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BEHAVIORAL AND PRODUCTIVITY TRAITS IN CHICKENS AS INFLUENCED BY GENETIC STRAINS, HOUSING TREATMENTS, PRESENCE OF MALE AND AGE

by

ASHOK LAXMANRAO BHAGWAT

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Approved by :

James V. Craig
Major Professor

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INTRODUCTION

The existence of social hierarchies in flocks of chickens is well documented and forms the basis of group behavior in adults. The development of such hierarchies or peck orders indicates differences among individuals in levels of aggressiveness. Genetic stocks are also known to vary in mean social dominance potential and in frequency of agonistic activity.

Effects of peck order status in small flocks have been studied and indications are that high ranking birds have priorities for food, water, nests, roosting places and mates if both sexes are present. Peck-order status is associated with level of social stress and can significantly influence productivity traits.

Recently there has been a strong trend towards housing egg-producing stocks under high density environments, including multiple-bird or colony cages, because of economic factors. With the widespread use of colony cages the possibility of using natural matings in such environments for the production of hatching eggs arises. Information is limited on the consequences of such a management practice.

The present study had multiple objectives. One objective was to determine whether genetic stocks were likely to differ significantly in ability to produce fertile eggs in colony cages and how those differences (if present) were reflected by fertility under conventional floor-flock conditions. Other major objectives were to evaluate strain differences in agonistic behavior, the influence of breeder males' presence on social behavior and productivity and the effects of density, cage height, flooring, age and previous mating experience on behavior and productivity.

REVIEW OF LITERATURE

Agonistic behavior and its effect on productivity

The existence of social hierarchies of chickens was reported by Schjelderup-Ebbe (1922, 1923, 1924, 1935); cited by Wood-Gush (1955). He observed that the peck order forms the basis of all group behavior in adult chickens. On the basis of his observations on small groups of up to 25 birds and larger groups of 25 to 100 birds, Schjelderup-Ebbe (1922) reported that in large group of birds, linear hierarchies are rare and "triangular" and "square" relationships are common. Many observers have substantiated the results of his work. Masure and Allee (1934) confirmed Schjelderup-Ebbe's observations on domestic fowl and compared it to the type of social hierarchy found in pigeons.

Allee, Collias and Lutherman (1939) and Collias (1944) discussed the physio-psychological basis of the peck order. Those workers postulated that the peck order depends on two factors. Firstly, it depens on factors which determine the bird's position such as aggression and secondly on factors which maintain the status quo of this peck order, such as memory. Allee et al. (1939) and Allee and Collias (1940) investigated the effects of testosterone and oestradiol on the peck order. They injected testosterone and oestradiol in small doses daily into different birds. Birds receiving testosterone became rebellious in proportion to the dose received, whereas birds injected with oestradiol lost their positions to socially inferior birds.

Effects of debeaking and dubbing on agonistic behavior have also been studied. Hale (1948) investigated the effect of debeaking on the social hierarchy. He found that debeaked birds formed a peck order, but showed relatively higher pecking than the control flock. He also observed that debeaking did not lessen social tensions. Dawson and Siegel (1962) used four replicated subgroups of dubbed males, non-dubbed males, testosterone-injected females and control females for studying the effect of dubbing on agonistic behavior. They observed that non-dubbed males had an accelerated rate of agonistic behavior at an earlier age than dubbed males, whose rate in turn accelerated at an age earlier than found in either group of females. Although chronic testosterone injections increased comb growth in the third group, only minor behavioral differences were observed between the two groups of females.

Existence of social hierarchy or peck order indicates that the level of aggressiveness varies between individuals. Techniques for measurement of aggressiveness were developed by Collias (1943) based on the initial pair contest technique, Guhl (1953, 1960) using inter-pen contests and also caged contestants, McBride (1958) using standard panels or teams, Siegel (1960) with random sampling of opponents in pair contests and Biswas and Craig (1971) using social tension indexes from carefully randomized samples of observations on individuals within flocks as measures of intra-flock agonistic behavior.

Advantages of high social position have been recorded by Masure and Allee (1934) and Guhl and Allee (1944). High ranking birds in the group have priority for food, water, nests, roosting places and their choice of mates. Sanctuary (1932) found that individuals in the upper half of the peck order lay more eggs than those composing the lower half of the social order.

Guhl and Allee (1944) compared well integrated flocks with established peck orders to flocks undergoing constant reorganization, which had not established their peck orders. They found that in the organized flocks, pecking interactions were less, feed consumption was higher and more eggs were produced than in the unorganized flocks.

Potter (1949) studied the effect of different breeds on the social dominance in birds by using seven different breeds. An analysis of variance of the ranks achieved by all hens in all flocks showed that the ranks of different breeds were significantly different. Guhl (1953) observed that social stress and peck-order status within strains can significantly influence the productivity of individuals.

Tindell and Craig (1959) investigated inter-strain aggressiveness and performance in chickens. They demonstrated significant strain differences in aggressiveness and found that social status of strains in intermingled flocks differed depending on the age of the birds when assembled.

Significant correlations were found between social status within flocks and certain quantitative traits within strains and flocks. Hens high in social order tended to be heavier at five months of age, fed more often, matured earlier and had higher egg production for the first four months. Tindell and Craig (1960) further observed significant differences in aggressiveness between pullets of 8 sire families within a strain.

McBride (1964) also observed significant differences in social dominance between breeds. The most dominant in his experiment was the New Hampshire, second was synthetic A, third was synthetic B and the Australorp was at the bottom of the social order dominance.

Womack, Tindell and Cook (1966), after studying relative intra- and inter-stock aggressiveness and performance in chickens, reported that significant differences in relative aggressiveness were found to exist among six stocks of chickens of White Leghorn and Rhode Island Red breeds. However, their relative stock aggressiveness did not change materially with age.

Craig (1968) indicated that correlated responses were obtained when selection was directed towards high and low levels of social dominance, which implied that high social dominance is genetically associated with heavy weight in White Leghorns and with low weight in Rhode Island Reds; with earlier sexual maturity in both breeds and with lower rate of egg production in White Leghorns. He further stated that these conclusions should be regarded as tentative, as strains differing in social behavior may change in performance relative to each other depending on the environmental conditions, as to whether they are tested in intermingled *vs.* separate flocks or in high *vs.* low population density.

Craig and Guhl (1969) investigated the territorial behavior and social interactions of pullets kept in large flocks. They reported that a moderate but significant positive correlation between residence time in particular areas and relative dominance indicated that territorial behavior was found only in larger flocks. No significant differences in agonistic interaction rates due to flock size were detected, nor did flock size had any consistent effect on physical severity of agonistic interactions.

Craig and Toth (1969) studied the productivity of pullets in the White Leghorn and Rhode Island Red breeds in strains selected for high and low social dominance ability, under stable and unstable flock membership conditions. No adverse effects on productivity in unstable flocks were observed. More aggressive strains matured earlier in both breeds. Adult body weights were heavier for the high social dominance strain within White Leghorns and for the low social dominance strain for Rhode Island Reds. It was tentatively concluded that greater social stress in flocks of high social dominance White Leghorns was responsible for greater individual variability and lower rates of egg production and survival.

Frankham and Weiss (1969) tested for changes in relative aggressiveness of lines selected for part-record egg production under floor housing. The aggressiveness of two lines selected on part records under floor housing was compared with that of their unselected base population. The selected strains were either equal to or less aggressive than their base population. They hypothesized that the management in the flock under study (in terms of availability of feed and water) was sufficiently good during the period of strain development so that aggressiveness had only a minor influence on the ability to produce eggs. Aggressiveness was not indirectly selected for, therefore, and did not increase under selection for egg production.

Biswas and Craig (1970) investigated the differential effects of two types of environment on performance of White Leghorn strains previously selected for high and low social dominance for five generations and subsequently maintained as closed flocks. Significant interactions of housing methods and strain were found for hen-housed egg production. In a second study with the same strains Craig (1970) again found significant genotype by housing interactions. The more aggressive strain attained 50 % rate of lay earlier and laid more eggs per pullet housed when kept in individual cages, but opposite results were found in floor pens. He explained that high strain pullets appeared to be under greater social stress than lows when kept in flocks. Such genotype by environment interactions may result from differences in social stress within strains when kept in floor flocks and absence or reduction of such stress in individual cages.

Biswas and Craig (1971) obtained data on social tension indexes and egg production traits in chickens and concluded that social tension indexes, based on carefully randomized samples of observations, appear to be suitable as relative measures of intra-flock agonistic behavior of individuals and should be useful for estimating relationship between such behavior and production traits.

Choudary et al.(1972 a, b) studied the effects of strain, age at flock assembly and cage arrangement on behavior and productivity in White Leghorn type chickens and the effects of early flock assembly on agonistic behavior and egg production in chickens.

They reported, from the first study, that the frequency of agonistic interactions was significantly affected by strain, round, treatment and population size. In the second treatment it was found that differences in the agonistic interaction frequencies of flocks assembled at 6 and 19 weeks of age, though present at 19 weeks of age, were no longer evident after about 26 to 30 weeks of age in any of 4 strains. Their second study confirmed the previous results of Craig and Toth (1969) and Biswas and Craig (1970) that significantly greater variability of individual performance was found for the highly aggressive strain White Leghorn flocks for hen-day rate of production and hen-housed production.

Polley and Craig (1973) reported housing and genetic effects on social behavior of chickens. They found that 3 White Leghorn strains differed significantly in their study. Different housing environments also produced striking effects. Total agonistic interactions observed in colony cages were only one-fourth as frequent as observed in floor pens. They remarked, however, that the large reduction of agonistic interactions observed in colony cages does not necessarily indicate that colony cages should be considered a more desirable housing environment than floor pens. There was no significant difference in total interactions between the two sexes kept in unisexual flocks. However, there appeared to be a rise in agonistic activity associated with the onset of sexual maturity. They further postulated that the experimental evidence now available indicates that agonistic activity increases relative to bird density to a certain point, beyond which the increased bird density depresses agonistic interactions; that is, there is apparently a curvilinear relationship between bird density and agonistic activity rate.

Mating behavior in chickens

Mating behavior is of special interest to poultry breeders and hatchery-men. Frequency of mating in chickens has a well defined diurnal rhythm. This was reported by Upp (1928), Skard (1937), Parker et al. (1940), Penquite et al. (1930) and Long and Godfrey (1952). They reported that the maximum number of copulations take place in late afternoon.

The number of matings vary from individual to individual. Penquite et al. (1930) observed the matings of a single male with number of females from 6 A.M. to 6 P.M. Matings varied from 6 to 28. Skard (1937) observed that one male completed 53 matings in a day. Parker et al. (1940) observed that males mated as often as 41 times in a day.

Craft et al. (1926) observed that males which are regularly active sexually produce a higher percentage of dead or weak sperms than those less active sexually. Burrows and Titus (1939) claimed that sexual activity of the male is not correlated with semen production. Observations of Parker et al. (1940) indicated that the general appearence of body type of an individual was not a good indicator for mating behavior. They postulated that the male may copulate too frequently and thus sufficient sperms may not accumulate. They showed that in instances where 3 or more semen samples were obtained in a 15-minute period from one male, there was a tendency towards a decrease in volume, concentration and total number of sperms with each succeeding ejaculate. They also reported that males maintained in batteries were less active sexually than males maintained in breeding pens. Wood-Gush and Osborne (1956) also did not find any significant correlation between the mating rank of a male and the quality of his semen, assessed on volume, density and sperm morphology. Williams and McGibbon (1957) stated that sexually active males tended to have a lesser percentage of complete matings than less active males.

Some elements of male mating behavior are innate. This has been demonstrated by administration of hormones to young chicks. Hamilton (1938) injected testosterone propionate daily into chicks from the second day after hatching. Crowing started 180 hours after first injection. Another form of male display, wing flapping, was also observed. Noble and Zitrin (1942) started similar treatments at 12 to 15 days of age. Crowing started within 2 days after treatment was begun and by the 13th day treading had begun, but no cloacal contacts were observed. Domm and Davis (1948) observed the mating behavior of intersexual domestic fowls, produced by injections of oestrogenic hormones into the egg. They observed that the intersexual birds of each pen had a peck order or social hierarchy. The rank of males coincided roughly with the degree of masculinity of the plumage. They further reported that the behavior patterns depended upon the level or threshold of hormone concentration.

Social status or peck-order rank is another factor which influences male sexual activity and fertility. Guhl et al. (1945) studied mating behavior and social hierarchies in small flocks of White Leghorns. Significant negative correlations were found between the social position of hens and the frequency at which they were courted by males. In 4 out of 5 flocks, hens highest in the social order either failed to "invite" the cock to mate or crouched less frequently than most of their penmates. There was a high correlation in all observed flocks between the frequencies of the "sex invitations" by females and the number of matings of the hens. They further observed that in a multiple male unit, the dominant male did most of the matings and prevented others from mating. Thus, dominant males sired more offspring than their socially inferior penmates.

Grosse and Craig (1960) observed that young males, placed with older females for short test periods, beginning at 11 weeks of age, were in many cases socially dominated by females and appeared to be suppressed in their display of sexual aggressiveness.

Williams and McGibbon (1958) indicated that females which crouched often for males had a higher percentage of completed matings of the total attempted matings and females which crouched frequently for males escaped less frequently.

Guhl and Warren (1946) reported a marked relationship between social dominance order of a male and number of successful matings in multiple-male matings. They indicated that the factors which influence the rate at which males mate are : (1) sex ratio in flock, (2) breed differences, (3) space relationship, (4) accessibility of males to females, (5) anticipation and toleration, (6) individual differences in libido and (7) conditioning effects or learned patterns of behavior.

One would normally expect the male which was most successful in mating to fertilize more eggs and sire more chicks. There are, however, certain factors which may influence this relationship; for example, (1) individual differences among males in semen production, (2) non-random mating (preferential mating), (3) frequency at which a given female will mate with any male and (4) infertility which may result from the physiological state of the female. There is also evidence that some females which mate frequently tend to lay infertile eggs.

Wood-Gush (1954) has described the courtship of Brown Leghorn cocks. He reported that nine actions were found to be performed by all cocks at frequencies fairly characteristic for each cock. These were : waltzing, "tid-bitting", wing flapping, cornering, feather ruffling, tail wagging, head shaking, bill wiping and preening. He observed that the most active and forceful cock received the greater number of crouches by females.

Williams and McGibbon (1957) investigated the relationship of various mating behavior activities of male domestic fowl. They stated that the number of escapes by females from males was directly proportional to the number of matings attempted by males. Crouching of the female for the male did not influence greatly the decision of the male to attempt mating. Sexually active males tended to have a lower percentage of completed matings out of attempted matings, than less active males.

Guhl (1950) devised an experiment to determine whether the social dominance of males over females exerts any influence on success of mating. With the use of treated capons (with oestrogens) in an experimental hetero-sexual peck order, he found that the social dominance by hormonally treated capons over the females was not essential for treading and copulation, although it did facilitate mating. The results thus indicate that passive dominance of normal cocks over hens in well integrated flocks facilitates mating.

Guhl (1950) investigated the influence of the habit of domination associated with high rank in the social hierarchy upon receptivity in hens. He confirmed the earlier observation that hens composing the top level crouched less often than those of the middle or bottom levels and those of the bottom level crouched at higher rates. However, subsequent to subflocking by ranks, he noted that high ranking hens crouched more frequently or approximately as often as those composing the lowest level in the original flock.

Guhl (1951) further observed measurable differences in mating behavior of cocks. Relative sexuality of several cocks was determined in four White Leghorn flocks with varying genetic background. Differences between cocks were found. Some males varied in the frequency at which they courted. He further pointed out that the frequency of one category of mating behavior of a male was not necessarily indicative of his activity level in another category.

Siegel (1959) also observed significant differences among lines of White Plymouth Rock cocks for aggressiveness and sex drive indicating a genetic basis for these traits. Correlations between the behavior traits indicated a positive relationship between aggressiveness and mating ability. It was found that the males which exhibited the largest number of courts, mounts and treads also completed the largest number of matings.

Grosse and Craig (1960) investigated the sexual maturity of males representing 12 strains of six breeds of chickens. Significant strain and breed differences were found for age at first successful natural mating. Age at first successful natural mating was earlier in heavy breeds than light breeds. With males kept together by pairs they observed that dominated males reached sexual maturity later than males socially superior to them.

Wood-Gush and Osborne (1956) reported the study of differences in sex drive of 30 cockerels maintained under uniform conditions. These males belonged to 6 sire families and 15 full-sib pairs. It was found that there were significant differences between the sire families, indicating that mating frequency has a genetic basis. No correlation was found between the mating rank of a male and the quality of his semen assessed on volume, density and sperm morphology. Five top ranking and five lower ranking males were tested for fertility and the top ranking males gave the best results as a group.

Parker (1958) studied the seasonal differences in fertility of eggs from New Hampshire flocks mated to cocks and cockerels. Results from the experiments over a two-year period showed that cockerels fertilized 89.4 % of eggs laid by their mates, whereas cocks fertilized only 76.3 %.

McDaniel and Craig (1959) estimated the relationship between various behavior and semen characteristics and the association of these traits with fertilizing capacity in natural matings. Significant and highly significant associations were found between social aggressiveness scores, sexual effectiveness scores and crouches elicited from females.

Highly significant positive correlations were obtained among the measurements and scores of semen volume, sperm concentration and motility. Sexual effectiveness scores were significantly associated with fertility. However, no relationship appeared to exist between social aggressiveness scores and fertility.

Guhl (1961) designed an experiment to simplify the procedures for testing large number of males. His results indicated that cocks penned singly with flocks of females may yield data similar to actual performance in breeding pens, but more data can be obtained per unit of testing time, if the males are caged and released singly for short periods. He further indicated that relative acquaintance between the sexes influences the type of data obtained and hence recommended that the acquaintance might be increased by permitting each caged male to run with hens for half to one day prior to testing.

Justice et al. (1962) conducted three experiments to evaluate the importance of various factors in influencing sexual effectiveness of males under test conditions. They concluded that 8 males could be tested in pens of 30 hens consecutively without any significant loss of female receptivity. They observed that about 4 times as many matings were completed when the males were tested under familiar conditions. Significant effects due to different pretest sexual experience and acquaintanceship with tester hens and test pen environments were demonstrated within breeds, but no breed difference was found.

Brantas et al. (1972) tried to establish the minimum number of cocks needed for satisfactory fertility in White Leghorn flocks. An experiment was conducted on two groups of White Leghorns, each consisting of 50 hens. With the number of cocks increasing in one group and decreasing in the other it was shown that three experienced cocks with 44 hens could maintain fertility above 90 %.

Effect of housing environment and age on behavior, fertility and production

In recent years laying cages have become more popular than floor pens for commercial egg production. Extensive studies have been made comparing floor and cage systems. Various investigations have been carried out studying the effect of various cage sizes, bird densities and cage arragements on egg production. Some experiments have also been carried out on the influence of those variables on production of hatching eggs.

Lowry et al. (1956) reported superior performance in hen-day egg production of pullets housed in floor pens, while caged pullets showed significantly lower mortality, heavier eggs and higher incidence of blood spots in eggs.

Gowe (1956) compared seven strains of White Leghorns housed in individual cages and floor pens. He found highly significant strain differences for mortality and age at first egg. Strain by housing interactions were highly significant for hen-day egg production and body weight. He stated that some strains of White Leghorn can adapt themselves to battery cages better than others.

Francis (1957) investigated the performance of five strains of White Leghorns and two hybrids in individual batteries for a 6-month period. Results suggested that strains of White Leghorn were able to adapt themselves to cages better than hybrids.

Bailey et al. (1959) compared the performance of birds in cages and floor pens. It was found that cage-housed birds had higher percentage egg production than those housed on the floor. Caged birds were also heavier and had better feed conversion.

Effects of floor pens, colony cages and individual cages were reported by Shupe and Quisenberry (1961). Birds reared in floor pens had significantly lower body weights, but no significant difference was observed in the body weight of individual-cage or colony-cage birds. Individually-caged birds had significantly higher production rate than birds in colony cages or floor pens and had the best feed conversion ratio, followed by birds in floor pens and then in colony cages.

Logan (1965) compared 10 strains of pullets under floor and cage regimes. Floor birds had lower body weights, laid smaller eggs and had lower incidence of blood spots in eggs than caged birds.

Moore et al. (1965) housed layers in 5 housing regimes to evaluate the effect of cage density on performance. They reported that feed conversion and hen-housed production was significantly correlated with the density of birds. Birds having the smallest cage area required less feed per dozen eggs. However, as bird density increased, production decreased.

Cook and Dembnicki (1966) reported a study involving five commercial White Leghorn type stocks, 1 White Leghorn and 1 Rhode Island Red stocks, in single, double and five-bird colony cages. They observed that the average egg production in single cage was superior to others. As density increased, mortality also increased.

Champion and Zindell (1968) and Tower and Roy (1969) reported that if floor space per bird was kept constant in single or multiple-bird cages, return per investment over feed cost and the cage area was higher from the multiple-bird units.

Adams and Jackson (1970) conducted two experiments with six commercial strains of White-Leghorn type chickens with pullets being reared intermingled. They used two bird densities and two cage sizes. Significant strain differences were found for sexual maturity, mortality, Haugh unit values, average egg weight and hen-housed production. Larger cages with higher density resulted in the lowest egg production and highest mortality, whereas smaller cages with lower density resulted in higher egg production and lower mortality. They also observed that birds at the lower density matured earlier than those housed at higher density. Marr and Greene (1970) reported that performance of commercial-type laying hens was affected more by space and space in relation to capacity, rather than by the number per cage.

Mather and Gleaves (1970) found that egg production in cages was significantly influenced by both density and stocks. Egg production decreased as number of birds per cage was increased. One commercial stock had a significantly higher egg production than the other 6 stocks.

Ruszler and Quisenberry (1970) studied layers in cages at different population densities, but did not find any significant difference between body weights and feed efficiency. Increased density depressed hen-day and hen-housed egg production to a greater extent than increases in population numbers.

Biswas and Craig (1970) investigated floor vs. cage and crowded vs. uncrowded as distinct physical and social environments. They found significant interactions of strain and housing method for hen-housed egg production for three periods and rate of lay for the entire period. Craig (1970) also confirmed the presence of genotype by housing interactions for part-year egg production and survival of White Leghorn high and low social dominant strain pullets when kept in individual cages or at 3 levels of crowding in floor pens.

Poultry breeders and hatcherymen are evincing interest in the possibility of using colony cages for the production of hatching eggs. Some studies have been undertaken in this regard. Mulkey (1972) reported that even though the level of fertility was respectable, the mortality in a cage breeder house had been higher than in floor flocks.

The number of cracked eggs was also high. He concluded that this is a new management system for breeders and more experience is needed.

Kreuger et al. (1972) investigated the feasibility of producing broiler breeder hatching eggs in colony-type cages using natural matings. They obtained good fertility in cages and livability was also better. Females housed 10 to the cage laid significantly fewer eggs than those housed 6 to the cage. Body weight with high density was also significantly depressed. They concluded that their study suggests that production of broiler breeder hatching eggs in colony cages is biologically feasible, but the economical feasibility remains to be answered.

Campos et al. (1973) further investigated the performance of commercial broiler breeders in cages. They compared units of 8 to 10 females with a male with units of 20 females with 2 males, with control groups in floor pens. They found higher egg production for females housed in cages. Percentage hatch of total eggs, as well as fertility percentages, were higher from floor flocks. There was not much difference in egg production percentage in the 10-hen and 20-hen units; 8-hen units had slightly lower egg production. Similarly, the percentage fertility in 10- and 20-hen units was comparable, with 8-hen units being lower.

Studies have also been conducted in West Germany and the U.K. Weinreich (1973) has been responsible for practical studies of economic and management aspects of breeding cages in West Germany. He recommends cages with A-shaped floors, sloping to both sides for reducing the incidence of broken and cracked eggs. Double-sided feed troughs with 13 to 14 cm. space per bird have also been recommended. There was a negative correlation between stocking rate and laying performance. Average rate of lay for a 21-hen cage was 75 % and of 30-hen cages was 72.5 %. A group size of 24 to 26 hens and 3 cocks was regarded as optimal.

PART A

PRELIMINARY STUDIES OF GENETIC AND ENVIRONMENTAL FACTORS INFLUENCING FERTILITY, SOCIAL BEHAVIOR AND WEIGHT GAINS IN COLONY CAGES

EXPERIMENT 1 : EFFECTS OF GENETIC STRAIN, DENSITY AND FAMILIARITY OF ENVIRONMENT ON FERTILITY IN COLONY CAGES.

MATERIALS AND METHODS

Genetic stocks : Three strains of White Leghorn chickens were used.

The Ottawa control strain (Oc) was established in 1950 by the Canada Department of Agriculture. This strain has been maintained as a random breeding, unselected population. Inbreeding and random genetic drift are minimized by carefully planned matings.

The Ottawa selected strain (Os) was derived from the same base population as Oc. This strain has been selected primarily for maximum number of eggs per pullet to 40 weeks of age. This has been largely achieved by decreasing age at sexual maturity. Os females now attain sexual maturity at about 84 % of the age required for Oc.

The S275 strain was originated at the Lacombe, Alberta, Research Station of the Canada Department of Agriculture in 1955 from a sample of the Oc strain. This strain has been selected essentially by the same criterion as Os, that is, for maximum number of eggs to 40 weeks of age. Females of this strain now attain sexual maturity at about 91 % of the age required for Oc.

All 3 strains were imported into Kansas State University as hatching eggs in August and September, 1970. The first generation of relaxed selection chicks was hatched during July, 1971. Experimental chicks for the present study represented the second generation of relaxed selection for the Os and S275 strains.

Experimental procedures : Twelve commercial-type colony cages (36" wide, 28" deep, 14.5" high in back and 17" high in front; 1" X 2" welded wire floor) were used.

Males were housed at random within strains at 12 weeks of age. Out of 10 males present within each unit, one male was retained in the cage at 28 weeks of age and the remaining males were removed. Thus, there were 4 replications of each of the 3 strains in 12 colony cages. Those males were therefore familiar with the colony-cage environment.

At 30 weeks of age females were randomly selected within strains from floor pens and 10 were placed in each of 4 colony cages.

Hatching eggs were collected beginning one week after introducing the females. A total of 10 eggs per week were selected from each cage; the maximum possible even number of eggs were selected from Wednesday collections and equal numbers of the remainder were from Tuesday and Thursday collections. This was done to have a representative sample of eggs from the maximum number of hens possible in a cage. The eggs were set on Thursday each week and the percentage fertility was tested after 4 days of incubation. In case of doubt, the egg was broken open to verify fertility. The fertility check was continued for a five-week period.

After five weeks of fertility testing, the number of females in half of the cages (two cages per strain) was reduced to 5. This was done to find out whether the density of birds (floor space per bird) has any significant effect on fertility buildup. Cages involved for density reduction were selected on a random basis. Thus, there were 6 colony cages with a male and ten females and 6 cages with a male and five females. After reduction in the number of females, the test was continued for 3 more weeks.

After the previous data were collected, males were removed and not replaced for three weeks, by which time fertility had dropped to zero. A different set of males was then introduced into the cages. The second set of males had been kept in individual cages from 12 weeks until introduction into colony cages at 41 weeks of age. Though age was confounded with previous housing environment, it was hoped that some indication of importance of familiarity and/or previous occupancy by the male <u>vs</u>. the introduction of a male into a strange environment could be obtained.

Eggs were again saved beginning one week after introduction of the new males. The same procedures for collection, setting and fertility check of eggs were followed for a total of four weeks.

Statistical analyses : The statistical analyses were carried out separately for each of three periods; that is, the first 5 weeks after the introduction of females, the next 3 weeks with reduced density of females in half of the cages and the third period of 4 weeks after introduction of a new set of males.

In the first period, strains were assumed to be fixed variables in the analysis of variance. In the second and third periods, strains and densities were both assumed to be fixed variables for analyses of variance.

RESULTS

There were 4 replications per strain, giving a total of 12 colony-cage units. Mean fertility percentages ranged from 0 to 74 for individual cages over the first 5 weeks; the overall mean was 24 per cent. Strain differences were nonsignificant, but exhibited a trend found to be significant in later comparisons (S275, 16 %; Oc, 24 % and Os, 32 %).

To test whether density, that is, area per bird has any significant influence on fertility, density in half of the cages was reduced. The average percentage fertility of the 6-to-8-week period was 55. Mean individual cage fertility varied from 0 to 97 %. An analysis of variance failed to detect significant differences between strains or densities. The trend of fertility observed in the first 5 weeks continued in the 6-to-8-week period; percentage fertility of strains was S275, 37; Oc, 60 and Os, 68. Low density flocks averaged 57 % and high density flocks 53 % fertility. As the density did not affect fertility significantly, fertility obtained in the second period was pooled over densities and Figure 1 shows the trend in fertility by strains for both periods.

To estimate whether familiarity with environment affects performance of the male, the original males were removed 9 weeks after females were added and different males (of the same strains) were introduced 3 weeks later. Mean fertility for the four-week period, beginning one week after new males were added was 23 per cent. Fertility in individual cages varied from 0 to 58 %. Analysis of variance failed to detect significant strain and density effects.

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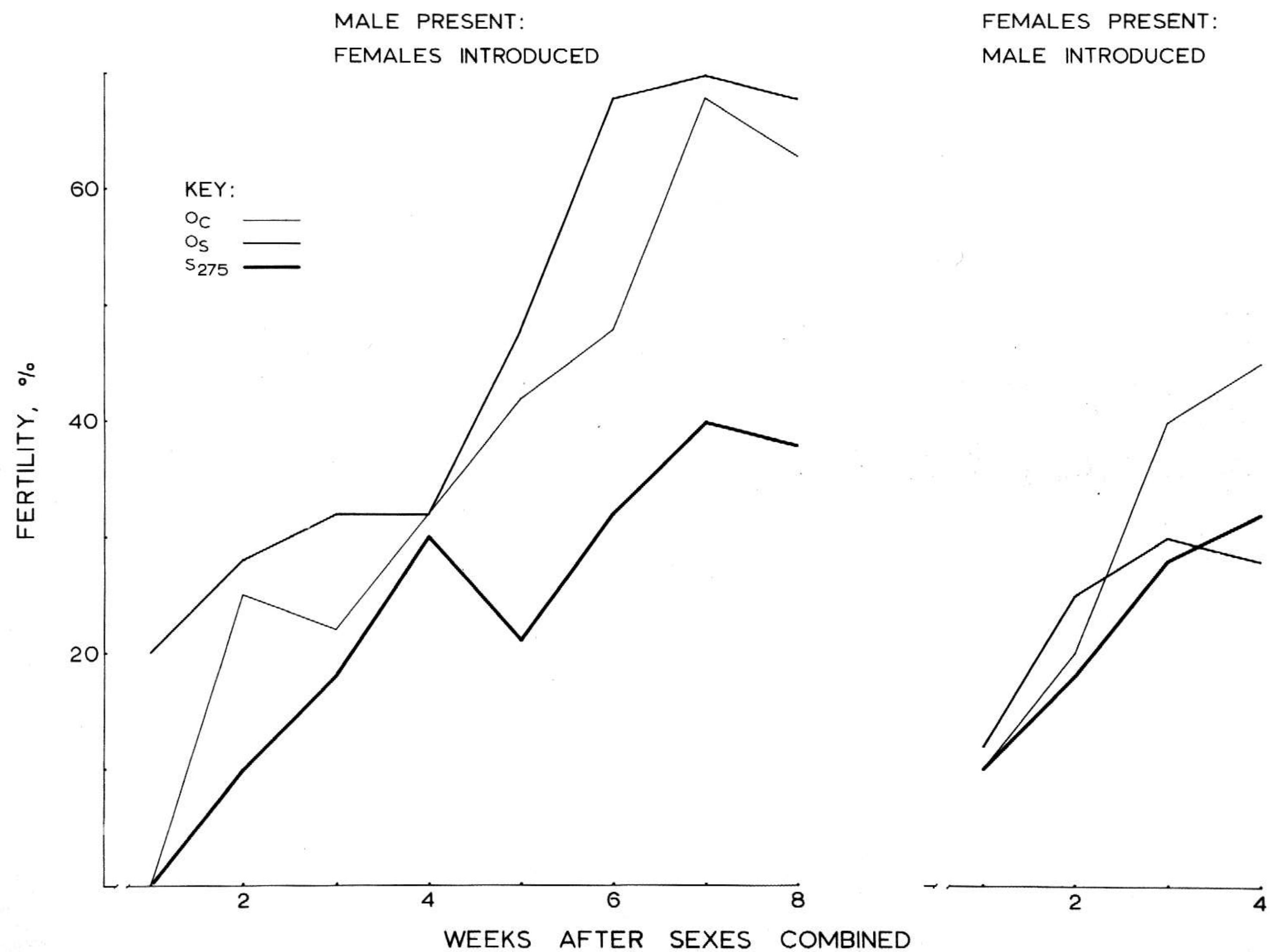
Fig. 1. Fertility in colony cages as influenced by genetic strai
familiarity with environment and weeks after the sexes
were combined.


MALE PRESENT:
FEMALES INTRODUCED
FEMALES PRESENT:
MALE INTRODUCED
KEY:
O_C
O_S
S_{275}
FERTILITY, %
60
40
20
2
4
6
8
2
4
WEEKS AFTER SEXES COMBINED

EXPERIMENT 2 : EFFECTS OF GENETIC STRAIN, DENSITY AND CAGE HEIGHT ON AGONISTIC BEHAVIOR AND WEIGHT GAINS OF MALES.

MATERIALS AND METHODS

Genetic stocks : Males of the three strains of White Leghorns previously described were used.

Housing : Four rearing batteries were remodeled by removal of floor and/ or side partitions, so as to have wire-floored cages with the dimensions shown in Table 1.

TABLE 1

AREA AND HEIGHT TREATMENTS OF MODIFIED REARING BATTERIES

Treatment	Dimensions, inches		
Area, Height	Length	Width	Height
Small, Low	27	27	16
Small, High	27	27	32
Large, Low	54	27	16
Large, High	54	27	32

Procedure : A total of 20 cages were used with 5 replications of each area-height treatment. Six males, including 2 of each of the 3 strains, were intermingled in each cage. The males carried numbered badges on both wings for identification and recording of agonistic acts.

Each bird was weighed at the beginning and end of the 6-week experiment, that is, at 19 and 25 weeks of age. Each day each of 10 cages was observed for 10 minutes. Observations were taken four days a week, so as to have two observations of each unit per week. Agonistic behavior observations included identification of birds involved and type of action. Agonistic acts were recorded as severe, other and total. Severe acts included fights and peck-avoidances. Other included threat-avoidances and chase-avoidances. The sum of both kinds of agonistic acts was used as total activity per group. After totalling the behavioral activity for the full period, mean frequencies per bird per observation period for each cage were calculated for statistical analysis.

Rankings of the birds in each cage were determined. For each agonistic act of an individual a tally was entered on a sheet maintained to record dominance and subordinance within each flock. The number of birds dominated by an individual was counted and a score was then given to the bird. The most dominant bird received the score of 6 and so on, till the lowest or least dominant (most submissive) bird was assigned a score of 1. When there were ties the mean score of the two ranks was given to both birds. These scores were designated "A".

Next, the number of birds which dominated a particular bird (the number of birds to whom this bird was submissive) was counted. The most submissive bird was given the score of 6 and so on, as above. Such scores were subtracted from the number 6 to obtain submissiveness scores. These scores were designated "B". The average of those two scores, $\frac{A + B}{2}$, was then taken as the rank of the specific bird. After such ranking, birds which had ties were placed in pair contests to decide the dominant and submissive bird for the decision of their ranking.

Two cages were not observed to exhibit any agonistic behavior and even with pair contests no agonistic acts were observed. Thus, rankings could not be established within them and they had to be deleted from the statistical analysis.

RESULTS

The intermingled groups of males were observed from 19 to 25 weeks. Mean frequencies of severe, other and total agonistic acts were calculated. Mean squares from the analyses of variance for those types of activity are given in Table 2 and means by area per male are shown in Table 3.

TABLE 2

MEAN SQUARES FROM ANALYSES OF VARIANCE FOR SEVERE, OTHER AND TOTAL ACTS

Source	D.F.	Mean squares		
		Severe	Other	Total
Treatments (Area-Height)	3	0.0076	0.5061 **	0.5997 *
Area	1	0.0005	0.9592 ***	0.9946 *
Height	1	0.0097	0.1445	0.2333
Area X Height	1	0.0125	0.4147 *	0.5712
Remainder	16	0.0162	0.0887	0.1508

* = $P < .05$
** = $P < .01$
*** = $P < .005$

TABLE 3

MEAN FREQUENCIES OF AGONISTIC ACTIVITIES CLASSIFIED BY AREA PER MALE

Area	Severe	Other	Total
Small	0.12 [1/]	0.59	0.72
Large	0.13	1.03	1.16
Small -- Large	- 0.01	- 0.44 ***	- 0.44 *

[1/] Frequency per male per 10 min.
* = $P < .05$
*** = $P < .005$

Peck-order ranks of the strains were analyzed with results as indicated in Table 4. Mean social dominance scores by strains are given in Table 5. All strains differed significantly from each other.

TABLE 4

MEAN SQUARES FROM ANALYSIS OF VARIANCE FOR RANKINGS OF MALES

Source	D.F.	Mean squares
Strains	2	45.13 ***
Remainder	51	4.93

*** = P < .005

TABLE 5

COMARISON OF MEAN RANKS OF STRAINS

Strains :	Os	S275	Oc
	2.7 [a]	3.5 [b]	4.3 [c]

Note: Means not sharing the same superscript are significantly different. (P < .05)

Weight gains from 19 to 25 weeks were analyzed with results as shown in Table 6. Strain and area effects on weight gains are shown in Table 7.

TABLE 6

MEAN SQUARES FROM THE ANALYSIS OF VARIANCE FOR GAIN IN WEIGHT IN MALES

Source	D.F.	Mean squares
Treatments (Area-Height)	3	83825.15 *
Area	1	213283.70 ***
Height	1	33627.60
Area X Height	1	4564.16
Strains	2	141426.70 ***
Treatment X Strain	6	25901.56
Remainder	106	22629.24

* = P < .05
*** = P < .005

TABLE 7

EFFECTS OF GENETIC STRAINS AND AREA PER BIRD ON WEIGHT GAINS OF MALES FROM 19 TO 25 WEEKS

Strains:	Os	S275	Oc
	746 [a]	812 [ab]	865 [b]

Area per bird :	Small	Large
	764 [a]	849 [b]

Note: Means not sharing the same superscript are significantly different ($P < .05$). Gains are in gm.

EXPERIMENT 3 : EFFECTS OF GENETIC STRAIN, DENSITY AND CAGE HEIGHT ON AGONISTIC BEHAVIOR, WEIGHT GAINS OF FEMALES AND FERTILITY

MATERIALS AND METHODS

Genetic stocks and housing were the same as for experiment 2, discussed earlier.

Procedure : Twelve cages were used instead of 20 as earlier, due to non-availability of pullets in required numbers. As such, there were only 3 replications of each housing treatment. Each cage contained 6 females with strain intermingled (2 females of each of 3 strains) and 2 males. All males used were of Oc strain. Males and females were housed at 25 weeks of age. All females were weighed at the beginning and at the end of the experiment, at 28 weeks of age. The agonistic behavior of these birds was observed four days a week for three weeks, as described earlier. In agonistic behavior, female to female activity was observed. The modified rearing battery units did not have sloping wire floors nor egg collection trays. Hence after the 3-week observation period all females were removed to individual cages, keeping the females from the same unit adjacent for collection of hatching eggs for that unit. Eggs were then collected over a 5-day period from each group of females which had been kept together in the rearing battery units. Eggs were then set for 7 days and then individually candled for a fertility test.

The mean frequencies of social acts per bird per observation period for each cage were calculated for statistical analyses. Rankings of the females were determined, as described in experiment 2.

RESULTS

Mean squares from the analyses of variance for severe, other and total agonistic acts are given in Table 8 and means are shown in Table 9.

TABLE 8

MEAN SQUARES FROM ANALYSES OF VARIANCE FOR SEVERE, OTHER AND TOTAL AGONISTIC ACTIVITIES

Source	D.F.	Mean squares		
		Severe	Other	Total
Treatments	3	166.22 **	648.31 ***	1470.97 ***
Area	1	432.00 **	1704.09 ***	3857.09 ***
Height	1	33.33	126.75	290.09
Area X Height	1	33.34	114.08	270.74
Remainder	8	21.17	33.50	90.00

** = P < .01
*** = P < .005

TABLE 9

MEAN FREQUENCIES OF AGONISTIC ACTIVITIES CLASSIFIED BY AREA PER FEMALE

Area	Severe	Other	Total
Small	0.42 1/	0.52	0.94
Large	0.75	1.18	1.93
Small - Large	- 0.33 ***	- 0.66 ***	- 0.99 ***

1/ Frequency per female per 10 min.
*** = P < .005

Peck order ranks of the strains were analyzed with results as indicated in Table 10. No significant differences were found in rankings of the strains for females.

TABLE 10

MEAN SQUARES FROM ANALYSIS OF VARIANCE FOR RANKINGS OF FEMALES

Source	D.F.	Mean squares
Strains	2	4.34
Remainder	33	3.83

Weight gains from 25 to 28 weeks were analyzed with results as shown in Table 11. Gain in weight was significantly affected by strains. Strain effects on weight gains are shown in Table 12.

TABLE 11

MEAN SQUARES FROM ANALYSIS OF VARIANCE FOR GAIN IN WEIGHT IN FEMALES

Source	D.F.	Mean squares
Treatments	3	3013.52
Strains	2	63602.27
Treatment X Strain	6	2430.50
Remainder	60	6912.27

*** = P < .005

TABLE 12

EFFECT OF GENETIC STRAIN ON WEIGHT GAINS OF FEMALES FROM 25 TO 28 WEEKS

Strains :	Oc	Os	S275
	378.8	424.5	481.5

Note : Means not underscored by the same line are significantly different (P < .05).

No significant differences were found in fertility due to different housing treatments, Table 13. Mean fertility obtained in the week following 2 weeks of exposure of 6 females with 2 males per cage was 82 %.

TABLE 13

MEAN SQUARES FROM ANALYSIS OF VARIANCE OF FERTILITY

Source	D.F.	Mean squares
Treatments	3	137.49
Remainder	8	231.22

EXPERIMENT 4 : EFFECTS OF GENETIC STRAINS, DENSITY AND CAGE HEIGHT ON EARLY FERTILITY IN MODIFIED REARING BATTERIES

MATERIALS AND METHODS

The same genetic stocks and housing methods as in experiments 2 and 3 were used for this experiment.

Procedure : A total of 12 cages were used with 3 replications of each area-height treatment. Seven females were first intermingled at the age of 28 weeks, without regard to strain, on a random basis. Twelve males were used of the same strain; one male was kept within each cage. Groups of birds were kept in these units for 2 weeks. The modified rearing batteries used did not have sloping wire floors nor egg collection trays. The same procedure of removing all females to individual cages, as explained in experiment 3, was followed for the collection and fertility testing of hatching eggs. After the first period with one strain of males, females were again randomized and placed in the experimental cages for two subsequent experimental periods. Males of the other two strains were used, one strain per period and the egg collection and fertility testing procedure repeated.

RESULTS

Fertility data were analyzed with results as shown in Table 14. It is realized that strain of male effects are confounded with experimental periods. Strain of male effects on fertility are shown in Table 15.

TABLE 14

MEAN SQUARES FROM ANALYSIS OF VARIANCE FOR FERTILITY

Source	D.F.	Mean squares
Treatment	3	613.45
Strains	2	2596.24 *
Treatment X Strain	6	423.19
Remainder	24	708.13

TABLE 15

EFFECTS OF STRAIN OF MALE ON PERCENTAGE FERTILITY IN MODIFIED REARING BATTERIES

Strains:	Oc	S275	Os
	55	80	82

Note : Means not underscored by the same line are significantly different ($P < .05$).

EXPERIMENT 5 : EFFECT OF MORE SOLID FLOORING IN COLONY CAGES ON FERTILITY

MATERIALS AND METHODS

The genetic stocks and colony cages were the same as used in experiment 1.

Procedure: More solid flooring was provided in 6 colony cages by placing 1/2" X 1/2" wiremesh reinforcing over the 1" X 2" flooring. One 40-week-old male was placed in each colony cage along with 10 females of the same age. Males had been housed from 12-to-40 weeks of age in individual cages.

After the introduction of males, eggs for a fertility test were collected on the 13th and 14th days. They were incubated for 10 days and fertility was checked.

RESULTS

Results of the fertility check are indicated in Table 16. Because of the limited data and non-normal distribution no analysis was attempted. It appears, however, as though more solid flooring confers some advantage.

TABLE 16

NUMBER OF COLONY CAGES AND FERTILITY BY STRAIN AND FLOORING TYPE

Flooring		Genetic stock			Totals and Means
		S275	Os	Oc	
More solid	No. cages	2	2	2	6
	Fertility, %	50	10	10	23
Control	No. cages	2	2	2	6
	Fertility, %	15	0	0	5

EXPERIMENT 6 : EFFECT OF PREVIOUS MATING EXPERIENCE OF MALES ON FERTILITY IN COLONY CAGES

MATERIALS AND METHODS

The genetic stocks and colony cages were the same as used in experiment 1.

Procedure : A total of 12 colony cages were used. All females were 56-weeks old. Six 40-week-old males which had previous mating experience in floor pens were placed into six colony cages. Six other colony cages received single males of the same age which had been housed in individual cages from 12-to-40 weeks of age.

After the introduction of males, eggs were collected on the 13th and 14th days, incubated for 10 days and then checked for fertility.

RESULTS

Results are indicated in Table 17. Because of limited data and its non-normal distribution an analysis of variance was not calculated. Nevertheless, previous mating experience of males in floor flocks appeared to have a large effect on fertility buildup; experienced males fertilized 50 % of eggs compared to 7 % for naive males.

TABLE 17

NUMBER OF COLONY CAGES AND FERTILITY BY STRAIN AND PREVIOUS MATING EXPERIENCE OF THE MALE

Previous Mating Experience		Genetic stock			Totals and Means
		S275	Os	Oc	
Floor flocks	No. cages	2	2	2	6
	Fertility, %	30	60	60	50
None	No. cages	2	2	2	6
	Fertility, %	0	20	0	7

DISCUSSION

Fertility :

Fertility obtained in commercial-type colony cages in experiment 1 was very much on the low side as compared with fertility normally achieved in floor pens. This could perhaps be explained partly as follows. Most workers, for example, Mulkey (1972), Kreuger et al.(1972) and Campos et al. (1973) used colony cages with about 24" height. Colony cages used in these experiments were 14.5" high at the back and 17" high in front. Secondly, Mulkey (1972), Weinreich (1973) and Mathews (1973) suggested that birds should be caged at 12 to 18 weeks of age to give them sufficient time to become acclimatized. Eggs in experiment 1 were tested for fertility beginning one week after males were introduced. Kreuger et al. (1972) and Campos et al. (1973), however, obtained satisfactory fertility after two weeks. Mulkey (1972) indicated that males and females should be raised together in colony cages to obtain high fertility.

Strains and densities did not have a significant influence on fertility in experiment 1, which was a preliminary study. In experiment 4, however, there was an indication of genetic strain differences in fertility obtained. The Os strain had a significantly higher percentage fertility than the Oc strain. Data to be presented later (Part B) confirms the presence of significant differences in fertility due to strains.

To investigate whether the density of birds, height of cages and familiarity of environment have any significant influence on fertility buildup, experiments 1, 3 and 4 were carried out. From the results of experiments 3 and 4, it appears that density of birds and height of cages do not have significant influences on fertility. From the comparison of mean fertility in period 1, 21 % and period 3, 23 %; of experiment 1, there does not appear to be any appreciable difference due to familiarity with environment on the performance of males.

The mean fertility obtained in commercial-type colony cages was 21 % two weeks after introduction of males, but was 80 % in modified rearing batteries. As there was a dramatic difference between those two results, attempts were made to improve fertility in the colony cages by providing more solid flooring and by using males with previous mating experience in experiments 5 and 6. In spite of the limited data from those two experiments, it appears as though more solid flooring confers some advantage and previous mating experience of males had an even larger effect in improving fertility buildup in colony cages.

Agonistic behavior :

Effects of genetic strain, density and cage height on agonistic behavior of males and females were investigated in experiments 2 and 3. In males, density/or area per bird had a significant effect on frequency of other and total agonistic acts. In females all three types of agonistic activity were significantly affected by area per bird. As the area per bird increased, the frequency of agonistic acts also increased.

In males all three strains differed significantly in their aggressiveness rankings. Oc strain males were most aggressive, followed by S275 and then by Os. In females, however, no significant differences were observed in strain aggressiveness rankings. Males used in these experiments attained sexual maturity at 9-to-13 weeks of age and hence were more advanced in sexual maturity than the females which averaged 21-to-25 weeks age at first egg and thus were just at the point of sexual maturity at the time of the experiment. These differences in developmental ages may be responsible for the difference between results for males and females.

Weight gains :

Strains and area per bird had significant effects on weight gain for males. However, only strains had a significant effect on weight gain of females. In males, birds having larger area per bird gained more weight. Oc strain males had larger weight gains than found in the other two strains.

PART B

EFFECTS OF GENETIC STRAINS, HOUSING ENVIRONMENTS, PRESENCE OF MALES AND AGE ON BEHAVIORAL AND PRODUCTIVITY TRAITS

MATERIALS AND METHODS

Genetic stocks : The same three strains of White Leghorns were used (Oc, Os and S275) as in the previous experiments.

Housing : The laying house used at the Avery Poultry Research Center has 24 floor pens (5' X 7 1/2') and 24 colony cages (36" wide, 28" deep, 14.5" high at the back and 17" high in front). This combination cage and floor-pen house is naturally ventilated. There are 3 rows of eight floor-pens each and 24 colony cages arranged 12 in a row, back to back. Floor pens and colony cages have horizontal feeder troughs and continuous water channels for each row. The central row of floor pens has platforms at intervals along the top. Observers on the platforms do not disturb the birds.

Experimental procedures : Chicks for the experiment were from two hatches. An attempt was made to use 20 males with 60 females per strain with a maximum of 2 sons per sire of the relaxed-selection generation as parents, so as to have a wide genetic base. For the second hatch, 15 to 18 sires were mated with 3 females each as for the first hatch. The first hatch was taken out on July 11th and the second on October 31st, 1972. All chicks were wingbanded, dubbed, sexed and vaccinated against NewCastle, Bronchitis and Marek's diseases on the day of hatch.

The first hatch received about 15 hours natural daylight initially, which decreased to 13 hours per day. The second hatch initially received 14 hours of natural daylight, which decreased to 13 hours per day. Subsequently, lights were used to provide 15 hours of light per day. Debeaking was done at about 3 weeks of age. A standard egg-laying ration with 17 % protein was fed ad libitum during the study.

Pullets were of two ages, 48 and 32 weeks of age, at the initiation of this study. Accordingly, 12 floor pens and 12 colony cages were used for each age group. There were four replications of each strain-housing-age subclass. To study the effects of presence (or absence) of male breeders on agonistic and mating behavior, half of the pens and cages contained males; whereas the other half was without males. Assignment of males, of the same age and strain as females, was at random within subclasses. The experimental design is shown in Table 18.

TABLE 18

NUMBER OF FLOCKS PER SUBCLASS AND DESIGN OF EXPERIMENT

Housing Method	Initial Age, wks.	Males Present	Genetic strains		
			S275	Os	Oc
Floor Pens	48	Yes	2	2	2
		No	2	2	2
	32	Yes	2	2	2
		No	2	2	2
Colony Cages	48	Yes	2	2	2
		No	2	2	2
	32	Yes	2	2	2
		No	2	2	2

The assignment of strains to floor pens and colony cages was done on a random basis. Individual birds were assigned on a restricted randomized basis, so as to bring together the maximum number of strangers possible in each flock. Ten females were housed in each unit.

The older-age group was initially placed in the laying house at 12 weeks of age and the younger group was placed in floor pens at 18 weeks of age. The younger group was reassembled at 30 weeks into 12 floor pens and 12 colony cages. The older group, assembled earlier, had established their peck order. Because only 10 females were housed per unit it was expected that the younger-age group would establish peck orders within flocks within 2 weeks. Accordingly, observations of social and mating behavior were started at 32 weeks of age for the younger group. Observations of the older groups were begun simultaneously at 48 weeks.

On June 13th, 1973, two weeks after the younger group was assembled, two males were introduced into half of the flocks as indicated in Table 18. Observations of agonistic and mating behavior were started the following day. Twelve units were observed on each occasion. Those 12 units were randomly selected earlier, so as to have 3 units of older and 3 units of younger groups in each of the floor-pen and colony-cage environments. Observations were made twice a day, in the morning between 6 and 8 A.M. and in the afternoon from 4 to 6 P.M. Observations were carried out 4 days a week.

Any group observed initially in the morning was observed subsequently during the same week in the afternoon and vice versa. Each floor pen and colony cage was observed for a 10-minute period per observation and all agonistic and mating behaviors were recorded. Thus, 8 observations per week were made, yielding two observations per flock per week.

The number of females in the unit and the number of females on the floor in the floor pens at the beginning and end of the observation period were recorded. Agonistic behavior classified as female to female, male to male, male to female and female to male was recorded. Agonistic behavior was primarily recorded under two categories, namely, "intense" or "severe" acts, which included fights and peck-avoidances and "other" which included threat-avoidances and chase-avoidances. Those interactions were summed to give the total interactions per group. Along with agonistic behavior, mating behavior was also recorded.

Mating behavior was recorded as follows :

Courting behavior of males :

This included all courting behavior of males such as waltzing, feather ruffling, wing flapping.

Reaction of females :

Crouching or avoidance of the female, in response to courting by a male.

Mounting by male :

Mountings by males were recorded.

Matings :

After mounting and treading, successful matings, if any, were recorded. A successful mating was assumed when the male mounted, treaded and when after apparent mating the female got up and ruffled her feathers.

In addition to agonistic and mating behaviors, any other significant behavior such as feather pulling, cannibalism was also recorded.

Egg production per flock (pen or cage unit) was recorded three days each week and mortality was recorded daily. All females were weighed at the beginning and end of the experiment, to allow calculation of gain in weight.

Hatching eggs from units with males were collected from the second week onwards. These were saved for periods up to 2 weeks at 55° F. and were then set for checking fertility. Fertility was determined after about 10 days of incubation by candling individual eggs. In cases of doubt, eggs were broken open and examined more closely.

After completion of all observations, the frequency of agonistic acts per bird per 10-minute observation was calculated. One calculation was done on the basis of the number of females present in the flock and a second on the basis of average number of females on the floor (in floor pens). The second calculation was based on the number of females in the "social group"; it was presumed that females on perches or in nest boxes did not contribute towards agonistic activity in floor flocks.

In a similar manner, mean numbers of agonistic acts per bird per 10-minute observation were also calculated for male to male, male to female and female to male combinations. During certain periods of observation, the submissive male hid from the dominant male by sitting on perches, crouching under the feed hopper. The amount of time of such hiding by submissive males was not recorded.

Frequencies of mating behaviors such as courting by males, crouching and/or avoiding by females, mounting by males and completed matings were calculated similarly.

Egg production was calculated on both hen-housed and hen-day bases for the 8-week period of the study. Fertility was calculated weekly and the total period of study was divided into 3 periods. The 2nd and 3rd weeks of the study constituted the first period, the 4th and 5th weeks constituted the second period and the 6th, 7th and 8th week constituted the third period. This subdivision by periods was done to study the buildup of fertility.

The average gain in body weight of female of each unit was calculated for the eight-week period.

Analytical procedures : Flock means were used as units of measure. Genetic strains, housing methods, presence of males and age groups were considered as fixed effects for analysis of variance. Fertility data collected in 3 periods were from the same groups of birds and were therefore analyzed by split-plot technique for analysis of variance. Least significant differences were calculated where required to indicate whether significant differences occurred between strains and between periods.

RESULTS

Agonistic behavior

Female to female :

The frequency of agonistic acts between females was significantly affected by presence (or absence) of breeder males and by housing, whether calculated on the basis of per female "alive" in the unit or as per female "on the floor" , Table 19.

TABLE 19

MEAN SQUARES FROM ANALYSES OF VARIANCE FOR FREQUENCY OF AGONISTIC ACTS BETWEEN FEMALES

Source of Variation			Frequency of agonistic acts	
			Per female alive	Per female on floor
		D.F.	M.S.	M.S.
± Male	(±M)	1	2.160 ***	2.560 ***
Strain	(S)	2	0.175	0.220
Housing	(H)	1	0.660 *	1.650 ***
Age	(A)	1	0.070	0.080
± M X S		2	0.115	0.150
± M X H		1	0.080	0.170
± M X A		1	0.150	0.130
S X H		2	0.100	0.125
S X A		2	0.030	0.030
H X A		1	0.085	0.080
± M X S X H		2	0.035	0.055
± M X S X A		2	0.025	0.040
± M X H X A		1	0.275	0.620 *
S X H X A		2	0.005	0.055
± M X S X H X A		2	0.060	0.020
Remainder		24	0.090	0.117

* = P < .05
*** = P < .005

The means of agonistic activity rates between females in 10-minute observation periods "with males" were 0.62 and 0.67 and "without males" were 1.05 and 1.13, on the basis of per female alive and per female on floor, respectively. Thus, agonistic acts between females without males were about 70 % higher than with males.

The frequency of agonistic activity was also significantly higher in floor pens than in colony cages; agonistic activity frequencies in floor pens were 0.95 and 1.09 on the basis of females alive and females on the floor, respectively, as compared with the frequency of 0.72 in colony cages. They were, therefore, 40 to 50 % higher in floor pens than in colony cages.

Male to male :

The agonistic behavior of pairs of males within flocks of females was similarly studied. One of the younger age S275 males died after 4 weeks and neither unit of the younger age S275 males in colony cages exhibited any agonistic behavior during observation periods. However, the mean frequencies of agonistic acts per male per 10-minute period in strain-housing-age subclasses were calculated and these measures were used for calculation of analysis of variance. Main effects only were tested by analysis of variance. Due to insufficient degrees of freedom, sums of squares associated with interaction terms were not separated but were pooled to provide the error term. Strains and housing both had significant effects on agonistic acts, Table 20. Means of strain-housing subclasses have been indicated in Table 21.

TABLE 20

MEAN SQUARES FROM ANALYSIS OF VARIANCE FOR FREQUENCY OF AGONISTIC ACTS BETWEEN MALES

Source	D.F.	Mean squares
Strains	2	0.6446 **
Housing	1	0.8480 **
Age	1	0.0721
Remainder	7	0.0635

** = $P < .01$

TABLE 21

MEANS OF STRAIN-HOUSING SUBCLASSES FOR AGONISTIC ACTS PER MALES

Housing	S275	Os	Oc	Housing Means
Floor	0.39 [1/]	1.08	0.83	2.30
Cage	0.22	0.21	0.19	0.62
Strain Means :	0.61	1.29	1.02	2.92

[1/] Each mean is based on data from 4 flocks with the exception of S275 floor flock, which is based on 3 instead of 4 flocks.

Male to female and Female to male :

Aggressive acts of male towards female and of female towards male were also recorded. Female towards male aggressive acts were very few and were observed initially only, when males were introduced into the units and had not yet established their dominance. Male towards female acts were also very infrequent. Due to insufficient data in both the categories, those frequencies could not be analyzed statistically.

Egg production and gain in weight

Egg production :

Egg production data were analyzed as flock means on hen-housed and hen-day bases. There were highly significant differences due to housing and age, Table 22. Both hen-housed and hen-day egg production were higher in floor pens than in colony cages. Similarly, the younger age group, from 32-to-40 weeks of age had a higher percentage egg production than the older age group of 48-to-56 weeks, in S275 and Oc strains, Table 23. However, the Os strain older age group females (48-to-56 weeks) had higher egg production than younger age females, thus exhibiting the strain X age interaction.

TABLE 22

MEAN SQUARES FROM ANALYSES OF VARIANCE FOR EGG PRODUCTION AND WEIGHT GAIN

Source		D.F.	Mean squares		
			Hen Housed	Hen Day	Weight gain
± Male	(±M)	1	203.858	94.14	5.21
Strain	(S)	2	54.644	86.09	573.19
Housing	(H)	1	2814.285 ***	2733.41 ***	472.51
Age	(A)	1	588.280 **	601.94 ***	20245.87 *
± M X S		2	31.386	24.00	750.55
± M X H		1	129.823	158.62	1138.80
± M X A		1	133.067	32.51	2120.02
S X H		2	21.974	37.96	641.57
S X A		2	289.844 *	205.84 *	11103.06 *
H X A		1	7.068	9.63	2184.30
± M X S X H		2	26.494	46.39	5103.65
± M X S X A		2	96.245	130.66	2672.33
± M X H X A		1	102.258	19.41	1.13
S X H X A		2	7.081	138.38	1293.62
± M X S X H X A		2	53.748	43.13	1242.02
Remainder		24	66.680	41.78	2852.65

* = $P < .05$
** = $P < .01$
*** = $P < .005$

TABLE 23

MEAN EGG PRODUCTION BY HOUSING METHODS AND AGES

Main Effects		Hen-Housed, %	Hen-Day, %
Housing :	Floor Pens	74.0	75.6
	Colony Cages	58.7	60.5
	Floor - Cage	15.3 ***	15.1 ***
Age :	Younger (32-to-40 wks)	69.8	71.6
	Older (48-to-56 wks)	62.8	64.5
	Younger - Older	7.0 **	7.1 ***

** = $P < .01$
*** = $P < .005$

Gain in weight :

Two age groups of females were weighed at the beginning and at the end of the experiment. The older-age group was weighed at 48 and 56 weeks of age and the younger at 32 and 40 weeks of age. Gain in weight was significantly affected by age. The gain in weight was larger in younger than in older females. Means of the gains in weight were 377.8 gms. per female in the older-age group and 418.9 gms. per female in the younger-age group. However, older females of S275 strain gained more weight than the younger females, thus exhibiting a significant strain X age interaction.

Mating behavior

In addition to agonistic behavior, mating behavior was also observed. Table 24 indicates the mean squares from analyses of variance for courting by males, crouching and avoidance by females, mounting and mating by males. Housing had significant effects on courting by males and avoidance by females. Age had significant effects on crouching by females and mounting and mating by males. Means of those traits have been calculated and are indicated in Table 25.

TABLE 24

MEAN SQUARES FROM ANALYSES OF VARIANCES FOR MATING BEHAVIOR

Source		D.F.	Mean squares				
			Courting by ♂	Crouching by ♀	Avoidance by ♀	Mounting by ♂	Mating by ♂
Strains	(S)	2	0.062050	0.000847	0.002075	0.01550	0.01188
Housing	(H)	1	0.351920 **	0.000267	0.008664 *	0.01469	0.00798
Age	(A)	1	0.039100	0.001768 *	0.000054	0.05572 *	0.05274 *
S X H		2	0.101445	0.000858	0.001741	0.02153	0.02018
S X A		2	0.014205	0.000082	0.000312	0.00052	0.00049
H X A		1	0.017950	0.000337	0.000704	0.00491	0.00406
S X H X A		2	0.012570	0.000042	0.000181	0.00054	0.00066
Remainder		12	0.037310	0.000367	0.001265	0.00606	0.00659

* = P < .05
** = P < .01

TABLE 25

EFFECTS OF HOUSING METHODS AND AGES ON FREQUENCIES OF MATING BEHAVIOR TRAITS 1/

Main Effect		Courting by ♂	Crouching by ♀	Avoidance by ♀	Mounting by ♂	Mating by ♂
Housing :	Floor Pens	0.54	0.04	0.07	0.19	0.18
	Cages	0.29	0.03	0.03	0.14	0.14
	Floor - Cage	0.25 **	0.01	0.04 *	0.05	0.04
Age :	Older	0.38	0.03	0.06	0.12	0.11
	Younger	0.46	0.05	0.05	0.22	0.21
	Older - Younger	-0.08	-0.02 *	0.01	-0.10 *	-0.10 *

1/ Frequencies per individual per 10 minutes.

The frequency of courting by males and avoidance by females was nearly twice as large in floor pens as in colony cages. Similarly, the frequency of crouching by females and mounting and mating by males was also about twice as large in younger stock as in older stock.

The frequency of matings during morning and afternoon periods was recorded. Data on total matings for morning and afternoon were classified on the basis of mating or no mating during each flock observation and were analyzed by Chi-square test. Chi-square test was carried out on all males and also on older and younger males separately; calculated Chi-sqaure values of 48.0, 19.7 and 29.4 were obtained for those groups, respectively. All three categories indicated highly significant differences ($P < .005$). More matings took place in the afternoons; 80 % of all matings observed occurred in the afternoon.

Fertility

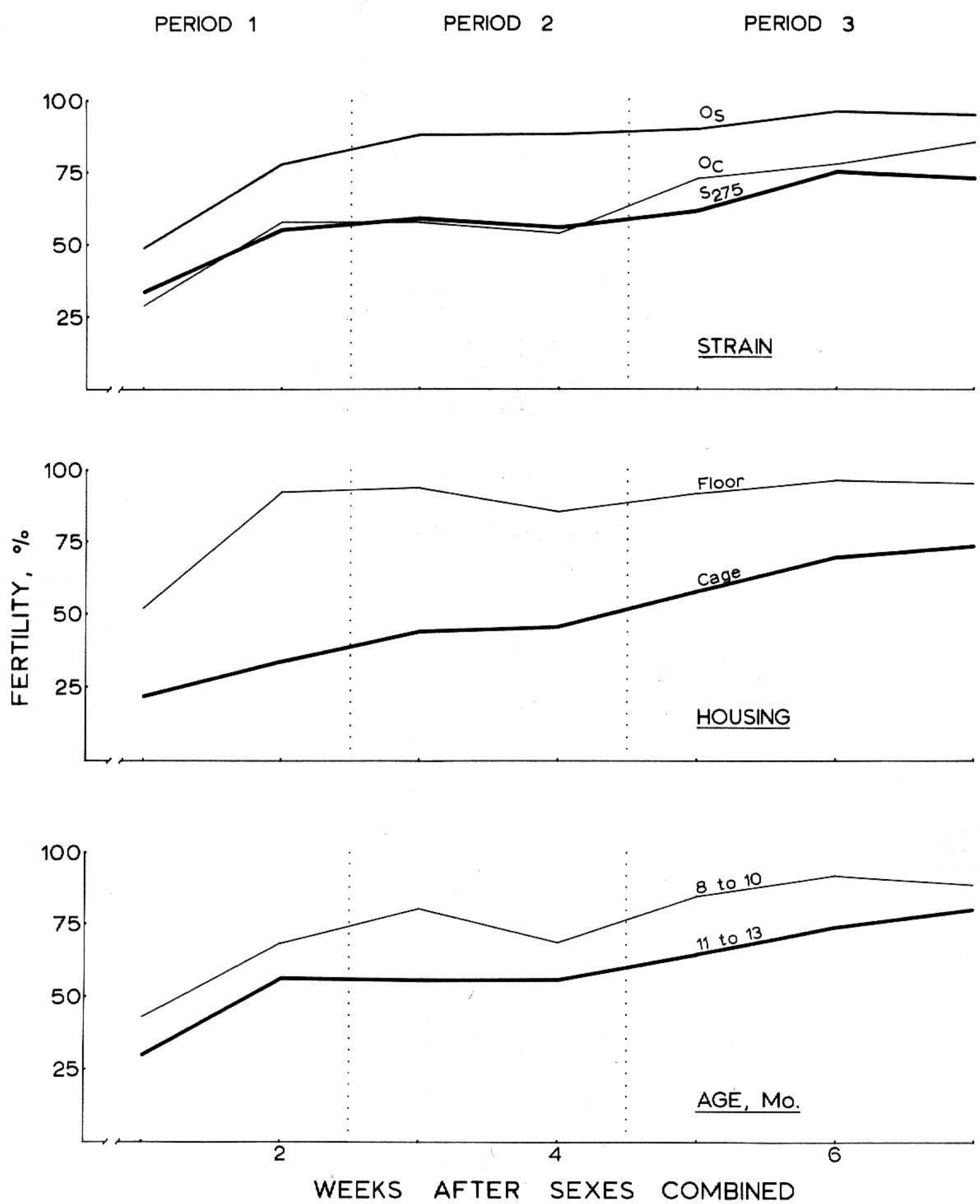
Fertility of hatching eggs produced in units with males was checked beginning one week after the introduction of male breeders. The total seven weeks of data were divided into three periods; the 2nd and 3rd weeks constituted the first period, the 4th and 5th weeks the second and the 6th, 7th and 8th weeks the third period. Mean percentages of fertility were determined for those three periods. Table 26 indicates mean squares from the analysis of variance of the fertility percentages.

Percentage fertility was influenced significantly by all main effects as well as by interactions of strain X housing, strain X age, period X housing and period X housing X age. Means associated with main effects are shown in Table 27. It may be seen that strain Os was significantly different than the other two strains and that all the three periods differed significantly from each other. Figure 2 shows the trend of fertility buildup by strains, housing and age. The various interactions observed in Table 26 can be explained as follows :

Strain X Housing :

The three strains differed in fertility in the different laying-house environments. The Os strain exhibited better fertility in both the floor pens and colony cages (91 % and 72 %, respectively).

Fig. 2. Fertility as influenced by genetic strain, housing, age and period after the sexes were combined.


PERIOD 1
PERIOD 2
PERIOD 3
100
75
50
25
O_S
O_C
S_{275}
STRAIN
Floor
Cage
HOUSING
FERTILITY, %
8 to 10
11 to 13
AGE, Mo.
2
4
6
WEEKS AFTER SEXES COMBINED

The Oc strain yielded 76 and 43 per cent in the two housing environments, whereas S275 performed quite differently in the two environments with 89 % and 25 % fertility in floor pens and colony cages. Thus, Os strain was consistently high performing in both environments. In contrast, the S275 strain performed well only in floor pens.

Strain X Age :

The percentage fertility was much higher in the younger age males of the S275 and Oc strains (higher fertilities of 15 % and 35 %, respectively), whereas both age groups were alike in the Os strain (both 82 %).

Period X Housing :

Differences between percentage fertility of floor pens and colony cages were decreased with the passage of time. Thus, floor pen superiority was reduced from a difference of 45 % during the first period to 28 % during the third period.

Period X Housing X Age :

Fertility was lower for older than for younger age males and lower in colony cages than in floor pens. The percentage fertility in cages increased from 30 % during the first period to 64 % in the second and 80 % in the third period for younger males. However, with older males, it was 26 % in both the first and second periods and increased to 54 % during the third period. Thus, the fertility buildup by older age males in colony cages was much slower than with younger age males. Differences between older and younger males were of lesser magnitude in floor pens, though younger males were found to yield higher fertility there also.

TABLE 26

MEAN SQUARES OF ANALYSIS OF VARIANCE FOR PERCENTAGE OF FERTILITY

Source		D.F.	Mean squares
Strains	(S)	2	4387.78 ***
Housing	(H)	1	27103.35 ***
Age	(A)	1	4923.29 ***
S X H		2	3239.38 ***
S X A		2	1820.72 **
H X A		1	569.09
S X H X A		2	831.67
Error 1		12	223.86
Periods	(P)	2	5689.40 ***
P X S		4	200.64
P X H		2	590.04 *
P X A		2	163.34
P X S X H		4	130.20
P X S X A		4	163.70
P X H X A		2	851.16 **
P X S X H X A		4	119.86
Error 2		24	118.05

* = $P < .05$
** = $P < .01$
*** = $P < .005$

Note : For calculation of F of the sources above the line, Error 1 term was used, whereas for the sources below the line, Error 2 was used.

TABLE 27

MEAN PERCENTAGES OF FERTILITY BY GENETIC STRAINS, HOUSING METHODS, AGES AND PERIODS

Main Effects		Percentage fertility
Genetic Strains :		
S275		57.4^{a}
Oc		59.4^{a}
Os		81.8^{b}
Housing Methods :		
Floor Pens		85.6^{a}
Cages		46.8^{b}
Ages :		
Younger	(32 to 40 wks)	74.4^{a}
Older	(48 to 56 wks)	57.9^{b}
Periods :		
First	(Wks. 2 and 3)	50.2^{a}
Second	(Wks. 4 and 5)	67.4^{b}
Third	(Wks. 6, 7 and 8)	80.9^{c}

Note : Means within main effect categories followed by different superscripts differ significantly ($P < .05$).

DISCUSSION

Agonistic behavior

Female to female :

The frequency of agonistic acts between females was significantly influenced by the presence (or absence) of breeder males. Agonistic activity was about 70 % higher in units without males. Thus, the presence of males reduced agonistic activity between females. It may be postulated that this occurred either because of male social dominance in the group or because mating behavior in these units suppressed agonistic behavior. In the literature reviewed, there does not appear to be any earlier study on these aspects of social behavior.

Housing had a significant influence on agonistic activity which was 40 to 50 % higher in floor pens as compared to colony cages. Polley and Craig (1973) observed nearly 4 times more agonistic acts in floor pens as compared to colony cages. They stated that, " the large reduction in agonistic activity observed in colony cages does not necessarily indicate that colony cages should be considered a more desirable environment than floor pens. "

This is confirmed by results of the present study as egg production was 15 % lower in colony cages as compared to floor pens ($P < .005$).

Male to male :

Strains and housing both had significant effects on frequency of agonistic acts between males. Os males exhibited more agonistic activity than the other two strains. The frequency was nearly 4 times more in floor pens as compared to the colony cages.

Male towards female and Female towards male :

The data obtained for those two categories were insufficient for any statistical analyses.

Egg production and Gain in weight

Egg production :

Both hen-housed and hen-day egg production were significantly affected by housing and age of the flock. Egg production was about 15 % higher in floor pens than in colony cages. Younger-age-group females (32-to-40 weeks) had about 7 % higher rate of egg production than older-group females (48-to-56 weeks). Presence or absence of males was not associated with a significant influence on egg production. However, the mean percentage egg production in units with males was 4 % lower than the units without males. The present study was carried out for an 8-week period only. It would be interesting to investigate whether the presence of males over a longer period would have any significant effect on egg production.

Gain in weight :

Two age groups, one from 32-to-40 weeks and the other from 48-to-56 weeks of age were used in this study. The younger-age-group females gained significantly more than the older-age group. The gain in the older age group birds was expected to be less because of their approach to maximum body weight at the beginning of the study.

Mating behavior

Frequencies of courting by males and avoidance by females were significantly affected by housing. Age had significant effects on crouching by females and on frequency of mounting and mating by males.

Courting by males and avoidance by females was nearly twice as frequent in floor pens as in colony cages. This is presumably associated with more space per bird available in floor pens. Males had more room for exhibiting courting behavior and unwilling females had more opportunity to escape in floor flocks. Parker *et al.* (1940) observed that males maintained in batteries were less active sexually than males maintained in floor pens. Williams and McGibbon (1957) showed the number of escapes by females from males to be directly proportional to the number of matings attempted. In the present study the higher incidence of courting behavior by males in floor pens was also associated with higher incidence of escapes.

Crouching by females and mounting and mating by males were also nearly twice as frequent in younger stock as compared to the older-age group. Guhl, Collias and Allee (1945) and Williams and McGibbon (1958) found a high correlation between the frequencies of "sex invitations" by females and the number of matings. In the present study, younger females exhibited 3/4th times higher receptivity to males than older females and the total completed matings in younger females were nearly twice that of older females.

Significantly higher numbers of matings, about 80 % of the total observed, took place in the late afternoon, which is in agreement with the earlier observations of Upp (1928), Skard (1937), Parker *et al.* (1940) and Long and Godfrey (1952).

Fertility

Percentage fertility was significantly affected by strains, housing, age and periods. The Os strain had significantly higher fertility than the other two strains. This strain performed better in floor pens as well as in colony cages. The S275 strain had only about 30 % as high fertility in colony cages as compared with floor-pen fertility; Oc had about 55 % fertility as compared to floor pens; whereas Os had about 80 % as high fertility in cages as in floor pens. Males of both age groups performed at nearly the same level in Os, thus showing it to be the most consistent and best-performing strain of the three. Such strains as Os would appear well suited for hatching egg production under the rigorous conditions of the colony cage environment.

Average fertility over the 7-week test period in floor pens was 86 % whereas in colony cages it was only 47 %.

Younger males had about 15 to 16 % higher fertility than older males. Parker (1958) obtained about 13 % higher fertility from younger cockerels than from older males.

All three periods were significantly different in fertility. The results indicate the fertility buildup was gradual. Figure 2 shows this trend by period for strains, housing and age groups. The slow and gradual buildup of fertility in colony cages appears to be the reason that Mulkey (1972), Weinreich (1973) and Mathews (1973) recommended housing breeders by 12 to 18 weeks of age so as to acclimatize them before hatching eggs were to be saved.

SUMMARY AND CONCLUSIONS

Six experiments were conducted as preliminary studies to investigate effects of genetic strains, area-height treatments and flooring type of cage units, familiarity of breeder males with the environment and previous mating experience of males on fertility, agonistic behavior and weight gains.

For all six experiments 3 strains of White Leghorn type chickens were used. Three experiments were conducted in commercial-type colony cages. The first was carried out to study effects of strain, density and familiarity of males on fertility buildup. Another experiment compared conventional flooring of the cage with more solid flooring and the third compared naive males with males having previous mating experience. From those results it appears that fertility buildup in commercial-type colony cages was low as compared with fertility normally achieved in floor pens. Strain differences, though non-significant, indicated a trend found to be significant in later comparisons. Density did not have any significant effect on fertility, when reduced after the first 5 weeks. Breeder male familiarity with environment had no appreciable effect on fertility. More solid flooring appeared to confer some advantage and previous mating experience of males in floor flocks had a large effect in improving fertility in colony cages.

The other three preliminary experiments were conducted in modified rearing batteries with varying area-height dimensions. Genetic strains had a significant effect on frequency of agonistic activities in both sexes. Area per bird affected frequency of agonistic activities for males; as area increased the frequency of agonistic acts also increased. Strains also had significant effects on weight gains in both sexes. In males, area available per bird affected the weight gain; birds with larger areas gained more weight. In one experiment females were kept with males and hatching eggs were collected for fertility tests. Males of one strain were used at one time and the whole procedure was repeated for all three strains. Area or height of cage had no appreciable influence on fertility. Strains of males, though confounded with different testing periods, had a significant effect on fertility. Fertility obtained 2 weeks after sexes were combined, was 80 % in modified rearing batteries as compared to 21 % in commercial-type colony cages.

The second phase of the study involved effects of genetic strains, presence of males, housing environments and age on behavior and productivity traits. The same three strains of chickens were used. Twenty-four floor pens and 24 colony cages were used. The experiment was conducted over an 8-week period with two age groups; the younger was 32-to-40 weeks of age and the older was 48-to-56 weeks of age. Two breeder males were introduced into half of the flocks.

Behavioral data were collected for agonistic as well as mating behaviors. Birds were weighed at the beginning and at the end of the experiment and hatching eggs were collected weekly, beginning one week after introduction of breeder males into the flocks. Egg production was recorded 3 days per week and mortality daily.

Egg production was significantly affected by housing facilities and age of flock. Rate of lay was about 15 % more in floor pens and 7 % more for the younger birds. Gain in weight was significantly larger for the younger females. Agonistic activity between females in units without males was 70 % higher than in units with males, ($P < .005$). For males, both strains and housing had significant effects on frequency of agonistic acts, ($P < .01$). For mating behavior, courting by males and avoidance by females were more frequent in floor pens ($P < .01$ and $P < .05$, respectively). Receptivity of females and mounting and mating by males was about twice as frequent in younger stock as in older stock ($P < .05$). About 80 % of all observed matings took place late in the afternoon.

Percentage fertility was influenced significantly by strains, housing, age and periods. One strain exhibited higher fertility in both, floor pens and colony cages than the other two. Another strain performed well only in floor pens. Average fertility in colony cages over the 7-week period was 54 % of that obtained in floor pens. Younger males yielded 15 to 16 % higher fertility than older males. The fertility buildup in colony cages was gradual. All three periods were significantly different from each other in fertility. Significant interactions of strain X housing, strain X age, period X housing and period X housing X

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BEHAVIORAL AND PRODUCTIVITY TRAITS IN CHICKENS AS INFLUENCED BY GENETIC STRAINS, HOUSING TREATMENTS, PRESENCE OF MALE AND AGE

by

ASHOK LAXMANRAO BHAGWAT

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Six experiments were conducted as preliminary studies to investigate effects of genetic strains, area-height treatments and flooring type of cage units, familiarity of breeder males with the environment and previous mating experience of males on fertility, agonistic behavior and weight gains.

For all six experiments 3 strains of White Leghorn type chickens were used. Three experiments were conducted in commercial-type colony cages. The first was carried out to study effects of strain, density and familiarity of males on fertility buildup. Another experiment compared conventional flooring of the cage with more solid flooring and the third compared naive males with males having previous mating experience. From those results it appears that fertility buildup in commercial-type colony cages was low as compared with fertility normally achieved in floor pens. Strain differences, though non-significant, indicated a trend found to be significant in later comparisons. Density did not have any significant effect on fertility, when reduced after the first 5 weeks. Breeder male familiarity with environment had no appreciable effect on fertility. More solid flooring appeared to confer some advantage and previous mating experience of males in floor flocks had a large effect in improving fertility in colony cages.

The other three preliminary experiments were conducted in modified rearing batteries with varying area-height dimensions. Genetic strains had a significant effect on frequency of agonistic activities in both sexes. Area per bird affected frequency of agonistic activities for males; as area increased the frequency of agonistic acts also increased. Strains also had significant effects on weight gains in both sexes. In males, area available per bird affected the weight gain; birds with larger areas gained more weight. In one experiment females were kept with males and hatching eggs were collected for fertility tests. Males of one strain were used at one time and the whole procedure was repeated for all three strains. Area or height of cage had no appreciable influence on fertility. Strains of males, though confounded with different testing periods, had a significant effect on fertility. Fertility obtained 2 weeks after sexes were combined, was 80 % in modified rearing batteries as compared to 21 % in commercial-type colony cages.

The second phase of the study involved effects of genetic strains, presence of males, housing environments and age on behavior and productivity traits. The same three strains of chickens were used. Twenty-four floor pens and 24 colony cages were used. The experiment was conducted over an 8-week period with two age groups; the younger was 32-to-40 weeks of age and the older was 48-to-56 weeks of age. Two breeder males were introduced into half of the flocks.

Behavioral data were collected for agonistic as well as mating behaviors. Birds were weighed at the beginning and at the end of the experiment and hatching eggs were collected weekly, beginning one week after introduction of breeder males into the flocks. Egg production was recorded 3 days per week and mortality daily.

Egg production was significantly affected by housing facilities and age of flock. Rate of lay was about 15 % more in floor pens and 7 % more for the younger birds. Gain in weight was significantly larger for the younger females. Agonistic activity between females in units without males was 70 % higher than in units with males, ($P < .005$). For males, both strains and housing had significant effects on frequency of agonistic acts, ($P < .01$). For mating behavior, courting by males and avoidance by females were more frequent in floor pens ($P < .01$ and $P < .05$, respectively). Receptivity of females and mounting and mating by males was about twice as frequent in younger stock as in older stock ($P < .05$). About 80 % of all observed matings took place late in the afternoon.

Percentage fertility was influenced significantly by strains, housing, age and periods. One strain exhibited higher fertility in both, floor pens and colony cages than the other two. Another strain performed well only in floor pens. Average fertility in colony cages over the 7-week period was 54 % of that obtained in floor pens. Younger males yielded 15 to 16 % higher fertility than older males. The fertility buildup in colony cages was gradual. All three periods were significantly different from each other in fertility. Significant interactions of strain X housing, strain X age, period X housing and period X housing X age were detected. Causes of those interactions are discussed.