craig and Toth (1969), Craig (1970), and Biswas and Craig (1970) confirmed McBride's prediction relative to the importance of frequency of aggression within flocks; hens of a highly aggressive stock were not only less productive when kept with others of their own kind than were hens of a less aggressive stock but also were significantly more variable in productivity.

Results of this study suggest that reduced stress, resulting from family selection for improved survival and greater productivity in 12H cages, was likely to have been involved in the lesser variability and superior feathering found in 12H cages of strain S hens as compared with hens of strain C. The results from 1H units, in contrast with those from 12H units, also confirm expectations based on McBride's hypothesis. Thus, differences in variances and feather scores of the S and C hens were generally not detected within 1H cages, where a relatively asocial and presumably less stressful environment existed.

Although differences in foundation stocks and selection procedures existed between strain X hens and those of S and C, their specific contributions to the differences found are unknown. Nevertheless, it is seen that S strain hens were better feathered in all regions and less variable for two regions than X when kept in 12H cages. Such differences were not found (with one exception) for

TABLE 2. Median variances of feather scores and body weight and percentages[1] exceeding the median within ages and genetic stocks

Variable	Feather scores[2] by region of the body: Back-Wing (B-W)	Front (F)	Rear (R)	All regions (FS)	Body weight
1-hen cages					
Median variances	0.2500	0.9167	0.3333	0.2500	28,446 g
	Percentages exceed the median				
Age, wk					
40	52	38	41	48	51
59	42	38	73	54	48
P	NS	NS	***	NS	NS
Genetic stock[3]					
X	54[a]	42[a]	60[a]	58[a]	40[a]
C	45[a]	44[a]	52[a]	56[a]	52[a]
S	44[a]	27[a]	42[a]	35[b]	58[a]
P	NS	NS	NS	*	NS
12-hen cages					
Median variances	1.5379	1.5076	3.2598	1.2113	32,845 g
Age, wk					
40	29	35	34	32	42
59	98	79	81	85	67
P	***	***	***	***	**
Genetic stock[3]					
X	56[a]	52[a]	71[a]	60[a]	46[a]
C	56[a]	56[a]	48[b]	58[a]	52[a]
S	44[a]	42[a]	31[b]	31[b]	52[a]
P	NS	NS	***	**	NS

[a,b]Means within a column for genetic stock with no common superscript differ significantly ($P \leq 0.05$).

[1]Chi-square tests were based on actual numbers, not percentages.

[2]Feather scores ranged from 0 to 9 and approximated tenths of area covered in a fully feathered hen (0 = 0 to 9%, 1 = 10 to 19%, . . . 9 = 90 to 100%).

[3]X = DeKalb Delta; C = North Central Randombred Control; S = selected, derived from C by 7 generations of selection.

*$P \leq 0.05$.

**$P \leq 0.01$.

***$P \leq 0.001$.

TABLE 3. Medians of feather scores and body weights and percentages[1] exceeding the median by ages and genetic stocks

Variable	Feather scores[2] by region of the body: Back-Wing (B-W)	Front (F)	Rear (R)	All regions (FS)	Body weight
	1-hen cages				
Medians	8.25	7.75	8.50	8.17	1,698 g
	Percentages exceeding the median				
Age, wk					
40	26	65	56	56	45
59	40	8	13	17	60
P	NS	***	***	***	NS
Genetic stock[3]					
X	27	44	29	35	58
C	29	42	44	42	48
S	35	52	52	52	44
P	NS	NS	NS	NS	NS
	12-hen cages				
Medians	5.50	6.21	6.04	5.71	1,619 g
Age, wk					
40	56	58	64	63	53
59	27	33	21	25	44
P	***	**	***	***	NS
Genetic stock[3]					
X	27[b]	44[b]	19[c]	27[c]	50
C	38[b]	42[b]	54[b]	48[b]	50
S	75[a]	65[a]	77[a]	75[a]	50
P	***	*	***	***	NS

[a–c]Means within a column for genetic stocks with no common superscript differ significantly ($P \leq 0.05$).

[1]Chi-square tests were based on actual numbers, not percentages.

[2]Feather scores ranged from 0 to 9 and approximated tenths of area covered in a fully feathered hen (0 = 0 to 9%, 1 = 10 to 19%, ...9 = 90 to 100%).

[3]X = DeKalb Delta; C = North Central Randombred Control; S = Selected, derived from C by 7 generations of selection.

*$P \leq 0.05$.

**$P \leq 0.01$.

***$P \leq 0.001$.

comparisons in 1H cages. On the other hand, comparisons of medians and variances of feather scores for X and C hens showed fewer differences. Comparisons of other genetic stocks by Craig and Lee (1990) also indicated that strain differences in feathering scores are not uncommon.

Body Weights

Although body weights were heavier in 1H than in 12H cages, differences in body weights were not detected as significant in comparing hens at 40 vs 59 wk or among the three genetic stocks within 1H and 12H environments. From comparisons of mortality and feathering it seemed that S hens should have been relatively heavier than hens of the other strains when kept in 12H cages compared with 1H cages. Nevertheless, strains did not differ in either comparison. In a roughly relevant finding, Cunningham and Van Tienhoven (1983-84, 1984), working with hens in multiple-hen cages, failed to find a social status effect on body weight although such an effect was present for feeding frequency and egg production. Thus, body weight appears to be a relatively insensitive indicator of social stress.

General

Results of this and previous studies (Kuo *et al.*, 1991; Craig and Muir, 1993) indicate that when cannibalism among intact-beak hens is a significant problem for a genetic stock, selection of hens on the basis of family averages, when sisters are housed together but separately from hens of other families, improves both survival and hen-housed egg production.

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