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FEAR-ASSOCIATED BEHAVIOR OF PULLETS AS INFLUENCED
BY CAGE DESIGN AND GENETIC STOCKS

By

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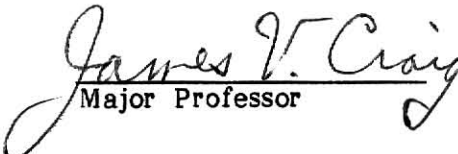
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INTRODUCTION

Studies with egg strain chickens have shown that selection for early sexual maturity or increased part-year egg production is likely to change not only the trait selected, but increase social dominance as well (Craig et al., 1975; Bhagwat and Craig, 1977, 1978; Lee and Craig, 1981). Random genetic drift has also been identified as a potent force in causing behavioral traits to change in experimental populations. Thus, frequency of aggressive acts differed between replicated strains within unselected populations and between strains selected alike for part-year egg mass (Bhagwat and Craig, 1978) and fearful behavior was strikingly different between strains selected alike (Craig et al., 1982b).

Genetic variation has been identified in ability of different genetic stocks to cope with large group sizes in high-density cage systems (Al-Rawi et al., 1976; Hansen, 1976). Craig (1982) has suggested ways in which genetic selection can be used to reduce stress in high-density housing environments.

On several criteria which might be used in evaluating stressful conditions for hens in modern confinement systems, behavior has been suggested as an index (Duncan, 1980). Nevertheless, behavior, as an indicator of welfare, is sometimes viewed with skepticism because the behavior seen in highly artificial environment differs from that seen in more natural habitats, and the behavior of hens in cages has not been adequately characterized in terms of its relationship to well-being (Murphy, 1978).

Changes in cage design can affect production of laying hens (Bell, 1972, and 1977; Hughes and Black, 1976), influence feather loss (Hill and Hunt, 1978) and alleviate hysteria (Elmslie et al., 1976). It appears that feeder space may be of major importance in cage design (Ouart and Adams, 1982) but other design changes such as "get-away" features (Hansen, 1976) and partitions of various types

between adjacent cages (Shupe and Quisenberry, 1961), may also have significant effects.

This experiment was conducted to study fearful behavior of 42 week old pullets over an 8 week test period, as influenced by cage design and genetic stocks. Ready availability of two unselected strains and of two strains selected for party-year egg mass, made this study possible. These strains have been characterized previously for egg production traits (Craig et al., 1982a), for agonistic behavior (Bhagwat and Craig, 1978) and differences between the selected strains in measures of fearfulness have been found (Craig et al., 1982b). Reciprocal crosses were also available between strains within the unselected and selected groups, so that hybridization effects, if present, should be detectable. Relatively large laying-type cages were available and these were altered so as to be relatively narrow and deep with either solid or welded-wire partitions separating adjacent cages. A separate group of pullets housed in individual-bird cages and not subjected to fear-inducing stimulus, was used to obtain egg production data for comparisons with those pullets housed in experimental cages. Information on body weight, feather damage and loss, party-year egg production, and mortality was also collected and associations were estimated among all variables.

REVIEW OF LITERATURE

GROUP SIZE AND DENSITY

Effect on Egg Production. Although Parker and Rodgers (1954) could not find consistent differences in mortality and egg production when comparing hens in individual and colony cages, Shupe and Quisenberry (1961) found that hens in individual cages laid at a higher rate, had lower mortality, and better feed efficiency than when 25 or 35 hens were housed per colony cage. Lowe and Heywang (1964) found a lower hen-housed production in groups of five hens per 24 x 18 inch cage than in single birds in 8 x 18 inch or 10 x 18 inch cages. Elmslie et al. (1964) reported that hens with less than 72 inch (465 cm) floor space in cages had higher mortality than those with more floor space. They used two types of birds, a medium, docile hybrid ("404") and a White Leghorn (W.L.) hybrid ("606") of typically more nervous temperament, at two different locations. Higher hen-day production was obtained with the "606" at both locations and for 8-10 vs 10-14 hens housed in 48 x 15" cages. Thus smaller group size was associated with higher egg production. They found the above trend for the "404" at only one location. Studying the contour map of egg production based on flock size and bird density, they indicated the physical limit of crowding is around 50 in² (330 cm²) per bird. Increasing flock size at the same stocking density caused food consumption to increase. Conversely, they found that increasing the stocking density caused food consumption to decrease.

Wilson et al. (1967) studied the performance of layers in 8 x 18" and 10 x 18" cages with 1, 2 and 3 birds per cage. Hen-day egg production for 11, 28 day periods was not different between birds housed in either cage sizes regardless of bird density. Egg production was less with three birds per cage than with one or two birds per cage regardless of cage size.

Adams and Jackson (1970) conducted two experiments and found that birds housed at low density in cages matured earlier than those housed at high density. In both experiments, hens housed in small cages (30.5 x 45.7 cm) and with density (0.070 m² area per bird) had higher egg production than the hens housed in large cages (71.1 x 81.3 cm) and with high density (0.035 m² area per bird). In a similar study, Mather and Gleaves (1970) compared the performance of six commercial stocks housed at 2, 4 and 6 hens per 16 x 18" cage with a cage floor space of 144, 72 and 48 in² respectively. Egg production was decreased for all stocks as number of birds per cage increased.

Bell et al. (1981) compared a wide variety of cage shapes and colony cages and found that two layers per 30.5 x 30.5 cm cages resulted in better laying performance than the other combinations. Significant positive correlations were also reported between feeder space per hen and egg production, feed efficiency, feed consumption, and egg income minus feed cost. In another study they included 25.4 and 30.5 cm widths and depths in four combinations with two hens per cage, a fifth treatment using three hens in a 30.5 cm square cage and control group placed three hens in a 30.5 wide x 40.7 cm deep cage. They found that each additional cm of feeder space per hen resulted in 5.6 more eggs per hen-housed, .46 kg feed consumed per hen housed, .26 g per egg, 2.3% less mortality, .4% fewer cracked eggs and \$.12 additional egg income minus feed cost.

Effects on Feather Damage, Hysteria and Nervousness. Preliminary studies on hyperexcitability in flocks of laying hens housed in floor pens with litter, were reported by Hughes (1961). He observed that feather eating and lack of feathers appear to accompany hysteria, but the resulting mortality was primarily due to piling and occasionally from claw inflicted tears. The onset of hysteria was found to be around 12-18 weeks of age in most of the cases and was not contagious. Some of the ways cited to alleviate hysteria were debeaking, detoeing growing

pullets, keeping the noise level up in the house, breaking groups of laying hens into smaller lots and mixing affected with unaffected birds.

Elmslie et al. (1964), in their interesting work on the effect of flock size and stocking density on layers, found that hysterical and featherless conditions developed between 40-50 weeks of age in one of the breeds grouped at 14 hens per 48 x 15" cage. Hysteria disappeared and birds grew new feathers when the cages were divided into 16 x 15" sub-cages with three birds each.

Hughes and Duncan (1972), in a rearing experiment, reported on factors influencing feather and vent pecking in chickens. They reported that even though density had no significant effect on pecking damage, group size had a significant effect in weeks 15-17 and an even more pronounced effect in weeks 19-21. Pecking damage was greater in groups of eight pullets than in groups of four.

Hysteria in groups of caged hens resulting from increased nervousness, was characterized by sudden wild flying, squawking, and hiding resulting in scratches and torn skin, especially on backs (Hansen, 1976). He used two strains - Strain 1 known for its cannibalistic tendency and Strain 2, believed to have a quieter temperament than Strain 1 and observed no hysteria in six-hen groups housed at 387 cm² per hen while five of eight, 30-hen lots housed at 464 cm² per hen, became hysterical in both strains.

Adams et al. (1978), while studying the breeding performance of egg-type chickens, found that birds in flocks of 2 males:20 females in 164 x 71.7 cm colony cages had poorer feathering at 40 weeks of age than those in flocks of 1 male:10 females in a 82 x 71.7 cm colony cage. Feather scoring was done by matching the feather condition of the birds with a series of photographs showing various degrees of feather damage. Cage floor space per bird for both small and large flocks was the same. They found that birds housed at 12 weeks had poorer feathering at 40 weeks when compared to those housed at 20 weeks.

Simonsen et al. (1980) subjectively evaluated the feather condition of W. L. Hens at 49 weeks of age. They had housed 7 and 14 birds per m² in deep litter and on sloping wire floor pens. Broken claws and skin wound, along with feather loss in the dorsal rump, back and tail areas were greater problems in birds housed in high density on wire as compared to those housed at low density. They also reported that the wire floors and high density acted synergistically as far as the prevalence of neck feather damage and denudation of dorsum were concerned.

Hughes (1977) explored the preferences of hens for different group sizes to determine the most preferable group size for caged hens. He reared Shaver 288 (light hybrid) and Warren SSL (medium hybrid) in either cages or pens. During the test period of 5 days, hens of both strains with different rearing experience were given a multi-choice test comprising unfamiliar cages and group sizes of up to six birds along with empty cages. In both cage and pen reared hens, empty cages were chosen most often, followed by preference of occupied cages being inversely related to the number of hens. However, cages with three or more birds were preferred more by pen-reared hens than by cage-reared hens. In another experiment, using different hens but the same rearing procedure as in his previous experiment, he found that all hens spent the greater part of their time in large rather than small cages during the preference test. Hens reared singly chose empty cages occupied by one other unfamiliar bird, whereas group-reared hens selected the occupied cages. A third experiment was conducted using the Warren and Babcock strains to study whether the preference of an occupied cage is based on the familiarity or unfamiliarity of the residents. He found that hens of both strains preferred familiar rather than strange birds. Preference for group size appeared to depend both upon the experience of the test bird and upon its relationship with the residents.

MANAGEMENT PRACTICES

Debeaking and Declawing. Lowe and Heywang (1964) noticed higher mortality, mainly from vent pecking, in groups with five birds per cage than those with two birds per cage. They used tranquilizers and employed debeaking in an attempt to decrease vent pecking. The percent mortality from "all causes" and from vent pecking were respectively, 14:0 in individually caged birds, 18:10 in 24 x 18" cages having five hens with both mandibles cut back, 16:8 in 24 x 18" cages having five hens with only upper mandible cut back, and 22:11 in 24 x 18" cages having eight hens with only the upper mandible cut back. Severe debeaking did not result in a decrease in mortality from vent pecking, in the 24 x 18" cages.

Ruszler and Kiker (1975) compared the effects of the removal of toe nails from the three front toes of a commercial strain of W. L. pullets with a hot blade at one day of age on growth and egg production. The toe clipped (TC) birds were heavier at 20 weeks and matured 1 week earlier than the control (N) birds. Hen-day egg production for (TC) vs (N) birds was 67.5 vs 65.4% and for hen-housed production it was 62.1 vs 58.9%. Mortality from 20 through 74 weeks was higher for the (N) birds than the (TC) birds.

Dewinging, debeaking and defeathering effects on male White Rock chicks were studied in floor pens by Oluyemi and Olagbaju (1974). Full dewinging was the removal of the whole wing while partial dewinging comprised the amputation of the wing at the coracohumeral joint. Debeaking involved cutting back half of the upper mandible. Defeathering was the removal of the primary, secondary and the axial feathers from the wing at one day of age and at three week intervals thereafter. Least mortality was noticed in the debeaked and debeaked plus dewinged birds. Defeathering lowered mean body weight which they attributed

to the partial utilization of available nutrients to regenerate lost feathers. Debeaked birds tended to perform better than any other group.

Martin et al. (1976) studied the effects of wing and toe amputation on layers housed in either colony cages or two bird cages or in half-litter, half-slat pens. Treatments included day-old bilaterally and unilaterally dewinging, day-old detoeing, dewinging at day-old and detoeing at 42 weeks old. Effects of bilateral and unilateral dewinging were essentially the same and reduced age at 50% lay, rate of production, feed per dozen eggs and income over feed and chick cost. Detoeing increased rate of production, income over feed and chick cost and decreased feed per dozen eggs. They also reported that treatment x housing interactions were observed.

Hansen (1976) studied the effect of declawing on nervousness and hysteria in hens. In one experiment, when hens in community cages became hysterical 104-106 days after housing at 2 weeks of age, claws of all hens were trimmed using a hot blade debeaker. Claw removal stopped hysteria for 6-12 weeks. In another experiment, using docile strain of pullets, toe-clipping was done at 1 day of age and the birds housed in community cages with all birds in a cage being clawless or with normal feet. Some lots without claws became abnormally nervous but in no cases were hysterical episodes observed.

Ruszler and Quisenberry (1979) conducted trials in two separate years to study the effect of declawing on 23-week old pullets housed in flock sizes of 7 and 10 birds per cage at a common density of 290 cm² per bird. Even though no hysteria was observed, declawing improved livability (2.0%) in the second year and was associated with improvement in hen-housed egg production (1.7%) in both years. Declawing depressed the percent large eggs by 3.7% and 2.1% in the first and second year, respectively. Income per unit area also was increased by declawing.

Recently, Compton et al. (1981) studied the effects of day-old declawing and cage design on the production performance of caged layers. Cage designs included high profile cages (61.0 x 40.6 x 40.6 cm high) and low profile cages (61.0 x 50.8 x 30.5 cm high) with equal stocking densities. Intact hens had higher feed consumption and body weight, but lower hen-day egg production between 20 - 68 weeks of age than declawed birds. There was no difference in egg production between treatments in later periods of production. Claw removal had no effect on cumulative mortality due to oviductal prolapse, but did reduce mortality caused by other factors.

Cage Design Modifications. Shupe and Quisenberry (1961), in addition to comparing the performance of hens in different housing systems, also compared birds housed in wire and slat-sided colony cages during the egg production phase. They reported that highest incidence of mortality was in colony cages with wire sides. Birds in wire-sided cages had a larger average body weight and laid heavier eggs for 11 28-day periods, than those in slat-sided cages, which they attributed to the better air movement across the wire-sided cages, larger body size of birds, and reduction in number of birds in the wire-sided cages. However, hens housed in slat-sided cages had slightly higher egg production than the hens in wire-sided cages, though not statistically significant. Higher feed efficiency was shown by the hens in slat-sided cages.

Elmslie et al. (1964) housed 14 birds per 14 x 15" cage and noticed a hysterical and featherless condition in one of the two genetic strains between 40-50 weeks of age. At 55 weeks, when the 14-bird cages were reduced to nine birds and flocks of three by insertion of partitions, hysteria disappeared, new feathers grew, and production improved dramatically within 2 weeks. They concluded that reduction of cage size and stocking density were responsible.

Bell (1977) compared the performance of commercial W. L. in a reverse and two conventional cage designs using two bird densities. Both conventional cage designs had the same width but one was deeper. Hens in shallower conventional cages had consistently poorer performance than those in the reverse of the deeper conventional cages, based on egg production from 20-76 weeks of age. In comparing hens in conventional versus reverse cages over both densities, he found consistently better egg production, livability and feed efficiency of hens in reverse than in conventional cages, though differences were not statistically significant.

Hughes and Black (1976) compared the performance and feeding pattern of Babcock B300 hens from 18 to 72 weeks of age in deep cages, (460 mm deep) and shallow cages, (305 mm deep). Both cage types provided equal floor space per bird. More eggs were produced per hen from 30 to 70 weeks in the shallow cages than the deep cages with the difference approaching significance. Deep-caged hens showed greater feather damage, presumably caused by pecking, at 70 weeks and a higher proportion of cracked eggs. There was a tendency for more birds to be present at the front of the shallow cage (73.8%) than in the deep cages (61.4% based on the plotting of the position of each individual bird at two different times of the day).

Hill and Hunt (1978) studied the effects of deep and shallow laying cages on three populations of 3, 6 and 12 birds, each with 310, 387, and 464 cm² of floor space per bird. In shallow cages, annual average egg weight, body weight, feed per bird and back feathering were greater than in the reverse cages. However, hens in deep cages were superior in feed conversion and relative freedom from soft-shelled and broken eggs. In a special case of three birds per cage at 464 cm per bird, where dimensions of the deep and shallow cages were exactly

reversed, those in shallow cages were less nervous, had more feather and egg cracking losses, inferior egg production, feed conversion, and net egg income.

Ouart and Adams (1978) studied the effects of cage depth on laying performance of W. L. layers. Shallow cages were 51 x 31 cm in size while deep cages were 31 x 51 cm with three or four birds per cage of either shape. No significant difference in egg production was observed between the cage types. Group size was important eggs per hen in three-bird cages was 183 compared to 175 per hen in four-bird cages between 20 and 56 weeks of age.

Muir et al. (1980) reported a similar experiment on the performance of laying hens in deep and shallow cages and with different feeding regimes. Deep cages included two birds per 25.4 x 45.7 cm cage and three birds per 30.5 x 45.7 cm cage, while shallow cages were represented by three birds per 45.7 x 30.5 cm cage and four birds per 50.8 x 30.5 cm cage. Feeding regimes included unrestricted and restricted food supply at the time of sexual maturity and at the peak of egg production. There were no significant differences in the-day egg production, egg shell damage and body weight between hens in deep and shallow cages at various densities and also among the different feeding regimes. Egg shell damage was nonsignificantly reduced for the layers housed in shallow cages.

Dorminey et al. (1972) housed dwarf W. L. layers in various group sizes in either 61 x 61 cm or 30.5 x 45.7 cm cages with or without perches. There was a trend for mortality and feed per egg to increase and feed consumption and body weight gain to decrease as bird density increased in both cage sizes. Performance was better in the smaller cages when similar space was provided per bird. The presence of perches in both sizes and at different densities did not effect egg production, livability, feed consumption, feed per egg, egg weight, and body weight gain but increased the incidence of cracked eggs in the 30.5 x

45.7 cm cages, perhaps as a result of some individuals habitually laying while sitting on the perches.

Bareham (1976) compared the behavior and production of laying hens in an experimental cage and a barren conventional cage. The experimental cages as compared with the conventional cages had a horizontal floor, were extended in height, had food and water provided at two levels, had two perches, and had nesting boxes containing litter. Forty-eight W. L. layers were housed at six per cage in both the experimental and conventional cages. Floor and perch area together was 715 cm per bird in the experimental cages, while in the conventional cages it was 200 cm² per bird. During a 6-month observation period, the experimental birds laid nearly all their eggs in the nest boxes and showed more movement, reflex activity, preening and sitting but less feeding, drinking, pecking, pushing and stereotyped behavior. They also showed less feather damage and foot damage than the convention-caged birds. Egg production in both cage types was similar over the 6-month test, but samples of eggs from experimental-caged hens were of a higher mean weight. He reported that in general, birds in the experimental cages were much quieter and less 'flighty' than those in conventional cages.

Hansen (1970) studied the effect of cage design modifications on nervousness and hysteria in laying hens. Some of the community cages were increased in height by 29 cm to a total of 80 cm and contained a roll-away nest and two perches, some were increased in height by 29 cm to a total-eight of 80 cm with four perches, while others were divided into smaller cages by wire partitions. There was no hysteria in cages with nests and perches. Hens in cages with nests laid more eggs per hen housed than hens in controlled community cages. Dividing the cages also alleviated hysteria.

Choudary et al. (1972) compared the behavior and production of different strains of hens assembled at different ages in either nearly square or long and narrow cages. All treatments had 14 hens per cage with an area of 400 cm² per bird. Although the hens in the square cages had a higher incidence of severe agonistic interactions than those in the long and narrow cages, birds in the latter cage type appeared to be more 'flighty' and showed marked feather loss and bruises.

GENETIC STOCK X ENVIRONMENT INTERACTIONS

Studies comparing the performances of genetic strains under different housing systems were conducted by Gowe (1956). Seven strains of Single Combed W.L. pullets were housed at 160 days of age. Thirty five pullets of each strain were randomized into a three deck 12 x 18" individual cage laying battery, while three pullets per strain were assigned to 14 floor pens with a little over 4 ft of floor space per pullet. There was highly significant interaction between strains and housing systems with respect to hen-day production and body weight, but not for hen-housed egg production, sexual maturity, egg weight and mortality.

Elmslie et al. (1964) used a medium-sized docile hybrid ("404") and a W.L. hybrid ("606") of typically more nervous temperament in studying the effects of flock size and stocking density on performance in cages. At 40-50 weeks of age, a hysterical and featherless condition developed in the 606, housed at 40 birds per cage. Hysteria was alleviated by reducing the number of hens to nine per cage and dividing them into three flocks by insertion of partitions. Age at sexual maturity was brought forward by larger flocks and high stocking densities only in 606.

In 1970, Adams and Jackson reported their findings from two experiments on the performance of six strains of commercial layers, as affected by cage size and bird density. Birds were housed at two densities in each cage size, .07 and

(low) and .035 m (high) of floor area per hen. Two and 8 birds were housed at low density in the small and large cages, respectively, and 4 and 16 birds at high density. Both experiments were conducted in a similar way, but in separate years. Strain differences were found for sexual maturity, mortality, egg mass, and average egg weight in experiment 1 and for sexual maturity, hen-housed egg production, and egg mass in experiment 2. A significant strain by density interaction was found for age at sexual maturity in experiment 1.

Relationships between strain, environmental factors and feather damage were investigated by Hughes and Duncan (1972). Two light hybrids, the Thornber 808 and Shaver 288 and one medium hybrid, the Thornber 909 were used. They were housed in both floor pens and cages of different sizes with various flock sizes and densities. Until 21 weeks of age, the birds were scored from 0 to 5 for feather damage at weekly intervals by looking at the degree of feather loss on the bird's body. They found that pecking damage was higher in cages than pens. Strain differences for pecking damage only between 8 and 19 weeks of age was found, but none before 8 weeks or after 19 weeks of age. Pecking damage was greater in the groups of eight birds than in groups of four between 15-17 weeks of age and the differences were more pronounced in 19-21 weeks of age suggesting an association with vent pecking.

Al-Rawi et al. (1976) studied genetic strain and group size effects on the agonistic behavior and egg production of five stocks of commercial W. L. layers. Four, 8 and 14 birds were housed in different cage sized thereby maintaining constant floor area and feeder space of 412 cm² and 5 cm per bird, respectively. Agonistic behavior was recorded, both on individual bird and group bases as well as time spent in ingestive, "active", resting and preening behavior. Birds with closed eyes were considered to be resting, otherwise they were considered active, whether they moved about or not. Records of egg production and mortality were

kept from 20 to 60 weeks of age. Agonistic activity observed on individual birds and groups was affected by both genetic strain and group size between 20 and 28 weeks of age. Three of the 5 strains interacted about three times as frequently as did the other two. Agonistic acts occurred more frequently in groups of 8 and 14 than in 4 birds per cage. They reported that pecking accounted for 77.6% of all agonistic interactions and noted that rates of agonistic acts were higher during ingestive and active behavior. Differences were found among strains for age at sexual maturity, egg production and mortality. Group size of 14 had the lowest egg production and highest mortality and a stepwise decrease in hen-housed production was found as group size increased. There was a significant strain x group size interaction for hen-housed production. Birds in groups of 8 and 14 spent less time in feeding than those in groups of 4. No associations were found between frequency of agonistic acts by flocks and their egg production or between social status of individual birds and duration of feeding times.

Dickerson and Mather (1976) compared the laying performance of six major commercial stocks with that of the Cornell Random Leghorn Controls housed in either floor pens or 3-bird cages or 5-bird cages at densities of 2230 cm, 622 cm, and 372 cm floor area per bird. They reported that commercial stocks in all the three housing systems had earlier sexual maturity, produced more eggs per hen-housed in floor pens and more pronounced in cages, produced more eggs per hen-day, larger eggs, greater egg mass per hen-day and hen-housed, greater albumin height, had lower body weights at 71 weeks of age, and greater egg/feed conversion than the controls. They compared these results with that of Random Sample Test of 1958 to see the relative changes in performances of Commercial and Controls under floor and cage environments. Between 1958 and 1970 Commercial stocks had improved their performance by producing more number of eggs, greater egg mass per hen-housed, greater feed conversion, lighter final

body weight, earlier age at sexual maturity and greater albumen height than the Controls. They also found significant genotype-by-environment interactions between the relative performances of Commercials and Controls when tested in floor pens and in 3 - or 5 - hen cages. The Commercials, though more productive in all three environments, were especially superior to the unselected population in cages.

Jones et al. (1981) studied the behavioral and physiological responses of two strains of hens from two rearing environments to a fear stimulus using remote observation and radio-telemetry of heart rate. Strains included a medium hybrid (Warren SSL) and a light hybrid (Babcock B300), while the rearing environment included deep litter pens and cages. Fear was induced in the isolated hungry hen under test by a looming human stimulus after the delivery of food by remote control. Behavioral changes as looking around, ceasing feeding, head shaking, complete withdrawal, crouching, and flight were observed. Latencies to feed were also recorded in seconds. Differences in fear responses between the medium hybrid and light hybrid hens existed. Medium hybrid hens were more disturbed by food delivery than the light hybrid hens as shown by their mean latencies to feed.

INDICES OF BIRD WELFARE

Duncan (1980) in a detailed report on animal welfare, suggested that estimates of welfare include evidence based on health, productivity, physiology and behavior. He discussed the pros and cons of each kind of estimate and highlighted the behavioral index as having advantages over the others.

Health Though the incidence of avian tuberculosis, fowl typhoid, and intestinal parasites are low in the caged birds, all intensive systems increase the

risk of spread of respiratory and viral diseases, and incidence of feather damage (Vestergaard, 1978). Gross and Siegel (1965), producing social stress in chickens by introducing birds into an established group of birds, found that stressed birds were more resistant to E.coli but susceptible to Newcastle disease and sometimes to M.gallisepticum.

Productivity. It has been shown that the stress response of an organism has a catabolic nature with regard to protein (Baster and Forsham, 1972). However, use of productivity, as a gauge for the welfare of animals at the farmer level is not feasible if measured in terms of egg numbers and live weight gain on a flock rather than on an individual basis.

Physiology. Some of the physiological responses to stressors are an elevation in the level of plasma corticosterone (Zachariasen and New Comer, 1975), involution of lymphoid tissue (Howard, 1974 Duncan et al., 1973), increase in plasma glucose (Davison, 1975), drop in shank temperature (Duncan et al., 1975) and changes in number of leucocytes which includes acidophilia and heterophilia (Wolford and Ringer, 1962). However, the physiologican and biochemical measurements are difficult to take, particularly in the field. Some of them require the slaughter of bird while others involve procedures such as withdrawal of blood or restraint, which are themselves likely to be stressful.

Duncan (1980) pointed out the practical difficulties in measuring physiological changes and suggested the used of refined techniques such as radio-telemetry for measuring the physiological changes with minimum interference to the bird. Jones et al. (1981) employed radio-telemetry of heart rate as the physiological response to a fear stimulus consisting of a looming effect of a human being.

Behavior. Hughes (1976) suggested that welfare could be measured by studying behavior in an environment which is assumed to be ideal and then comparing it with the environment under investigation.

In a study carried out by Black and Hughes (1973), nine behavior patterns were observed weekly in three different strains of laying hybrid chickens reared from day-old to 6 months in groups of seven in .41 x 1.07 m cages and in groups of eight in 2.14 x 1.83 m deep litter pens. There were 12 groups two cages and two pens for each strain. Each group was observed for 10 min, twice weekly until they were 24 weeks old, for behavioral patterns such as head shake, head scratch, body/wing shake, wing flap, wing/leg stretch, ground scratch, dust bath and preen. At 30 weeks of age, the caged birds were transferred to floor pens and the floor birds to cages. The same observations were recorded after the transfer. In addition, activity in terms of resting, part movement, body movement, pacing, feeding, and drinking were observed in another experiment both before and after the transfer of the birds used in the previous experiment at the age of 32 weeks. Based on the pooled means of each behavioral pattern for all cages and all pens, there were significant differences between hens in cages and pens before the transfer for all behavioral patterns except for body-wing shake and head scratch. There was a significant increase in head shaking and decrease in wing flapping, ground scratching, dust bathing, and movement flapping when birds were moved from floor pens to cages. Interestingly, wing flaps performed by a number of birds moved from cages to pens in the first 10 minute period after transfer, were abnormal and incoordinated. In the latter experiment, hens in cages spent more time resting, moving their body parts, feeding and drinking, but spent more time pacing when transferred to pens.

Bareham (1972) compared the behavior, adrenal response and productivity of two strains of laying hens housed in either individual battery cages or deep

litter pens. The battery cages were 8" wide x 17" deep x 18" high, each, giving .94 ft² of floor space per bird while deep litter pens housed 30 birds each with a floor space of 2.17 ft² per bird. Quantitative records of gross behavioral patterns such as feeding, drinking, grooming, reflex, pecks, turns and head flicks were made periodically. Deep litter birds showed significantly more reflex activity, pecking, cage/floor pecks and turns than their battery counterparts. Battery birds spent more time feeding and head flicked more often than the deep litter birds. There were no significant differences within breeds for pituitary weights, adrenal weights, or circulating heterophi numbers. Battery caged birds produced significantly more eggs and matured earlier than the deep litter birds.

Hughes and Black (1974) compared activity, behavioral patterns, and fear of the chickens in cages and pens under the influence of group size, stocking rate and illumination intensity. Behavioral observations was started at 14 weeks for a total of seven times at approximately two week intervals. Observation periods lasted for 5 minutes and every 30 seconds, a record was made of whether each individual was resting, standing, or pacing while head flicking and preening was noted during the preceeding 30 seconds. Fear scores were obtained by the orientation of birds toward a novel object which was a wooden block placed in food trough, with higher scores representing increasing degrees of avoidance. In caged birds, activity as shown by more pacing and less standing increased with brighter light, more space per bird and more birds in a group. Increased preening was observed in caged birds at a lower stocking rate. Birds in pens at lower stocking rates had significantly higher activity and lower head shaking than the birds at higher stocking rates. Fear response in caged birds was enhanced in dim light and in larger groups.

Hughes and Black (1973) approached the problem of animal welfare from an animal-centered rather than a human-centered point of view, be presenting

animals with the opportunity of choosing between different environments. Brown Leghorn laying hens were presented with four different types of floor much as the "N" (Normal) floor of 5 cm x 25 cm rectangular wire mesh with wire thickness of 2.0 mm, the "B" floor which is similar to "N" floor but with wire thickness of 3.25 mm, the "W" floor of hexagonal 13 mm mesh with wire thickness of .71 mm, and finally the "P" floor consisting of a galvanized steel sheet perforated with 2.0 cm circular holes at 2.8 cm centers. Birds were reared in groups and later housed in individual cages on "N" floor until the preference test was started. After an acclimatization period of 48 hours on different floors, the birds were presented with the four choices of floors and were scored individually for 1 hour depending on the time spent by the bird on each floor. A record was also kept of the floor from which eggs were collected. The total scores for each type of floor showed that the most time was spent on the "P" floors. Based on the significant difference between the "W" and "P" floors and between "W" and "N", they counted the number of wires supporting the feet of the bird in each floor and pointed out that "W" floors provided quantitatively much more support. There was a close association between the total amount of time spent by the birds on each floor and the total number of eggs laid on each floor.

In a similar experiment, Hughes (1975) tested the preference for space of six, 1½ year old hens derived from three different strains. The preference test was done at two different times of the day to assess the effect of photoperiodicity. A small cage (30.5 x 20.5 cm) and a large cage (91.5 x 61 cm) were used. Before the test period, all the birds were equally familiarized with both cage types. The entire apparatus was rotated through 180 degrees after the test period, to avoid any positional preference of birds. All the birds expressed significant preference for the large as opposed to the small cage, irrespective of the time of the day and even after changing the position of the cages.

Dawkins (1982) also studied the preference of the nine 35 week-old hens for the physical space allowed to them and the nature of the floor. They were reared on deep litter to 20 weeks of age, then housed in battery cages with two birds per cage and were familiarized with litter for four weeks immediately preceeding the preference tests. Small cages (.38 x .43 x .40 m) and large cages (.76 x .86 x .46 m) with a floor area four times that of small cages were used for the tests. Floor types included wire and 6 to 7 cm of litter. Preference tests were run between small and large cages with wire floors, small cages with wire floors, and litter floors, and between small cages with litter floors and large cages with wire floors. Based on the time spent in each of the two cages under question, hens spent more time in large wire floored cages than in small wire floored cages, in small litter floored cages than in small wire floored cages, and interestingly in small litter floored cages than in large wire floored cages. During the experiment, five out of nine hens showed dust bathing movements in the cages with litter, even in the limited time available during the tests. To ascertain the preference of hens for litter rather than space, another experiment was conducted using the small wire floored cages of previous experiments and an even smaller cage (.38 x .215 m) with litter floor. There was a significant preference of hens for the smaller cage with litter even though it was half the size of the small cage used in the previous experiment.

More recently, Dawkins (1982) extended her work on preference of hens for different group sizes and cage sizes. In experiment 1, she confirmed the results of Hughes (1977) that both the battery reared birds and those used to living outside preferred a familiar hen to an empty cage and preferred an empty cage to a strange hen. In experiment 2, 20-week old pullets were presented with a choice between a small empty cage (.38 x .43 x .43 m high) and a large cage (1.06 x .43 x .43 m high) containing all five of its cage-mates. Birds preferred

being with their cage-mates to being on their own, even though the birds had been together for only 2 to 4 days. She also found that those birds which are familiar to each other and to the test apparatus, exhibited a decline in preference for their cage-mates after 4 weeks and instead showed a tendency to be alone. Contrarily, naive birds which not familiar to each other and to the test apparatus did not show a decline in their preference to their cage-mates. In experiment 3, birds which had become familiar with the test apparatus and their cage-mates till the age of 30 weeks, preferred to be on their own and were increasingly reluctant to enter a cage the more of their cage-mates it contained. She concluded by cautioning the preference of hens to a group size is not a constant, but depends upon how familiar the cage-mates are and how familiar the surroundings are.

Fear-associated Behavior In a series of observations by Hamm (1967), records indicated that egg production was seriously damaged for varying periods of time of stress. He reported that single stressing of less than half a day was not damaging but activities extending 3 days and beyond were damaging.

Phillips and Siegel (1966) compared two lines of White Rock chicks, selected for high and low body weight, at varying ages for development of fear responses. Half the birds of each line were held in isolation and half in groups. All were exposed individually to sudden ringing of an electric door bell for 2 seconds and the behavioral responses of the chick during the following 3 minutes were scored by observers. Responses increased to an early peak at about 2 to 3 days post-hatching after which they dropped to a fairly low plateau. Very young or decerebrate birds appeared to lack the emotional tone that is present in older intact birds. When the chicks were 6 hours old, high weight line chicks were more alert, vocalized more and ceased activity longer at the sound of the bell than did the low weight chicks. Highly significant differences were found between

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the grouped and isolated birds at both 48 and 72 hours. Significantly more chicks in high weight lines defecated at 135 and 144 hours than in the low weight line.

Hughes and Duncan (1972) conducted an experiment to find an association between fearfulness and degree of pecking damage. They used a medium hybrid (Thornter 909) that was about 18 weeks old, housed in two group sizes and two densities - 8 birds and 4 birds and 14.2 birds per m or 21 birds per m. Fear was induced by moving a pencil slowly from right to left for 60 seconds in front of the cage by the experimenter. Depending on the orientation of the birds towards the pencil at the beginning and at the end of 60 seconds, the birds were scored for fear responses. The amount of pecking damage was also scored subjectively by the experimenters depending on the amount of feather cover on the bird's body. They reported that birds with the least pecking damage had the lowest fear scores, while the severely pecked hens were the most fearful, the remainder being intermediate. A highly significant correlation of +.484 was found between pecking damage and fear for cage means. In another experiment, using body weight as an index of general well-being of the bird, they found that feather pecking had a harmful effect on the bird as shown by loss in the body weight.

Hughes and Black (1974) studied the relationships between feather pecking, "fear" response and activity of growing pullets in cages and floor pens under different combinations of stocking rate, group size and light intensity. The cage treatments were groups of four birds each at high stocking rate (61 x 46 cm cage), groups of four at low stocking rate (1.22 x 46 cm cage) or groups of two at low stocking rate (61 x 46 cm). Each group was housed either under high light intensity (55-80 lx) or low intensity (17-22 lx). Pen treatments were groups of four in either a large pen (2.14 x 1.33 m) or a small pen (1.22 m x 46 cm) with the same light intensity. Birds spent significantly more time standing when in

dim light, at the higher stocking rate, and in smaller groups. Birds in pens also spent more time standing and more time pacing when in bright light, at lower stocking rate, and in larger groups. Fear score, as obtained by the degree of avoidance of caged birds to the novel object of wooden block plain the food trough, was more for birds in dim light and in larger groups, than for birds in bright light and in smaller groups. There was no significant effect of group size, stocking density, and light intensity on feather pecking. They hypothesized that there is some relationship between activity and pecking damage but none between "fear" and pecking damage.

Sefton (1976) investigated the influences of cage size, flock size and genotype of bird on productivity, livability, and fearfulness. Pullets from 10 matings of Single Combed W. L. were housed at 20 weeks of age in three sizes of cages in a double tiered, modified stair step arrangement. Birds were housed in three cage-size and floor-area combinations (1) three hens per 30 x 46 cm cage with an area per bird of 460 cm, (2) two hens per 25 x 46 cm cage with an area per bird of 5675 cm and (3) two hens per 20 x 46 cm cage with an area per bird of 460 cm. Livability was calculated within matings for each cage size and tier from housing to 64 weeks of age. Egg production was measured on a cage basis from 60-64 weeks of age. Fearfulness was determined during 60-64 weeks of age using a modified method of Hughes and Duncan (1972). There was a reduction in egg production, when area per bird decreased and number of birds per cage increased indicating the sum of stresses imposed by each factor. Birds in cage size (1) were more fearful than either those in cage size (2) or cage size (3), which did not differ from each other. They reported that the level of fearfulness was influenced more by the number of cage mates than by the floor area provided per bird. Negative estimates of correlation between fear and production existed for nine of the ten matings, out of which only two were significant suggesting

the influence of genotypes. Average correlation between fear and production over all matings was $-.47$. Seven of the ten matings showed a negative correlation between fear and livability, out of which two of these were significant which also suggests for genetic factors influencing the relationship between fear and livability.

Sefton et al. (1978) conducted a study to determine if frustration and fear were associated with either body weight, age at first egg, egg production. They used two pure lines selected for high body weight and their reciprocal crosses. They were housed in individual cages of 30 x 46 x 46 cm. Head flicking was observed as one of the expressions of frustration. Fear was measured by the modified procedure outlined by Sefton (1976) involving movement of a pencil slowly by an observer in front of the cage. A least fear score of 1 was given if a bird pecked at the pencil, highest score of 5 for bird showing flight, while the intermediate scores were given based on the orientation of the bird towards the pencil. Correlations of fear and frustration with body weight taken at 24 and 38 weeks of age, age at first egg and percent hen-day production for 9 months were of a low order.

Behavioral and physiological responses to fear-inducing stimulus in two hybrid-type hens under two rearing environments was assessed by Jones et al. (1981). Fear stimulus was slowly approaching human beings towards a hungry hen in a cage. Behavioral response was measured by the time taken for the hungry hen to overcome avoidance to the fear stimulus and start feeding. Heart rate was used as criterion for physiological response. It was recorded by radio-telemetry devices which were implanted subcutaneously. There were significant correlations between sharp rises in heart rate, cessation of feeding and complete withdrawal, emphasizing the close relationship between the behavioral sequence and physiological measure. Based on behavior, medium weight strains were more

disturbed than light weight hybrid strains as shown by their latencies to feed. Penned hens were significantly more disturbed than caged hens. The reported that due to concomitant behavioral and physiological changes associated with fear stimulation, they should be regarded as complementary rather than alternative measuring assessing fear.

Tonic immobility is a fear-potentiated response, usually produced under conditions of manual restraint, in which the animal typically struggles and tries to escape from the experimenter, but after having been held firmly for a few seconds the struggling subsides and the subject assumes an immobilized posture which persists in the absence of further restraint. Gallup (1974) reviewed this phenomenon of animal hypnosis in great detail. Termination of immobility is usually abrupt and discrete, with the animal making an almost immediate transition from the immobile to mobile state. As reported in his article, of the six theories accounting for tonic immobility in animals, the "fear hypothesis" seems to give the best understanding of the phenomenon. According to this theory, tonic immobility represents an innate fear response which is exhibited under by aversive environmental events. Some of the finding in tonic immobility with chickens, which have been the most frequently used subjects, are as follows: 1) Duration of immobility for untreated subjects averages about 8-10 minutes, but there are very large individual differences. Eye closure during immobility is predictive of much more prolonged reactions and vocalizations usually indicate that the response is about to terminate., 2) Fifteen seconds of manual restrain is used in chickens for most durable reaction, 3) the fewer the number of inductions of immobility, the more susceptible the subject becomes, 4) birds tested in social isolation show more prolonged reactions than those immobilized in the presence of other birds. Similarly, rough handling, novel or unfamiliar test conditions lengthen the response. 5) Duration of immobility in chickens is inversely related to a bird's peck-order

position, with low ranking and presumably more stressed birds remaining immobile longer than dominant birds, 6) Birds may defecate during the immobility period. 7) Male birds, cage-housed birds, and light-weight birds were found to be more fearful than female birds, pen-housed birds, and medium hybrids or broilers, respectively, 8) No consistent evidence for immobility in chicks until 7-10 days of age was obtained, but after that the duration of immobility remains relatively constant for at least 7 weeks. This indicates a maturational delay in onset of tonic immobility. 9) There is considerable evidence showing that birds continue to monitor the environment and actually process information while in the immobile state. 10) Adrenalin potentiates tonic immobility while use of tranquilizers and conditioned safety signals lessens the reaction. 11) Heritability estimates of between .70 and .90 were found after only one generation of breeding birds for either prolonged or brief immobility reactions suggesting the robust effect of selective breeding.

REDUCTION OF STRESS

Mcbride (1971) suggested that social stress, which appears to be most important in crowding, may be reduced by provision of adequate feeders, waterers, nest boxes, grooming posts, use of subdued lighting, control of visual and social contacts between groups of birds by partitions, smaller group sizes, and use of tranquilizers for short-term stresses.

Freeman (1971), reviewing stress in the domestic fowl from the physiological point of view, suggested ways to minimize the effects of stressors. They include the use of tranquilizers and sedatives such as reserpine, use of compounds like corticosteroids and ascorbic acid, and finally by selecting stress-resistant stocks.

According to Hughes (1973), cages constitute an inadequate environment for birds as they contain various patterns either through limited space or through

lack of a suitable substrate such as litter, cause frustration due to lack of stimuli to release nesting behavior., and enhance feather pecking. He suggested that the real choice lies not between an ideal, natural system, but between several systems, all artificial to a greater or lesser extent and all with various imperfections. He further suggested that defects in the battery system should be identified and corrected in a manner which results in the minimum modification of the behavioral patterns which are observed in more spacious and complex environments.

Duncan (1973) suggested that research should follow three ways to reduce stress in intensive systems of animal husbandry: 1) objective judgement of disturbed behavior can be obtained by correlating the behavior patterns with various physiological parameters, 2) reappraise the design of battery cages, and 3) select strains suitable for intensive systems. Research may be oriented to selection for response to social strife that will increase the birds' general fitness (Siegel and Gross, 1973).

Hurnik (1981), in a report on animal welfare, suggested that for dependable analysis of behavioral dynamics, more attention should be given to ethology in agricultural research and in the education curriculum of future agrologists and veterinarians. Focusing on stress, he suggested that better techniques should be developed by research institutions to alter the physical appearance of farm animals, such as debeaking and declawing in chickens. As genotype contributes to the variation among individuals for all biological traits and characteristics, he proposed that animals should be selected for intensive environments.

Craig (1983) in his report on the adaptation of laying hens to high density environments suggested several approaches to reduce behavioral and other stressors in multiple-hen cages. Behavioral traits such as flightiness, tendency for feather and cannibalistic pecking, and feeding activity in group situation along with egg

production criteria may be included in selection programs. Use of mean performance records of families of pullets caged together for selection purposes would be an effective method for increasing adaptedness in high-density, multiple-hen cage environment. This is based on the hypothesis that those families which perform best tend to possess those physiological and behavioral characteristics most appropriate for group well-being and production which would then be transmitted to following generation. Practices such as debeaking and declawing probably should be abandoned so that tendencies toward feather and cannibalistic pecking and claw-inflicted injuries would be promptly revealed, allowing rejection of such families from the selection program. He also suggested an alternative approach of enriching the cages with nests, roosts, and dust baths to minimise stress and frustration in birds.

MATERIALS AND METHODS

Genetic Stocks. Eight combinations of White Leghorn strains were used in the experiment. All were derived from the Kentville Randombred Control. Two strains (C_1 and C_2) represent randombred, unselected controls and two others (Y_1 and Y_2) had been selected for part-year egg mass, as recently described by Craig *et al.* (1982). Behavioral differences have been detected between replicated strains within the C and Y systems, presumably because of random genetic drift within these relatively small populations. Bhagwat and Craig (1978) found the selected strains to be socially dominant to unselected controls, but frequency of aggression varied between strains within systems. More recently, Craig *et al.* (1982) compared fearful behavior of Y_1 and Y_2 strain hens and found that Y_2 hens remained away from fear-inducing stimuli 10 times as long as Y_1 hens. For this study, the four strains and reciprocal crosses of strains within systems were used. Abbreviations for the genetic combinations are presented in Table 1.

Procedures and Facilities. Chicks of all genetic combinations were hatched and vaccinated for infectious Bronchitis, Newcastle and Marek's diseases on May 17, 1980. Chicks had their combs removed at hatching and about 1/3 of the upper beak was removed at about 3 1/2 weeks of age. Pullets were housed individually at 19 weeks of age in 20.3 wide x 45.7 cm deep x 45.7 cm high wire cages present in a curtain-sided, cage-layer house. Feed was provided in a trough located in front of the cages. Birds received natural lighting photo perxxx during the brooding period, but were exposed to artificial lighting beginning at the time of housing to prevent delayed sexual maturity, due to decreasing natural day length. Birds received 13 to 15 hours light during the rearing period and 15 hour daily in the laying house. Egg records on individuals were obtained, beginning when pullets were 20 weeks old, except during the 8-week test period for experimental birds.

Pullets were fed the KSU 18% crude layer ration ad libitum. Formulation of the ration is given in the Table A-6.

Experimental cages consisted of two designs, each having eight replications and present in another curtain-sided and fan-ventilated house. Cages were 35.6 wide x 71.1 cm deep. One group of eight cages had solid wooden partitions on the sides, but were otherwise constructed of welded wire, as were the other eight cages. Hereafter, those with solid wooden sides are referred to as solid-sided and the rest as wire-sided. All cages were present in a single row and those of the same design were adjacent to each other.

When pullets were approximately 41 weeks old, 16 from each genetic combination were randomly selected on the basis of production records from those individuals having laid two or more eggs during the previous 2 weeks. These birds were moved into the experimental house at 42 weeks of age and were assigned to either solid-sided or wire-sided cages by a restricted randomization process, so that one of each of the genetic combinations was present in each cage. Thus a total of 64 pullets were present in cages of each cage design. The experimental design used during the group-housing phase (test period) of the study is presented in Table 2. Floor area per bird was 316 cm. Feed was provided in a trough located in front of the cages. A feeder space of 4.4 cm was thus provided per pullet. Observations indicated that only three pullets could usually gain access to feed at any one time. Free-flowing water was presented in a trough situated in front of the cages above the feeder.

Colored plastic badges were placed on both wings of each pullet within a flock. Eight different colors were used and they were randomly assigned to the different genetic combinations so that the observer would have no information as to that variable while measuring fear-associated behavior. Pullets were housed in experimental cages for an 8-week "test period" from 42 until 50 weeks of age.

Behavioral Observations. Observations were carried out once a week during the test period. Avoidance behavior was induced by striking the top of each cage. Prior to striking the cage, pullets were deprived of feed for approximately 6-8 hours, by covering the feed trough with pre-fitted cardboard at 0730 hr. Beginning at 1330 hr, the observer would stand approximately 50 cm away from the cage front, remove the cardboard sheet from the feeder and strike three times on top of the cage, followed by waving by both hands three times in front of the cage. The observer would then gaze directly into the cage to obtain data on (1) Latency to normalcy, which is the time taken by each pullet to come to the front half of the cage and no longer exhibit avoidance behavior, and (2) Latency to feed, which is the time taken by each pullet to overcome avoidance behavior and start feeding (beak touching feed and swallowing movements). The observer would call out the required information for each pullet and a second person, using a timer, would then record latencies. A maximum of 600 sec was allowed for observing a cage and pullets not meeting the criteria within that period was assigned values of 600 sec. All the cages in both designs were tested as described above in random order.

Other measures. Body weights were obtained at time of housing in experimental cages and when pullets were 43, 47, and 50 weeks old.

Amount of feathering on each pullet's back and wings was scored at the time of housing in experimental cages and at the end of test period, by matching the feather condition with a series of photographs showing various degrees of feather loss (Adams et al., 1978). A score of 9 represents maximum feather cover and a score of 1 represents total feather loss on the back and top of the wings.

Egg production was recorded 3 consecutive days per week on a flock basis during the test period. Mortality was recorded daily and there were no replacements of dead birds.

Post-test Period Data. When the pullets were 50 weeks old, they were moved back to their original individual-bird wire cages. Records of egg production were then kept 3 consecutive days per week on an individual-bird basis and mortality was recorded daily until they were 59 weeks old. Hereafter, the period between 51 and 59 weeks of age is referred to as the post-tested period.

Apart from the experimental pullets, a separate group was chosen from the original population of pullets housed in individual-bird cages. Sixteen pullets from each of the eight genetic combinations were picked at 42 weeks of age on the same criterion as the experimentals, i.e. that each laid two or more eggs during the previous 2 weeks. Thus a total of 128 layers, corresponding to the number of experimentals, were used to compare with the laying performance of the experimentals. They were kept in the same cages from 42 until 59 weeks of age and were not subjected to being moved into and out of the group cages and the fear-inducing stimulus, as in the case of the experimentals. Individual egg production records of the pullets in individual-bird cages were kept 3 consecutive days per week and mortality was recorded daily.

Analytical Procedures. Cage designs and genetic stocks were treated as main effects in analysis of variance. Traits analyzed were latency to feed, latency to normalcy, age at first egg, egg production between age at first egg and 42 weeks of age (pre-test hen-day production), body weight at 42 weeks, body weight changes during the test period, egg production during the test and post-test period, change in feather score and mortality of pullets in the test and post-test period.

Least squares means were calculated for main effects. Because of mortality, analyses of variance for unbalanced data were required for some traits measured on individuals, viz. latency to feed and to normalcy, change in bodyweight, and egg production during the post-test period. Period was used as a main effect for traits measured repeatedly. Mortality of pullets was analyzed for main effects using Chi-square analysis.

Correlation coefficients between all pairs of traits based on individual pullet data (except hen-day production during the test period) were calculated. Correlation coefficients between all possible pairs of traits based on flock (cage) means were also calculated.

RESULTS AND DISCUSSION

FEAR-ASSOCIATED BEHAVIOR

GENETIC EFFECTS

Random Genetic Drift. There were no significant differences between C_1 and C_2 or between Y_1 and Y_2 strain pullets for either latency to feed or to normalcy. Latency to feed for C_1 and C_2 pullets were 298 and 226 sec, while for Y_1 and Y_2 pullets they were 114 and 227 sec, respectively. Latency to normalcy for C_1 and C_2 pullets were 46 and 40 sec, while for Y_1 and Y_2 they were 29 and 24 sec, respectively. Had significant difference been found, they would have been ascribed to random genetic drift. In a previous study, Bhagwat and Craig (1978) found differences for frequency of aggressive acts between strains, within selection schemes, in 2 of 4 generations studied, when pullets were kept in flocks of their own kind. More recently, Craig *et al.* (1982b) found Y_2 strain pullets to be more fearful and nervous than Y_1 strain pullets. In both of those studies, the differences were postulated as being due to random genetic drift within these relatively small, closed populations which had been derived from the same foundation stock.

Lack of significant differences between Y_1 and Y_2 strain pullets for fear-associated behavior in the present experiment, as compared to the results of Craig *et al.* (1982b) is surprising, in view of the large differences found by them. Perhaps the inconsistency of results was caused either by the relatively small number of individuals tested within each strain in the present experiment (16 pullets per strain) or to differences in test conditions between the two studies. Craig *et al.* (1982b) had 10 to 14 pullets, all of the same stock, per cage and 36 cages of pullets were tested per stock. The presence of eight different genetic stocks within each cage in the present study, may have reduced variability of

fearful responses. Thus, a single pullet of a phlegmatic strain might exhibit increased avoidance behavior in the presence of more excitable and fearful strain pullets, while a pullet of a fearful strain might be calmed by the presence of pullets of less easily frightened strains when stimulated in the test situation.

Selection. There were no significant differences between the unselected controls and the selected strain pullets for either latency to feed or to normalcy (Table 3). With respect to agonistic behavior, Bhagwat and Craig (1978) found the Y strain pullets, selected for increased part-year egg mass, had become socially dominant to the unselected C strain pullets, as shown by peck-order ranks when strains were intermingled. Similar differences were obtained using cockerals. They hypothesized that the observed result was associated with the earlier sexual maturity occurring in the selected stocks as a result of selection for part-year egg mass. The lack of difference between the selected and unselected stocks for fearful behavior in the present study, and the difference in social dominance between them (noted above), suggests that agonistic and fearful behavior are inherited independently of each other and that fearful behavior is not a correlated response to selection for party-year egg mass. Nevertheless, this hypothesis should be considered as highly tentative in view of the possible "damping down" of behavioral differences which may occur between stocks tested in mixed flocks as compared to how they may behave when kept in separate flocks (as described in the previous section).

Crossing. No significant differences were found between the strains and their crosses for either latency to feed or to normalcy (Table 3). Therefore, non-additive genetic effects are not apparent for fearful behavior. The same cautionary statement is appropriate here as noted above for detecting behavioral differences in groups where genetic stocks are mixed.

Selection x Crossing. There were no significant selection by crossing interactions for latency to feed or to normalcy (Table 3).

CAGE DESIGN EFFECTS

Pullets in wire-sided cages had nonsignificantly longer latencies to *feeding* and significantly ($P < .05$) longer latencies to normalcy than those in solid-sided cages (Table 3). There was a very highly significant ($P < .0001$) period effect on latency to normalcy over the 8 week test period means for latency to normalcy showed a sudden decline after the first week of the test period (Table 4). This result suggests that pullets became at least partially habituated to the fear-stimulus after a single exposure. Craig *et al.* (1982b) reported that latency to feed and to normalcy dropped suddenly when pullets were frightened repeatedly with only a few days of intervening intervals.

Mean latency to feeding and to normalcy for pullets in solid-sided and wire-sided cages were 189 and 226 sec and 26 and 40 sec, respectively (Table 3). Thus pullets in solid-sided cages seemed to be less fearful than those in wire-sided cages. Perhaps pullets in solid-sided cages are less fearful because they are unable to see neighboring pullets' fearful responses to the human observer prior to their own test. Based on the above assumption, pullets in wire-sided cages should have been habituated to the fear-stimulus much faster than those in solid-sided cages. Contrary to our assumption, and for unclear reasons, pullets in both cage types were partially habituated to the fear-stimulus at comparable rates, as shown by lack of significant cage-design by period interactions on latency to feed and to normalcy (See Table 4).

MORTALITY AND EGG PRODUCTION

GENETIC EFFECTS.

Selection. There were no significant differences between selected and unselected strain pullets for mortality during the test period (Table 5). There was no mortality during the post-test period.

Selected strain pullets had earlier sexual maturity ($P < .05$), measured in terms of age at first egg, than did pullets of unselected strains (Table 6). Craig *et al.* (1982a) also reported significantly earlier sexual maturity for selected strain pullets. Thus, selection for part-year egg mass produced a correlated response of earlier maturity.

No significant difference was found between selected and unselected strain pullets for hen-day rate of lay (after first egg) prior to 42 weeks of age. This is in agreement with Craig *et al.* (1982a). Selected strain pullets had nonsignificantly lower hen-day rate of lay during 55-59 weeks of age. However, over the entire post-test period (50-59 weeks of age), selected strain pullets had a nonsignificantly lower hen-day rate of lay (7.4%) than the unselected strain pullets might have caused the performance level to drop faster in the selected strain pullets at later ages. Although data were not available on an individual bird basis for grouped pullets during the test period, information was available from comparable pullets kept in individual-bird cages. Based on this information, though not tested for significance, hen-day rate of lay of selected strain pullets did not differ much from that of the unselected strains during the test period (69.4 and 71.0% for selected and unselected strain, respectively). During the post-test period (50-59 weeks of age), selected strain pullets had 3% lower hen-day rate of lay than those of the unselected strains (60.5 and 63.5% for selected and unselected strain, respectively), which is in accordance with this assumption. The larger difference between selected and unselected strain pullets for hen-day rate of lay during 50-

59 weeks of age when group housed during the test period, than when kept throughout in individual-bird cages, suggests that the selected strain pullets were stressed more than the unselected strain pullets by housing in high density, multiple-hen cages for an 8-week test period, followed by their original individual-bird cages for another 8-week post-test period.

Crossing. There was no significant difference between the strains and their crosses for mortality during the test period (Table 5).

Strain-cross pullets matured about a week earlier than their parental strains, but the difference was not significant. Strain-crosses had nonsignificantly higher pre-test hen-day rate of lay than the parental strains, Table 6. There were no significant differences between the strains and their reciprocal crosses for hen-day rate of lay during 50-55 and 55-59 weeks of age during the post-test period and also for the entire post-test period, Table 6.

Cage Design Effects.

There were no significant differences between the pullets in solid-sided and wire-sided cages for mortality during the test period (9 and 5 dead for solid-sided and wire-sided, respectively), Table 5. Among the pullets that died in the test period, most died in the first week after group housing, with 8 and 2 dying in the solid-sided and wire-sided cages, respectively. Higher mortality of pullets during the first week may have been due to non-acquaintance of pullets to the new cage and social environment, and the extreme avoidance behavior shown by pullets in the first week than in any other week of the test period (see Table 4).

Comparable performance was present among pullets assigned to solid-sided cages, wire-sided cages and individual-bird cages before the test period, as they did not differ significantly for age at first egg, or pre-test hen-day rate of lay (Table 7).

Pullets placed in experimental cages at 42 weeks of age, had significantly ($P < .01$) lower hen-day rate of lay than those in individual-bird cages during the first four weeks (42-46 weeks of age), but had comparable hen-date rate of lay during the last four weeks (46-49 weeks of age) of the test period, Tables 7 and A3. The lowered performance of pullets in experimental cages during the first four weeks of the test period may have been due to effects of moving, high-density, multiple-hen cage environment, occasional interruptions in watering (noticed a few days after the first week), and presumably the stressful effect of striking on cage tops for a short period of time per week, especially before the pullets were partially habituated to it.

Several studies indicate that production declines sharply with larger group sizes and smaller areas per hen in colony cages (e.g. Adams and Jackson, 1970). The comparable hen-day rate of lay of pullets in experimental cages and those in individual-bird cages during the last 4 weeks of the test period, is obviously due to the improvement in laying performance of pullets in experimental cages during this period as compared to the first four weeks of the test period. Analysis of variance in Table A-4 shows a significant period effect on hen-day rate of lay of pullets in experimental cages during the test period. The improvement in laying performance of pullets in experimental cages might have been due to acquaintance with the strange multiple-hen cage environment and possibly due to partial habituation to the fear-inducing stimulus as shown by latency to normalcy after the first week of the test period (see Table 4). Pullets in individual-bird cages had significantly ($P < .01$) higher hen-day rate of lay than those in experimental cages for the entire test period (42-50 weeks of age).

There were no significant differences between pullets kept in individual-bird cages and those of experimental cages when the latter were moved back to their original individual-bird cages at 50 weeks of age, with respect to hen-day

rate of lay between 50-55 and 55-59 weeks of age. However, when the entire post-test period was considered, pullets returned from the experimental cages had significantly ($P < .01$) lower hen-day rate of lay than those kept throughout in individual-bird cages. Reduced performance of pullets from experimental cages might have been due to effects of moving, absence of familiar companions (Dawkins, 1982), and also due to after-effects of the stress involved during the test period. Dawkins (1982) found that 20-week-old pullets when presented with a choice between small, empty cage (.38 x .43 x 43 m high) and a large cage (1.06 x .43 x .43 m high) containing all five of its cage mates, preferred being with their cage mates, even though the pullets had been together for only 2-4 days.

During the first four weeks of the test period (42-46 weeks of age), pullets in solid-sided cages had significantly ($P < .01$) higher hen-day rate of lay than those in wire-sided cages. This suggests that fearful behavior may have had an harmful effect on egg production, as pullets in wire-sided cages were found to be more fearful. The possible harmful effect of fearful behavior on egg production, which was evident during the first four weeks was not detectable during the last four weeks of the test period. Pullets in solid-sided cages had significantly ($P < .01$) higher hen-day rate of lay than those in wire sided cages over the entire test period (42-50 weeks of age).

When the whole post-test period was considered, pullets from wire-sided cages had significantly ($P < .01$) higher hen-day rate of lay than did those from solid-sided cages. Perhaps pullets from solid-sided cages, being used to solid partitions during the test period, may have been adversely affected by the absence of solid partitions on cage sides in the individual-bird cages, during the post-test period.

BODY WEIGHT AND FEATHERING

GENETIC EFFECTS

Pullets of all genetic combinations had comparable body weights at 42 weeks of age (Table 8). There were no significant selection or crossing effects for change in body weight during the test period (Table 8). Similar losses in body weight of pullets in all genetic combinations suggest similar levels of stress were involved in all stocks.

No significant selection or crossing effects were found for change in feather score over the 8-week test period, Table 8. Although not tested for significance, decreased feather scores over the test period suggested that pullets had suffered feather damage and loss. Feather damage and loss in the group cages could be due to the combined effects of feather pecking and claw-inflicted injuries. Damage is likely to occur due to "piling up" of pullets in the rear portions of the cages when they are frightened. Craig *et al.* (1982b) found that the strain having more nervous and fearful hens suffered greater feather damage and loss.

CAGE-DESIGN EFFECT.

Pullets assigned to solid-sided and wire-sided cages had comparable body weights before being housed in groups at 42 weeks of age (Table 9). Pullets in solid-sided and wire-sided cages did not differ significantly for changes in body weight between 42-43, 43-47, or 47-50 weeks of age and for the whole test period (42-50 weeks of age), (Table 9). Shupe and Quisenberry (1961) found that hens in wire-sided colony cages had a larger average body weight during test carried out over a 11, 28-day period, than those in slat-sided cages, which they attributed to the free passage of air through the wire-sided cages.

Pullets in solid-sided and wire-sided cages did not differ significantly for changes in feather score over the test period (Table 9).

There was a significant ($P < .05$) period effect on changes in body weight of pullets in both cage types during the test period (Table A-5). As shown in Table 9, pullets in both cage types lost weight between 42-43 weeks of age, then gained weight between 43-47 weeks of age, and again lost weight between 47-50 weeks of age. The loss in weight between 42-43 weeks of age may have been due to the stressful effects of the new cage environment presence of strange pullets and limited feeder space per pullet. Responses of pullets to striking on top of cages, primarily used as a fear-elicitor once a week to measure fear-responses, suggests that fearful behavior may have had a harmful effect on body weight during the first week of the test period. The longest latencies to return to feed and to normalcy were obtained during this week (See Table 4)

Partial habituation of pullets to the new age environment may have aided in gaining weight during 43-47 weeks of age. However, gain during this period was somewhat unexpected, due to occasional interruptions in the watering system, noticed a few days after the first week of the test period. The reason for the loss in body weight between 47-50 weeks of age is unclear. There were no significant interactions among period, design of cage and genetic stocks.

CORRELATIONS AMONG TRAITS BASED ON INDIVIDUAL PULLET DATA

Correlation coefficients were calculated between the various traits measured on individuals (except egg production during the test period), within experimental cage groupings. Correlations were pooled after statistical tests indicated absence of heterogeneity between groups within cage design treatments and also between those treatments. The pooled estimates are presented in Table 10.

Mean latencies to feeding and to normalcy for individuals tested 8 times each during the test period, were correlated ($r = .59$, $p < .0001$), indicating an

association between them as measures of fear-response. Craig et al. (1982b) also found significant correlations between latency to feed and latency to normalcy in 5 of 8 comparisons involving two genetic stocks and two fear-inducing stimuli (r values ranged from .50 to .91). Latency to normalcy would be expected to be a better indicator of termination of fear-response. In the present study, the crowded cages with limited feeding space, some pullets, although apparently having overcome their fear, were unable to feed due to the presence of other pullets along the feeder.

There were no associations between the latencies and change in feather score over the test period. Hughes and Duncan (1972) found a significant correlation of .484 between feather damage and fear. Hughes and Black (1974) hypothesized that there is some association between activity and pecking damage, but none between fear and pecking damage. Craig et al. (1982b) reported that nervousness and fearful behavior were associated with greater feather loss.

Both latencies were associated with change in body weight over the total test period ($r = -.30$ and $-.19$ with $P < .01$ and $< .05$, respectively), but were not associated with initial body weight at 42 weeks of age. Pullets having greater latencies lost more weight. Sefton et al. (1978) found the correlation between their measure of fear and body weight taken at 24 and 38 weeks of age, to be of a low order. No associations were found between the latencies and productivity traits such as egg production during pre- or post-test periods and age at first egg.

No associations were found between change in feather score and any other trait measured except for change in body weight from 47 to 50 weeks of age. Nevertheless, no association between these variables were found over the total test period. Hughes and Duncan (1972) found that a greater degree of "feather pecking" was associated with loss in body weight.

There was a positive association between initial body weight at 42 weeks of age and change in body weight during 42-43, 47-50 weeks of age and over the total test period. Thus heavier pullets lost more weight during the above mentioned sub-periods and over the total test period. No associations were found between initial body weight at 42 weeks of age and other productivity traits except the hen-day production from age at first egg to 42 weeks of age (pre-test period). Thus heavier pullets were poorer layers during the above period.

Changes in body weight during the sub-periods of the test period were associated among each other negatively (r values ranged from $-.19$ to $-.43$) and positively with the change in body weight over the total test period (r valued from $.20$ to $.49$). The associations between the change in body weight during the sub-periods and total test period suggests that pullets which lost weight during 42-43 and 47-50 weeks of age, lost weight over the total test period and those which gained weight during 43-47 weeks of age, gained weight in the total test period. No associations were found between the changed in body weight during the sub-periods of the test period and any other trait.

Hen-day production during 50-55 weeks of age was positively associated with that of 55-59 weeks of age and both these sub-period productivity was associated with production over the total post-test period (r values $.87$ and $.88$, respectively). Pullets laying at a higher rate in the first four weeks of post-test period, continued to lay at a higher rate in the last four weeks. The above mentioned variables were significantly associated with the hen-day production during the pre-test period (r values ranged from $.21$ to $.29$). Pullets laying more eggs during the early age (between age at first egg and 42 weeks of age) continued to do so in the later age (between 50 and 59 weeks of age).

There was a negative association between age at first egg and pre-test hen-day production ($r = -.33$ $P < .01$), indicating that pullets which had matured

earlier had higher part-year rate of egg production when housed in individual-bird cages from age or at first egg to 42 weeks of age. No association was found between age at first egg and egg production during 50-55 weeks of age.

CORRELATIONS AMONG TRAITS BASED ON FLOCK MEANS

Correlation coefficients were calculated between the various traits based on flock mean within experimental cage groupings. Correlations were pooled after statistical tests indicated lack of heterogeneity between groups within cage-design treatments and also between those treatments. The pooled estimates are shown in Table 11.

There was an association between latencies to feeding and to normalcy ($r = .62$ $P < .01$), which is in agreement with the association found between the above latencies based on individual pullet data. No association was found between latencies and change in feather score over the test period. There was no association between latencies and initial body weight at 42 weeks of age, as well as with body weight changes during the test period.

No association was found between latencies and hen-day production during the test period. Craig *et al.* (1982b) found that correlations of fearful behavior and egg mass from 30 to 40 weeks of age were negative with several in the neighborhood of $-.50$, though no statistically significant. Both latencies were positively associated with hen-day production during the post-test period, except for non-significant association between latency to normalcy and hen-day production from 50 to 55 weeks of age (r values range from $.36$ to $.61$). Pullets which exhibited greater fearful behavior during the test period, had higher post-test laying performance.

There was no association between initial body weight at 42 weeks of age and any trait, except for age at first egg ($r = .64$, $p < .01$), though not found when calculated based on individual pullet data (see previous section).

Change in body weight during the sub-periods of the test period were not associated with any other trait, except for the positive association between the change in body weight during 42-43 weeks of age and egg production during 42-46 weeks of age ($r = .59$ $P < .05$). Thus pullets having lost weight during the first week of the test period, had reduced egg production during the first four weeks of the test period.

Hen-day production during 42-46 weeks of age was positively associated with that of 46-50 weeks of age and both these sub-period productivity were associated with production over the total test period (r values ranged from .68 to .92). Pullets with high laying performance during the first four weeks of the test period, also layed at a higher rate during the last four weeks of the test period. No associations between hen-day production during the test period and other traits were found. Similarly, hen-day production between 50-55 and 55-59 weeks of age were associated with each other and both these sub-period productivity were associated with the hen-day production over the total post-test period (r values ranged from .78 to .95).

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Table 1.
Genetic stocks classified according to mating system and selection
practiced

Mating System	Selection Practiced	
	None (Unselected)	Selected
Strains	C ₁	Y ₁
	C ₂	Y ₂
Crosses ¹	C ₁ X C ₂	Y ₁ X Y ₂
	C ₂ X C ₁	Y ₂ X Y ₁

¹In crosses, the male parent strain is listed first.

Table 2

Experimental design used during group-housing phase (test period) of the study¹

Design of Cage	Genetic Stocks ²	Cages	Number of	
			Pullets per Cage	Design of Cage
Solid-Sided	8	8	8	64
Wire-Sided	8	8	8	64

¹Group housing of pullets from 42 - 50 weeks of age.

²Genetic stocks used are shown in Table 1; each stock was represented by a single pullet per cage in both cage designs.

Table 3

Mean squares and least squares means from analysis of variance for latency to feed and to normalcy after subjecting pullets to a fear-inducing stimulus as influenced by genetic stocks and design of cage.

Source of Variation	d.f.	Error Term	Latency to Feed (sec)	Latency to Normalcy (sec)
-----M.S.-----				
Selection (S)	1	R	69417	1488
Cross (C)	1	R	6490	250
S X C	1	R	50375	2301
Rep. Within Genetic				
Combination (R)	4	R X D	32528	947
Design Of Cage (D)	1	R X D	38204	5142*
S X D	1	R X D	8900	245
C X D	1	R X D	25117	497
S X C X D	1	R X D	3038	64
R X D	4	Error	24752	351
Rep. Within Design				
Of Cage	14	Error	9015	442
Error	84		24575	1660
Least Squares Means				
Category			Latency to Feed (sec)	Latency to Normalcy (sec)
<u>Selection</u>				
Selected			183	30
Unselected			233	37
<u>Cross</u>				
Strains			200	32
Crosses			215	35
<u>Design Of Cage</u>				
Solid-Sided			189	26 ¹
Wire-Sided			226	40

* = $P < .05$

¹Treatments within category differ significantly ($P < .05$)

Table 4

Means squares and least squares means for latency to feed and to normalcy during weekly tests as influenced by design of group cages with period (week of Age) as the main effect.

Source of Variation	d.f.	Latency to Feed (sec)	Latency to Normalcy (sec)
-----M.S.-----			
Period	7	95140.40	51369.59***
Design Of Cage X Period	7	28893.68	7980.53
Error	889	55113.77	944.81

Least Squares Means

Period (Week of Age)	Latency to Feed (sec)	Latency to Normalcy (sec) ¹
42-43	249	84
43-44	229	28
44-45	200	21
45-46	176	29
46-47	174	20
47-48	179	21
48-49	232	27
49-50	216	36

*** $P < .0001$

¹Latency to normalcy differed significantly ($P < .0001$) among periods

Table 5

Mortality of pullets as influenced by genetic stocks and design of cage.

Source of Variation	Mortality	
	Number ¹	Percentage (%)
<u>Selection</u>		
Selected	5	8
Unselected	9	14
<u>Cross</u>		
Strains	9	14
crosses	5	8
<u>Design of cage</u>		
solid-sided	9	14
wire-sided	5	8

¹number of pullets that died during the test period

Table 6

Least squares means classified by genetic categories for age at first egg and for hen-day rate of lay measured on individual pullets during pre-test and post-test periods.

Category	Age at First (Week)	Pre-Test Period ¹	Hen-Day (%)		
			Post-Test Period by Weeks of Age		
			50-55	55-59	Total (50-59)
<u>Selection</u>					
Selected	24.7*	74.8	53.7	48.1*	50.8
Unselected	27.1	75.4	58.8	57.6	58.2
<u>Cross</u>					
strains	26.4	72.8	53.0	52.8	52.9
crosses	25.5	77.5	60.0	53.0	56.2

*=P<.05 between treatments within category.

¹Between age at first egg and 42 weeks of age.

Table 7

Least squares means for age at first egg and henday rate of lay during the pre-test test and post-test periods as influenced by type of housing.

Category	Type of Housing		
	Individual Bird Cages	Experimental Cages	
		Solid Sided	Wire Sided
Age At First Egg (weeks)	26.1	25.8	26.0
Pre-Test Hen-day (%)	74.6	76.0	62.0
<u>Test Period (by weeks of age)</u>			
<u>Hen-day (%)</u>			
42-46	72.0 ^{a1}	62.0 ^b	55.4 ^c
46-50	68.7 ^a	68.5 ^a	64.8 ^a
Total (42-50)	70.3 ^a	65.2 ^b	60.0 ^c
<u>Post -test period (by weeks of age)</u>			
<u>Hen day (%)</u>			
50-55	64.6	45.0	55.4
55-59	59.3	41.1	53.5
Total (50-59)	62.2 ^a	43.0 ^b	54.4 ^c

¹Means within a period with different superscripts differ significantly (P<.01).

Table 8

Least squares means by genetic categories for initial body weight at 42 weeks of age and for changes in body weight and feather score over the test period.

Category	Initial Body Weight at 42 Weeks of Age (g)	Test Period (Between 42-50 Weeks of Age)		
		Change in Body Weight		Change in Feather Score
		(g)	(%)	
<u>Selection</u>				
Selected	1780	-51.8	-3	-0.7
Unselected	1765	-65.5	-4	-1.0
<u>Cross</u>				
Strains	1761	-65.5	-4	-0.9
Crosses	1784	-52.8	-3	-0.8

Table 9

Least squares means classified by design of cage for initial body weight at 42 weeks of age, changes in body weight by weeks of age during the test period and change in feather score over the test period

Design of cage	Initial body weight at 42 weeks of age	Test period by weeks of age					Change in feather score between 42-50
		Changes in body weight between			Total (42-50)	%	
		42-43	43-47	47-50			
Solid-sided (S)	1754	-42.6	26.9	-49.7	-62.1	-4	-1.0
Wire-sided (W)	1791	-72.7	41.0	-30.0	-55.2	-3	-0.8
Average (S+W/2)	1773	-57.7a ¹	34.0b	-40.0c	-58.7	-3	-0.9

¹Means with different superscripts differ significantly (P<.05)

Table 10

Correlation coefficients among traits measured on individuals

	Mean Latency to Feed	Mean Latency to Normalcy	Change in Feather Score	Initial Body Weight at 42 Weeks of Age	Test Period by Weeks of Age Change in Body Weight Between			
					42-43	43-47	47-50	Total (42-50)
Mean latency to feed		0.59***1	-0.05	0.12	-0.30**	0.06	-0.03	-0.30**
Mean latency to normalcy			-0.04	-0.10	-0.15	0.11	-0.16	-0.19*
Change in feather score				0.14	-0.04	-0.14	0.22*	0.00
Initial body weight at 42 weeks of age					-0.35***	-0.14	0.21*	-0.35***
Test period by weeks of age								
Change in body weight between								
42-43						-0.43***	-0.19*	0.49***
43-47							-0.37***	0.20*
47-50								0.29**
Total (42-50)								

Continued....

Table 10. (Continued).

	Post-test period by weeks of age			Age at first egg	Pre-test Hen-day (%)
	50-55	55-59	Total (50-59)		
Mean lat. to feed.	-0.09	-0.03	0.00	-0.16	-0.05
Mean lat. to normalcy	-0.07	0.02	-0.02	-0.05	-0.04
Change in feather score	-0.01	-0.01	-0.02	0.04	-0.01
Initial body weight at 42 weeks of age	-0.03	-0.52	-0.05	0.10	-0.23**
<u>Test period by weeks of age</u>					
Change in body weight between 42-43	-0.09	-0.06	-0.08	0.16	0.03
43-47	0.12	0.06	0.10	-0.20	0.15
47-50	0.10	0.07	0.10	-0.04	-0.18
Total (42-50)	0.11	0.06	0.09	-0.07	-0.02
<u>Post-test period by weeks of age</u>					
Hen-day (%)					
50-55		0.54***	0.87***	-0.02	0.29**
55-59			0.88***	-0.07	0.21*
Total (55-59)				-0.03	0.28**
Age at first egg					-0.33**

¹8 = P<0.05, ** = P<0.0001.²mean over the 8-week test period.³between 42-50 weeks of age.⁴between age at first egg and 42 weeks of age.

Table 11

Correlation coefficients among traits based on flock means.

	Mean Latency To Feed	Mean Latency To Normalcy	Change In Feather Score	Initial Body Weight At 42 Weeks Of Age	Test Period By Weeks Of Age			
					Change 42-43	In Body 43-47	Weight 47-50	Between Total (42-50)
Mean latency to feed		0.62**	0.13	-0.40	-0.08	0.01	-0.18	0.44
Mean latency to normalcy			-0.26	-0.04	-0.08	0.08	-0.09	-0.07
Change in feather score				-0.07	.0.14	-0.42	-0.04	0.16
Initial body weight at 42 weeks of age					-0.46	0.33	0.29*	-0.15
<u>Test period by weeks of age</u>								
Change in body weight between								
42-43						-0.39	-0.45	0.18
43-47							-0.28	0.01
47-50								0.31
Total (42-50)								

Continued...

Table 11. (Continued).

	Test period by weeks of age					Age at first egg	Pre-test Hen-day(%)
	Hen-day (%)						
	42-46	46-50	Total (42-50)	50-55	55-59		
Mean lat. to feed.	-0.12	0.24	0.19	0.57	0.48	0.21	0.38
Mean lat. to normalcy	-0.10	0.00	-0.05	0.36	0.61**	0.03	0.27
Change in feather score	-0.15	-0.08	-0.13	0.05	-0.05	-0.31	-0.22
Initial body weight at 42 weeks of age	-0.34	-0.35	-0.39	-0.11	0.02	0.64**	-0.31
Test period by weeks of age							
Change in body weight b/n							
42-43	0.59*	0.12	0.39	-0.29	0.09	-0.13	-0.14
43-47	-0.22	-0.18	-0.22	0.12	0.13	0.19	-0.12
47-50	-0.45	-0.16	-0.34	0.31	0.05	-0.04	0.17
Total (42-50)	0.05	-0.22	-0.10	0.05	-0.03	-0.12	0.13
Hen-day (%)							
42-46		0.68**	0.91***	-0.11	0.06	0.26	-0.01
46-50			0.92***	0.26	0.21	0.02	0.16
Total (55-59)				0.09	0.16	0.14	0.08
Post-test period by weeks of age							
Hen-day (%)							
50-55					0.78**	-0.16	0.10
55-59						0.02	-0.08
Total(50-59)						-0.08	0.01
Age at first egg							-0.13

† * = $P < 0.05$, ** = $P < 0.01$, *** = $P < 0.0001$.

Table A-1

Mean squares from analyses of variance for age at first egg, and hen-day rate of lay measured on individual pullets during the pre-test and post-test periods as influenced by genetic stocks and design of cages.

Source of Variation	d.f.	Error term	Age at first egg (weeks)	Hen-day (%)		
				Pre-test period	Post-test period 50-55	Total (50-59)
Selection (S)	1	R	184.09*	11	724	2493* 1486
Cross (C)	1	R	27.58	710	1206	1 306
S X C	1	R	0.0	44	967	296 581
Rep. within genetic combination (R)	4	R X D	23.41	293	920	201 459
Design of cage ² (D)	1	R X D	3.64	36	1267	2644 1846
S X D	1	R X D	2.43	61	2	355 74
C X D	1	R X D	1.91	288	5	294 88
S X C X D	1	R X D	8.06	216	926	1004 940
R X D	4	Error	17.42	179	480	223 276
Rep. within (D)	14	Error	13.04	172	679	289 369
Error			12.34	175	523	675 453
			(97d.f.)	(97d.f.)	(83d.f.)	(83d.f.) (83d.f.)

1* = P<0.05.

²solid-sided group cages and wire sided group cages.

Table A-2

Mean squares from analyses of variance for initial body weight at 42 weeks of age, changes in body weight by weeks of age during the test period and change in feather score over the test period as influenced by genetic stocks and design of cages.

Source of variation	d.f	Error term	Initial body weight at weeks of age	Test period by weeks of age					Change in feather score between 42-50
				Changes in body weight between				Total (42-50)	
				42-43	43-47	47-50			
Selection (S)	1	R	6410	16203	4256	10851	5125	1.51	
Cross (S)	1	R	16251	7709	2479	4276	3791	0.05	
S X C	1	R	68382	33819	538	10082	1327	0.40	
Rep. within genetic combination (R)	4	R X D	13868*1	9839	5191	7150	16256	1.29	
Design of cage ² (D)	1	R X D	42433	26600	5544	10452	1308	1.26	
S X D	1	R X D	25124	1704	7320	7663	151	2.22	
C X D	1	R X D	8927	31470	5124	8840	40552	0.31	
S X C X D	1	R X D	10724	1753	2221	96	764	0.05	
R X D	4	Error	7609	5646	6616	4817	15229	1.29	
Rep. within (D)	14	Error	36751	14360	11498	8300	9695	1.77	
Error			42172	11237	9647	6768	8502	1.05	
			(97d.f.)	(89d.f.)	(84d.f.)	(83d.f.)	(83d.f.)	(83d.f.)	

1* = P<.05

²solid-sided group cages and wire-sided groups cages.

Table A-3

Mean squares from analyses of variance for age at first egg and hen-day rate of lay during the pre-test test and post-test periods with individual-bird cages and experimental cages as treatments and period as main effect.

Source of Variation	d.f.	Age at First Egg (Weeks)	Pre-Test Hen-Day (%)
Design of cage ²	2	0.16	8.27
Error (Rep. within design of cage)	23	1.2	15.12

Source of Variation	d.f.	Test period Hen-Day (%)
Design of cage	2	549.79** ¹
Error (Rep. within design of cage)	29	72.38
Period ³	1	266.26**
Design of cage X period	2	245.09**
Error	29	24.94

Source of Variation	d.f.	Post-Test Period (50-59 Weeks of Age) Hen-Day (%)
Design of cage	2	1866.08**
Error (Rep. within design of cage)	29	106.84
Period ⁴	1	187.28**
Design of cage X period	2	13.50
Error	29	21.49

¹** = $P < 0.01$

²Individual bird cages solid-sided group cages and wire-sided group cages.

³42-46 and 46-50 weeks of age.

⁴50-55 and 55-59 weeks of age.

Table A-4

Mean squares from analyses of variance for hen-day rate of lay during the test period as influenced by design of grouped cages with period as main effect.

Source of Variation	d.f.	Test Period (42-50 Weeks of Age)
		Hen-Day (%)
Period ²	1	251.22** ¹
Design of cage ³ X period	1	8.56
Error	46	20.88

1 ** = $p < 0.01$

2 42-46 and 46-50 weeks of age during the test period.

3 solid-sided group cages and wire-sided group cages.

Table A-5

Mean Square from analysis of variance for change in body weight during the sub-periods of the test period as influenced by design of cage and genetic stocks.

Source of Variation	d.f.	Error	Change in Body Weight ¹ M.S.
Design of Cage (D)	1	R	0.37
Rep. W/N Cage Design (R)	14	ERROR	2705.11
Genetic Stocks (G)	7	D X G X P	3771.26
Period (P) ¹	2	D X G X P	267481.95***
D X P	2	D X G X P	21302.97
G X P	14	D X G X P	11269.50
D X G	7	D X G X P	4202.05
D X G X P	14	ERROR	7702.32
ERROR	287		9813.11

*** = $P < .0001$

¹Changes in body weight during 42-43, 43-47 and 47-50 weeks of age.

Table A-6

Formulation of KSU 18% crude
protein layer ration

Ingredients	Amount per 909.05 kg (kg)
Corn Yellow Ground	268.18
Sorghum grain ground	268.18
Soybeen oil meal 44% cp.solv. ext.	259.09
Alfalfa Meal 17% cp. dehydrated	22.72
Limestone	30.45
Oyster shell flake	30.45
Dicalcium phosphate	22.72
Salt Iodized	2.27
Trace Mineral mix (Z-10)	0.45
Vitamin and Methione Premix (g)	
a. Vitamin A (10000 USP/g)	300
b. Vitamin D ₃ (15000 ICU/g)	120
c. Vitamin B ₁₂ (20 mb/lb)	240
d. B-Complex	908
e. D-L methionine	681

¹Mg/lb; riboflavin 8000 pantothenic acid 14720 niacin 24000 choline chloride 80000.

FEAR-ASSOCIATED BEHAVIOR OF PULLETS AS INFLUENCED
BY CAGE DESIGN AND GENETIC STOCKS

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A B S T R A C T

Fearful behavior in terms of latencies to feeding and to "normal activity" of 42-week-old pullets over an 8½ week test period was studied as influenced by design of cage and genetic stocks. Fear-inducing stimulus consisted of striking on top of cages by a human observer. Genetic stocks included two unselected strains and two strains selected for part-year egg mass and also the reciprocal crosses within the unselected and selected groups. Pullets were housed during the test period in laying-type "experimental cages" with either solid or welded-wire partitions separating adjacent cages. Pullets of all genetic combinations were housed per cage in both types of cages. A separate group of pullets housed in individual-bird cages and not subjected to fear-inducing stimulus, was used to obtain egg production data for comparison with those pullets housed in experimental cages. Information on body weight, feathering, mortality and productivity traits such as age at sexual maturity and part-year egg production was also collected.

There was no clear-cut influence of genetic stocks on fearful behavior or for other traits studied. Pullets in cages with solid partitions exhibited less fearful behavior and had higher egg production during the test period than those in cages without partitions. Other traits were not influenced by design of cage. Pullets in experimental cages had lower laying performance than those in individual-bird cages, suggesting that pullets in experimental cages were stressed.

Correlation coefficients pooled within cage design treatments showed a significant correlation between latencies to feeding and to normalcy, indicating the similarity between them in effectiveness of measuring fear-response. Greater fearful behavior of pullets was associated with greater loss in body weight over the test period, but not with feather damage and loss. There was

no clear association between fearful behavior and productivity traits such as age at sexuality and part-year egg production.